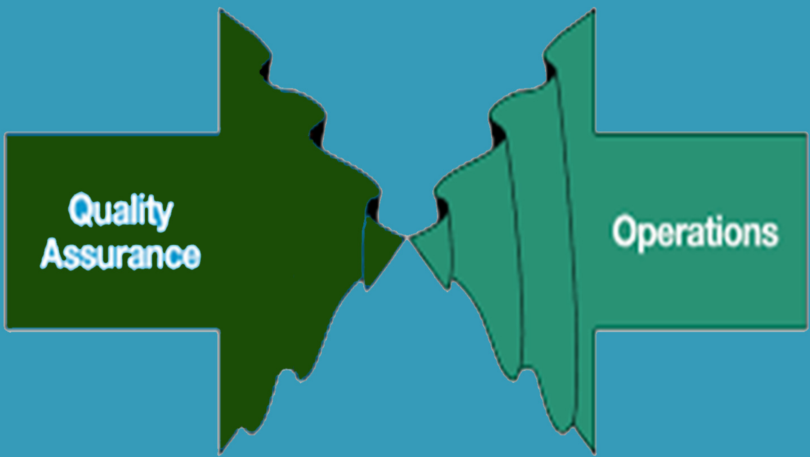
KARNATAKA STATE OPEN UNIVERSITY

Mukthagangothri Mysuru 570006

# MBA

## (Fourth Semester)





# QUALITY AND OPERATIONS MANGEMENT

Department of Studies and Research in Management

Course 19 Module- 1 to 5

# KARNATAKA STATE OPEN UNIVERSITY

**MUKTHAGANGOTHRI, MYSURU- 570 006.**

**DEPARTMENT OF STUDIES AND RESEARCH IN MANAGEMENT**

## M.B.A IV Semester

**COURSE - 19**

# QUALITY AND OPERATIONS MANAGEMENT

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**Dear Learner,**

It gives me immense pleasure to welcome you to the Department of management to study MBA Second Year (Fourth Semester) in our esteemed university.

I am Extremely happy in placing this study material in your hand. The Department of Studies and Research in Management, Karnataka State Open University is providing you Self Learning Materials (SLM) for all the courses developed by the team of experts drawn from various conventional universities, Open Universities, B-Schools, Management institutions and professionals.

This study material explains even the most complicated topics in a very simple and user-friendly manner, it starts with the Objectives, explanation of concepts followed by Case study, Notes, Summary, Key Words, Self Assessment Questions and References. It provides more value added information on contemporary issues.

Department has focussed on conceptual learning and on avoiding bulky and prolonged description. Every concept has been explained in the simplest manner. Some complicated concepts have been simplified in the study material, so that the learner can learn easily.

The Department of Management, Karnataka State Open University is offering three electives or specialization. You have already chosen the stream in which you wish to specialize i.e. Finance, Marketing and People Management. Hope you will gain expertise in you field.

The specialization in an MBA is due to business complexities and diversities. The MBA is over 100 years old now. Leading management institutes are trying to come up with new and innovative ways to educate the next generations of business leaders. In an MBA, an elective facilitates learners to plank extra focus on one particular area of interest and tailor their MBA in a different way depending on their background and future goals.

a) **Finance** – Finance is one of the most popular specialization of Master of Business Administration (MBA) program. MBA specialization in finance offers, benefits to working professionals in a variety of industries, including commercial and corporate banking, investment services and real estate. MBA specialization in Finance gains you business and financial skills need to work in a number of enterprises. Finance Specialization balances mathematical rigor with management techniques. The finance papers offered by the department builds you as a stock market experts coupled with the knowledge of corporate finance and banking.

b) **Marketing** – Marketing has become one of the most desired specialization both by students and employees in recent years. With the shift to digital and online marketing, most businesses now have their own, in-house marketing teams specialized in bringing customers to the company. Prospective students aspiring to demonstrate that they have the potential to become an excellent marketing manager require a broad skill set. Individuals with soft skills, such as communications, tend to grow well in marketing field. Other desired skills for marketing typically include analytical and leadership skills. The department has carefully chosen the papers to impart the above skills in you.

c) **People Management** – The ever increasing importance of the individuals in the success of a business, makes an in depth study of human behaviour very crucial. Effective management requires insight over the aspects of human behaviour, which can only be gained through study of the related theories and principles of people management. The Department has strived to provide you knowledge on training, change management, labour loss and so on to prepare you to face these soft challenges.

In addition to the study material provided to you, I advise you to go through the books which are suggested in the references of every unit. Further, I also suggest you to make yourself acquainted by reading newspapers and journals.

Apparently, the curriculum designed by the board of studies helps you to prepare for UGC NET, various state commission examinations and UPSC examinations. With these words I welcome you for the wonderful learning experience of business education.

I wish all the best and good luck in your education and successful management career.

**Dr. C. Mahadevamurthy**
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# INTRODUCTION

Quality and Production Management is the study of fundamentals aspects of any manufacturing industry. Quality speaks about the way of doing things. It deals with instilling good things in every step of manufacturing. It provides an assurance to the end user about the product or service. Quality looks into every stage of manufacturing right from the inspection of the incoming material to the inspection of the final product to be delivered the customer.

Production on the other hand deals with the process of manufacturing a product. It deals with getting an order from the customer in case of job production or estimating the market size in case of a general product, procurement of raw material, processing of it, manufacturing of sub assemblies, assemblies and then the final product.

A manufacturing unit can engage itself in mining, processing of such mined products, manufacturing of end products, manufacturing of parts which would fit into assembles that would be developed by the customer companies, or the manufacturing of final assemblies. A car manufacturer for example engages himself in assembling more than 6000 different parts.

Sub contracting is another type manufacturing which receives components produced by a parent company and processes it and gives it back to the parent company. It performs value addition process. The various manufacturing processes include machining, drilling, boring, facing, knurling, thread cutting, honing, lapping, grinding, cutting, grooving and so on. The various assembly process include riveting, screwing, welding, brazing, soldering and so on.

In this subject attempt has been made to provide an insight towards the production and quality management issues. It is expected that an MBA graduate should have a fundamental knowledge about the these manufacturing processes. Usually this subject is supplemented with an industrial visit in the forth semester for the students to obtain a practical insight to the manufacturing.

## QUALITY AND OPRETIONS MANAGEMENT

The **Module 1** consists of 4 units. The first unit provides the fundamentals of production management. The second unit speaks about various types of production systems. The third unit throws light on world class production strategy. The fourth unit highlights advances in production systems

The **Module 2** has 4 units. The first unit analyzes the product and process design. The second unit gives an overview of studying of plant location. The third unit describes Forecasting and Production Planning and Control. The forth unit talks about material management.

The **Module 3** contains 4 units. Unit 9 explains about Productivity and Time Study. Unit 10 gives Just-In – Time and Kanban System. Unit 11 explains Material and Maintenance Management. Unit 12 explores Production Planning and Control.

The **Module 4** consists of 4 units. The first unit talks about Total Quality Management- Introduction. The second unit gives description on Quality Costs. The third unit speaks about Bench Marking and BPRE. The last unit gives an account of Quality Gurus of TQM.

The **last Module** possesses 4 units. The first unit deals with Japaneese Techniques of Quality Improvement. Unit 18 gives an account of Quality Control and Improvement. Unit 19 examines Japaneese Techniques Of Quality Improvement. Unit 20 makes an attempt to trace Quality Standards.

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# MODULE-I
# BASICS OF OPERATIONS MANAGEMENT

## UNIT-1: INTRODUCTION TO OPERATIONS MANAGEMENT

**Structure:**

## 1.0 OBJECTIVES

After studying this unit, you should be able to;

- Get insight into Operations Management
- Explain the meaning and definition of Operations Management
- Examine the scope of Operations Management.
- Describe a production system
- Differentiate between product and service
- Classify the production systems
- Picture the Evolution of Operations Management

## 1.1 INTRODUCTION

Production/operations management is the process, which combines and transforms various resources used in the production/operations subsystem of the organization into value added product/services in a controlled manner as per the policies of the organization. Therefore, it is that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services) having the requisite quality level. The set of interrelated management activities, which are involved in manufacturing certain products, is called as **production management**. If the same concept is extended to services management, then the corresponding set of management activities is called as operations management.

## 1.2 MEANING AND DEFINITION

Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs (products) having the requisite quality level.

Production is defined as *"the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user."*

Thus production is a value addition process. At each stage of processing, there will be value addition. Edwood Buffa defines production as '*a process by which goods and services are created*'. Some examples of production are: manufacturing custom-made products like, boilers with a specific capacity, constructing flats, some structural fabrication works for selected customers, etc., and manufacturing standardized products like, car, bus, motor cycle, radio, television, etc.

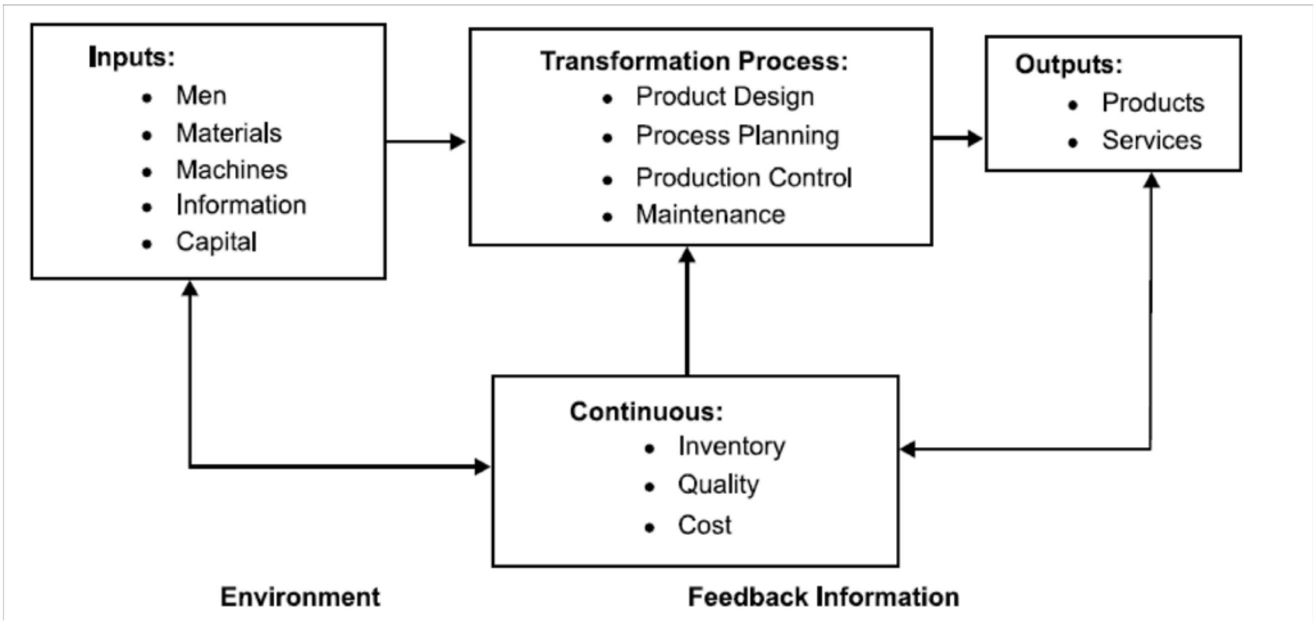


**Fig. 1.1 Schematic Production System**

Production is the basic activity of all organizations and all other activities revolve around production activity. The output of production is the creation of goods and services which satisfy the needs of the customers. In some organization the product is physical (tangible) good. For example, refrigerators, motor cars, television, toothpaste etc., while in others it is a service (insurance, healthcare etc.).The production system has the following characteristics:

- ♦ Production is an organized activity, so every production system has an objective.
- ♦ The system transforms the various inputs (men, material, machines, information, energy) to useful outputs (goods and/or services).
- ♦ Production system doesn't oppose in isolation from the other organization system such as marketing, finance etc.
- ♦ There exists a feedback about the activities which is essential to control and improve system performance.

The transformation process involves many activities and operation necessary to change inputs to output. These operations and activities can be mechanical, chemical, inspection and control, material handling operation etc.

| Product | Services |
|---|---|
| 1-Tangible, durable products. | 1- Intangible, perishable products. |
| 2- Output can be inventoried. | 2- Output can't be inventoried. |
| 3-Consumption/use takes more time. | 3-Immidiate consumption. |
| 4-Low costumer's involvement. | 4- High costumer's involvement. |
| 5-Long response time. | 5- Short response time. |
| 6-Available at regional, national and international market. | 6-Local market. |
| 7-Require large facilities. | 7- Require small facilities. |
| 8-Capital intensive. | 8-Labour intensive. |
| 9-Quality easily measured. | 9- Quality not easily measured. |
| 10-Demand variable on weekly, monthly, seasonally. | 10- Demand variable on hourly, daily, weekly basis. |

**Table 1.1 Product vs. Services**

**Classification of production system**

The production system can be classified on the basis of the following:

- Type of production – Job shop production, Batch production, Mass production
- Size of the plant – Large size plant (eg. Oil refinery), Medium size plant, Small size plant (eg. Printing press)
- Type of product- Complex to manufacture (Aircraft) and simple to manufacture
- Physical flow of material – Automated flow, Semi-automated flow and Manual flow
- Nature of order/demand pattern – Stable demand, Unstable demand
- Variety of jobs – More variety (eg. Automobiles/electronic goods), One variety (eg. Oil refinery)

## 1.3 SCOPE OF OPERATIONS MANAGEMENT

Production and operations management is concerned with the conversion of inputs into outputs, using physical resources, so as to provide the desired utilities to the customer while meeting the other organizational objectives of effectiveness, efficiency and adoptability. It distinguishes itself from other functions such as personnel, marketing, finance, etc., by its primary concern for 'conversion by using physical resources.' Following are the activities which are listed under production and operations management functions:

1. Location of facilities
2. Plant layouts and material handling
3. Product design
4. Process design
5. Production and planning control
6. Quality control
7. Materials management
8. Maintenance management.

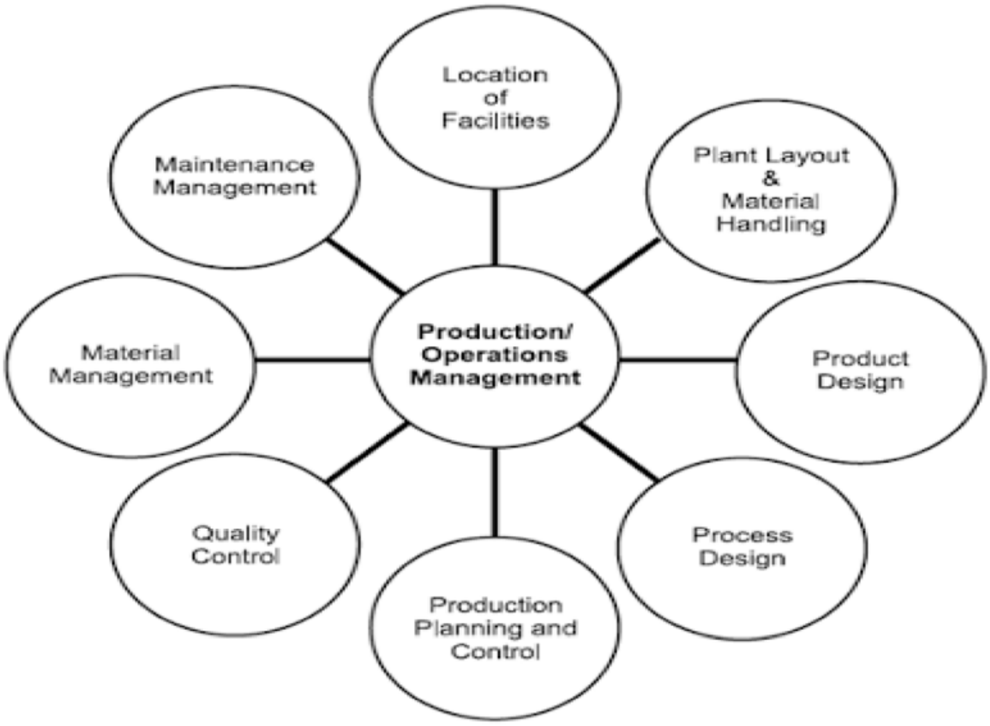


**Fig 1.2 Scope of Production and Operations Management**

**LOCATION OF FACILITIES**

Location of facilities for operations is a long-term capacity decision which involves a long term commitment about the geographically static factors that affect a business organization. It is an important strategic level decision-making for an organization. It deals with the questions such as 'where our main operations should be based?'

The selection of location is a key-decision as large investment is made in building plant and machinery. An improper location of plant may lead to waste of all the investments made in plant and machinery equipments. Hence, location of plant should be based on the company's expansion plan and policy, diversification plan for the products, changing sources of raw materials and many other factors. The purpose of the location study is to find the optimal location that will results in the greatest advantage to the organization.

**PLANT LAYOUT AND MATERIAL HANDLING**

Plant layout refers to the physical arrangement of facilities. It is the configuration of departments, work centers and equipment in the conversion process. The overall objective of the plant layout is to design a physical arrangement that meets the required output quality and quantity most economically.

According to ***James Moore,*** *"Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipments and all other supporting services along with the design of best structure to contain all these facilities".*

'Material Handling' refers to the 'moving of materials from the store room to the machine and from one machine to the next during the process of manufacture'. It is also defined as the 'art and science of moving, packing and storing of products in any form'. It is a specialised activity for a modern manufacturing concern, with 50 to 75% of the cost of production. This cost can be reduced by proper section, operation and maintenance of material handling devices. Material handling devices increases the output, improves quality, speeds up the deliveries and decreases the cost of production. Hence, material handling is a prime consideration in the designing new plant and several existing plants.

**PRODUCT DESIGN**

Product design deals with conversion of ideas into reality. Every business organization have to design, develop and introduce new products as a survival and growth strategy. Developing the new products and launching them in the market is the biggest challenge faced by the organizations. The entire process of need identification to physical manufactures of product involves three functions: marketing, product development, and manufacturing. Product development translates the needs of customers given by marketing into technical specifications and designing the various features into the product to these specifications. Manufacturing has the responsibility of selecting the processes by which the product can be manufactured. Product design and development provides link between marketing, customer needs and expectations and the activities required to manufacture the product.

## PROCESS DESIGN

Process design is a macroscopic decision-making of an overall process route for converting the raw material into finished goods. These decisions encompass the selection of a process, choice of technology, process flow analysis and layout of the facilities. Hence, the important decisions in process design are to analyse the workflow for converting raw material into finished product and to select the workstation for each included in the workflow.

## PRODUCTION PLANNING AND CONTROL

Production planning and control can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing dates for each item, to give production orders to shops and to follow up the progress of products according to orders.

The principle of production planning and control lies in the statement 'First Plan Your Work and then Work on Your Plan'. Main functions of production planning and control includes planning, routing, scheduling, dispatching and follow-up.

**Planning** is deciding in advance what to do, how to do it, when to do it and who is to do it. Planning bridges the gap from where we are, to where we want to go. It makes it possible for things to occur which would not otherwise happen.

**Routing** may be defined as the selection of path which each part of the product will follow, which being transformed from raw material to finished products. Routing determines the most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape.

**Scheduling** determines the programme for the operations. Scheduling may be defined as 'the fixation of time and date for each operation' as well as it determines the sequence of operations to be followed.

**Dispatching** is concerned with the starting the processes. It gives necessary authority so as to start a particular work, which has already been planned under 'Routing' and 'Scheduling'. Therefore, dispatching is 'release of orders and instruction for the starting of production for any item in acceptance with the route sheet and schedule charts'.

The function of **follow-up** is to report daily the progress of work in each shop in a prescribed proforma and to investigate the causes of deviations from the planned performance.

## QUALITY CONTROL

Quality Control (QC) may be defined as 'a system that is used to maintain a desired level of quality in a product or service'. It is a systematic control of various factors that affect the quality of the product. Quality control aims at prevention of defects at the source, relies on effective feedback system and corrective action procedure.

Quality control can also be defined as 'that industrial management technique by means of which product of uniform acceptable quality is manufactured'. It is the entire collection of activities which ensures that the operation will produce the optimum quality products at minimum cost.

The main objectives of quality control are:

- To improve the companies income by making the production more acceptable to the customers *i.e.,* by providing long life, greater usefulness, maintainability, etc.
- To reduce companies cost through reduction of losses due to defects.
- To achieve interchangeability of manufacture in large scale production.
- To produce optimal quality at reduced price.
- To ensure satisfaction of customers with productions or services or high quality level, to build customer goodwill, confidence and reputation of manufacturer.

## MATERIALS MANAGEMENT

Materials management is that aspect of management function which is primarily concerned with the acquisition, control and use of materials needed and flow of goods and services connected with the production process having some predetermined objectives in view.

The main objectives of materials management are:

- To minimize material cost.
- To purchase, receive, transport and store materials efficiently and to reduce the related cost.
- To cut down costs through simplification, standardization, value analysis, import substitution, etc.

## MANINTENANCE MANAGEMENT

Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: "the work of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order.

## 1.4 SIGNIFICANCE OF OPERATIONS MANAGEMENT

The operations manager will have to be involved in the development of the business's goals so that the operations department knows what resources and production methods are needed to meet goals. The Japaneese could excel in exports of cars even though they do not have indigenous raw material. The average salary paid to Japanese workers is more than average salary in US or in Europe. Still they could ear more profit than their competitors in US and Europe because they divert al their efforts in excelling their manufacturing system. The companies can adopt various practices which makers their operations significant in bringing the overall profit to their company.

**Cost leadership**

Cost leadership refers to the strategies to produce goods or services at the lowest possible cost whilst they are still acceptable to customers. By reducing the costs of production and distribution, a business will be able to gain an advantage over competitors. However, it is important that customers see that they are gaining value for money, otherwise this strategy will not see long term rewards for the business. If the strategy is successful, the business will become the leading provider of a particular good or service based on their lowered costs. Businesses adopting a cost leadership strategy commonly have standardised products

The car manufacturer Kia is well known for being a cost leader. It has concentrated on reducing costs of production but also focused on the 'look' of the car because customers will not buy a car that looks cheap.

**Good/ service differentiation**

Product differentiation is the way that a business will make their good or service stand out from other similar products. A business will use differentiation so that they can improve sales and/or charge a higher price. For example, airlines will try to differentiate their product so as to attract consumers. Businesses can differentiate themselves from others by changing obvious aspects such as price, quality or performance but also in more innovative ways such as changing the technology used in the process, speeding up delivery time and building alliances.

Porsche focus on a differentiation strategy to set it apart from other cars in relation to design, marketing and technology. For Porsche, further developing high performance sports cars also serves as a value adding activity and enhances its reputation.

**Goods and/or services in different industries**

The operations function will look different in different businesses depending on their industry category. Some businesses make tangible products known as goods. These businesses are usually found in industries in the primary and secondary sectors. For example, a primary producer, such as a sheep farmer, will provide fleece to a wool manufacturer. In these sectors, operations managers will focus on obtaining the materials that go into the making of the product (inputs) and the actual production processes.

Other businesses supply intangible (non-physical) products to customers. This is called a service and the businesses that provide these are found in industries in the tertiary sector. The tertiary sector is where the output is sold to the customer. For example, the banking industry sells financial services to customers and the retail industry sells retail products. In these industries, the operations manager will focus on customer service and after care.

**Interdependence with other key business functions**

The operations department brings together the materials and the activities needed for the production of goods and services to meet consumer demand. It also shares ideas across the business about how to improve processes or achieve cost savings to bring about best practice. The operations manager will liaise with the other department in the following ways:-

- Discuss staffing and training and development needs with the Human Resources department/manager.
- Discuss financing requirements with the Accounting and Finance department/manager.
- Discuss product design with the Marketing department/manager.

Therefore, it can be seen that the Operations department carries out a coordinating role in the business to ensure that the prime function (main activity) of the business is carried out efficiently and effectively so that consumer demand is met. In this way the business will be profitable.

Operations management refers to the design, operation and control of the transformation process that converts such resources as labour and raw materials into goods and services that are sold to customers and just as every organization produces something ,every unit in an organization also produces something. Today, every successful organization recognize the crucial role that operations management plays as part of the overall organizational strategy to establish and maintain global leadership. The strategic role that operations management plays in successful organizational performance can be seen as more organizations move towards managing their operations from a value chain perspective which means the entire series of organizational work activities that add value at each step beginning with the processing of raw materials and ending with the finished product.

There are various reasons which make operations management important. It encompasses both services and manufacturing, its important in effectively and efficiently managing the productivity as every organization should have high productivity which can lead to economic growth and development and help employees in receiving high wages as well as lead to increase in company's profit without causing inflation. Operations management is also important as it plays a strategic role in an organization's competitive success.

## 1.5 OBJECTIVES OF PRODUCTION MANAGEMENT

The objective of the production management is 'to produce goods services of right quality and quantity at the right time and right manufacturing cost'.

### 1. RIGHT QUALITY

The quality of product is established based upon the customers' needs. The right quality is not necessarily best quality. It is determined by the cost of the product and the technical characteristics as suited to the specific requirements.

### 2. RIGHT QUANTITY

The manufacturing organization should produce the products in right number. If they are produced in excess of demand the capital will block up in the form of inventory and if the quantity is produced in short of demand, leads to shortage of products.

### 3. RIGHT TIME

Timeliness of delivery is one of the important parameter to judge the effectiveness of production department. So, the production department has to make the optimal utilization of input resources to achieve its objective.

### 4. RIGHT MANUFACTURING COST

Manufacturing costs are established before the product is actually manufactured. Hence, all attempts should be made to produce the products at pre-established.

## 1.6 HISTORICAL EVOLUTION

The present position where the operations management finds itself today has gone through a large number of stages to reach the present formidable stage. Although the history of operations management is not very old—the roots of this type of management can be easily linked with the concept which deals with the phenomenon of division of labor. This concept was given by Adam Smith in his very famous book 'The Wealth of Nations' in 1776.

Experts in the field, from the time of Adam Smith and F.W. Taylor, leading to Dodge and Tippet, have contributed to the important present status of operations management in today's world.

The various contributors who have played a very important role in the formation and also the development of operations management are as under:

**1. Adam Smith (1776)**

The world has observed Adam Smith as one of the world's best Scottish economist – who was the very first person to draw some attention towards the scientific operations management. He was the one for advocating the importance of division of labor in his book 'The Wealth of Nations'. According to Adam Smith the division of labor was a very handy tool having the following benefits –

- Higher skill accompanied with greater degree of dexterity is achieved by the workmen who are performing work in repetition.
- Specialization in certain works or tasks by the workmen very often results in improvement of the various steps involved in the production methodology.
- Time is saved while changing from one activity to another.

Adam Smith is considered to be the originator of the production management concept, as the division of labor concept given by him served as the foundation for many other concepts of the operations management in the following years.

**2. Charles Babbage (1883)**

The English mathematician Charles Babbage was the first one to follow the concept advocated by Adam Smith. He advocated the concept of specialization of tasks as the next stage (logically related) to the division of labor. Babbage considered specialization in tasks as a very important advantage of the division of labor.

Charles Babbage presented his concept to the world through his book 'The Economy of Machinery and Manufacture' – in which he explained about the concept and the defining advantages of specialization. The pin industry finds reference in his book and also the seven operations, which include drawing, straightening, pointing, twisting, cutting heads, heading and tinning to highlight the gains, have been included. Workmen trades developed from the concept of specialization as a result of impetus which was provided in the beginning of the twentieth century.

**3. F.W. Taylor (1859 to 1915)**

F.W. Taylor is known as the father of scientific management – he was the one who explained the concept of functional management. Four duties of management given by Taylor are:

* Work is to be divided between the workers and the management – each of them has to take responsibility for the work for which each is best suited.

- Science of every element of the work done by man is developed in order to replace the old rule -of- thumb methods.

- The performance of workmen's work according to the scientifically devised methods by the management and also trying to achieve the co-operation between the management and the workers in order to get highest amount of production accompanied with higher worker wages.
- The best worker is selected for performing each particular task along with training accompanied with development of the worker on individual basis.

F.W. Taylor was very much against of the approach followed by the management which dealt with allowing the workers to choose the tasks which they wanted to perform – choose the methods by which they wanted to perform a task – also getting themselves trained on the jobs.

The four principles discussed above over a period have developed into great expansions, and without these four expansions the organization is inconceivable. Taylor also contributed towards the work of direct advantage to operations management.

The rules devised for time study by Taylor are as follows: –

(a) Every element of the task under study should be analyzed.

(b) Examination of the elements should take place and the one found not to be a part of the work cycle should be dropped.

(c) Timing of the elements should be accurate and should be done with the help of a stop watch.

(d) Classification of elements should be done carefully, leading to convenience for future reference.

Taylor has also made a defining contribution in the development of principles of functional organization and a financial incentive plan called "Taylor Differential Piece Rate Method".

### 4. Frank B. Gilbreth (1917)

Frank B. Gilbreth is known as the founder father of work study. He laid emphasis on explaining the importance of the correlation between the physical effort and the operators output through his two books 'Motion Study' (1911) and 'Applied Motion Study' (1917). He was the one to devise a very famous method for the classification of motions into 17 basic divisions, referred to as Therbligs by him.

### 5. Henry Ford ( 1913 )

The concept of mass production and organized work stations into a conveyorised assembly line was given to the world by Henry ford.

### 6. Henry Gantt ( 1913 )

His main contribution is the "Gantt chart "– which is a very important practical tool even in today's world, in order to chart the production schedules and also the machine load schedules.

### 7. F.W Harris ( 1914 )

The first economic lot size (EOQ) model was developed by Harris – F.W Raymond also made a very important contribution in this regard.

### 8. Walter Schewhart (1924)

In 1924 Walter was the one to introduce the concept of statistical quality control.

| *Date* | *Contribution* | *Contributor* |
|---|---|---|
| 1776 | Specialization of labour in manufacturing | Adam Smith |
| 1799 | Interchangeable parts, cost accounting | Eli Whitney and others |
| 1832 | Division of labour by skill; assignment of jobs by skill; basics of time study | Charles Babbage |
| 1900 | Scientific management time study and work study developed; dividing planning and doing of work | Frederick W. Taylor |
| 1900 | Motion of study of jobs | Frank B. Gilbreth |
| 1901 | Scheduling techniques for employees, machines jobs in manufacturing | Henry L. Gantt |
| 1915 | Economic lot sizes for inventory control | F.W. Harris |
| 1927 | Human relations; the Hawthorne studies | Elton Mayo |
| 1931 | Statistical inference applied to product quality: quality control charts | W.A. Shewart |
| 1935 | Statistical sampling applied to quality control: inspection sampling plans | H.F. Dodge & H.G. Roming |
| 1940 | Operations research applications in World War II | P.M. Blacker and others. |
| 1946 | Digital computer | John Mauchlly and J.P. Eckert |
| 1947 | Linear programming | G.B. Dantzig, Williams & others |
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## 1.7 NOTES

## 1.8 SUMMARY

Operation is a broader term which encompasses both manufacturing and services activities. 21st century has paved way for innumerable technology and has simplified the production process. Operation in simple is a value addition process. Both manufacturing and services are interdependent, as such one activity cannot happen in isolation with other. Managers today are facing a big challenge in coping with the changes happening in the manufacturing and service industry. Hence a better insight into operation management will help the students to gear up to the requirnts of the industry concerned.

This unit cover the aspects like evolution of production management, meaning, definition transition of PM to OM and scope of OM. Developing operations; the issues to focus in formulation of operations strategy has been dealt in detail. A clear picture about the production System and the operations has been described with a neat diagram to help the students to have an insight about production system which in the heart of any operations.

## 1.9 KEY WORDS

Production

Operations

Tangible

Conversion

Layout

## 1.10 SELF ASSESSMENT QUESTIONS

1. Define Operations Management.
2. What is the difference between production management and operation management?
3. Define Production system
4. Explain the production system with a neat diagram
5. Give a brief account of the evolution of operations management.
6. Describe the scope of operations management.
7. Explain the various issues to be considered while developing and formulating a operations strategy.
8. Write a note on the evolution of Operations Management

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3. Production and Operations Management- R. Paneer Selvam

4. Production Management – Manoj Kumar Sarkar

# UNIT-2 : TYPES OF PRODUCTION SYSTEM

**Structure:**

## 2.0 OBJECTIVES

After studying this unit, you should be able to;

- ♦ Get insight into Operations Management
- ♦ Explain the meaning and definition of Operations Management
- ♦ Examine the scope of Operations Management.
- ♦ Describe a production system

## 2.1 INTRODUCTION

Production management is one functional area of total business management. It is also called production function of management. Production is the creation of utilities for meeting human wants. Here, men, material and equipment are used for the creation of goods, which can be used fordifferentpurposes.

In the production process, raw material and other inputs are converted into finished goods for actual use. Production is transformation of raw materials by factory methods into things wanted by people or users. There is creation of utilities through the process of production. Satisfaction of human wants is the guiding principle of all production activities. Thus, production is a process by which goods and services are manufactured or brought into existence. Production is a combined result of materials, machines and other factors in operation. Workers/employees play an important role in bringing such combination of resources.

## 2.2 TYPES OF PRODUCTION SYSTEM

The types of production system are depicted in the following image.

The types of production system are grouped under two categories viz.,

1. Intermittent production system, and
2. Continuous production system.

Now let's discuss in detail each of the above-mentioned categories.

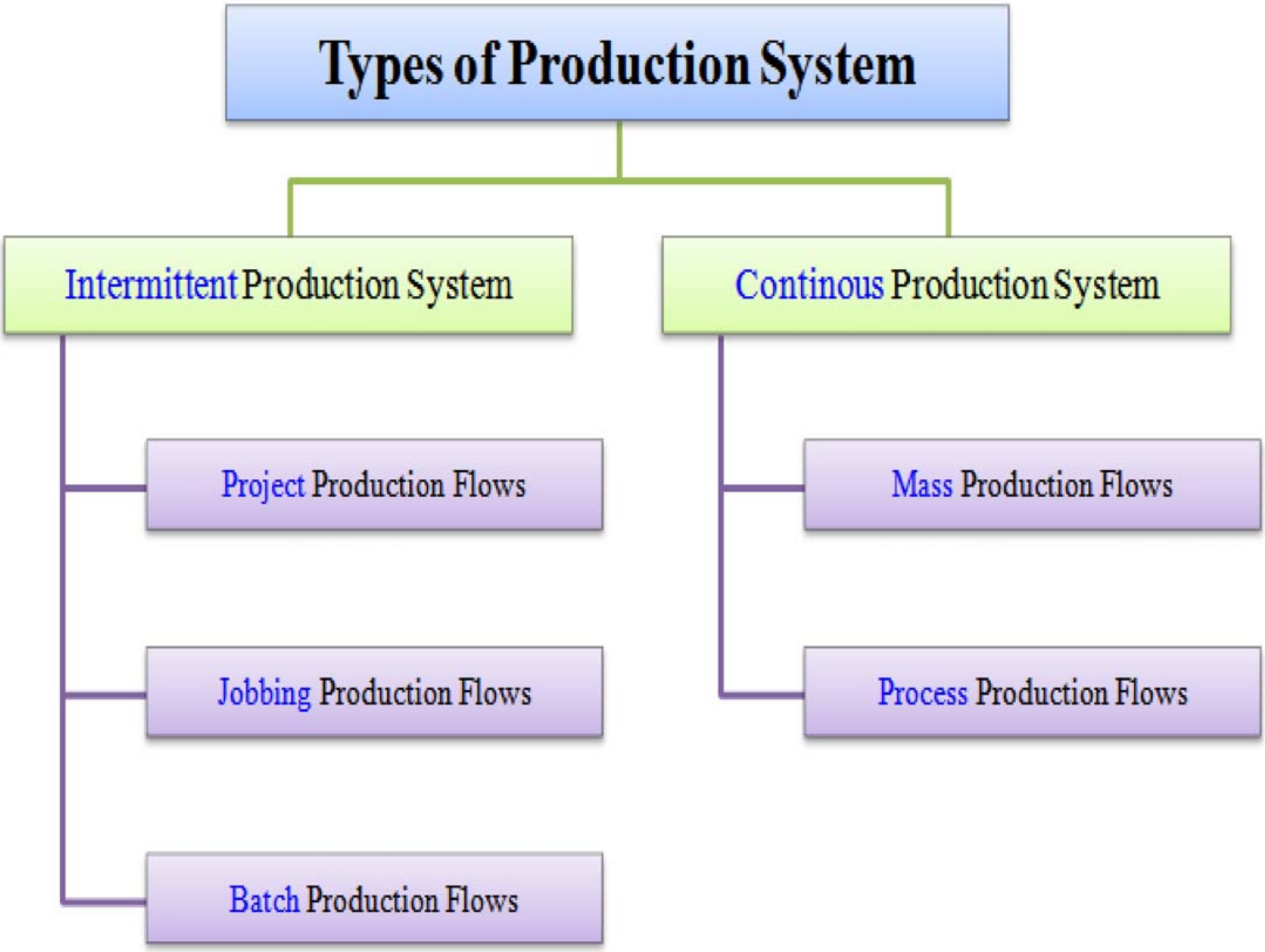


**Fig 2.1 Types of Production System**

**Intermittent production system**

Intermittent means something that starts (initiates) and stops (halts) at irregular (unfixed) intervals (time gaps).

In the intermittent production system, goods are produced based on customer's orders. These goods are produced on a small scale. The flow of production is intermittent (irregular). In other words, the flow of production is not continuous. In this system, large varieties of products are produced. These products are of different sizes. The design of these products goes on changing. It keeps changing according to the design and size of the product. Therefore, this system is very flexible.

Following chart highlights the concept of an intermittent production system.

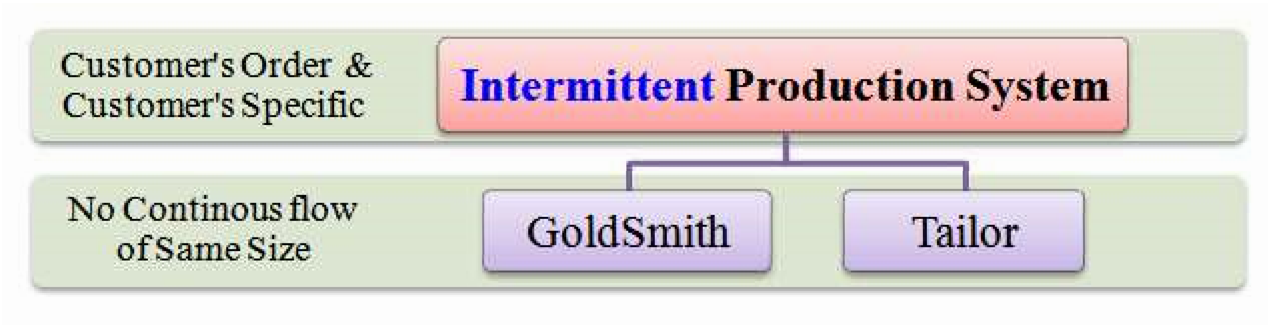


**Fig 2.2 Intermittent Production System**

2.2 Intermittent Production System

Following are examples on the intermittent production system. Please refer above chart while reading examples given below.

1. The work of a goldsmith is purely based on the frequency of his customer's orders. The goldsmith makes goods (ornaments) on a small-scale basis as per his customer's requirements. Here, ornaments are not done on a continuous basis.

2. Similarly, the work of a tailor is also based on the number of orders he gets from his customers. The clothes are stitched for every customer independently by the tailor as per one's measurement and size. Goods (stitched clothes) are made on a limited scale and are proportional to the number of orders received from customers. Here, stitching is not done on a continuous basis.

The features of an intermittent production system are depicted below.

The characteristics of an intermittent production system are listed as follows:

1. The flow of production is not continuous. It is intermittent.
2. Wide varieties of products are produced.
3. The volume of production is small.
4. General purpose machines are used. These machines can be used to produce different types of products.
5. The sequence of operation goes on changing as per the design of the product.
6. The quantity, size, shape, design, etc. of the product depends on the customer's orders.

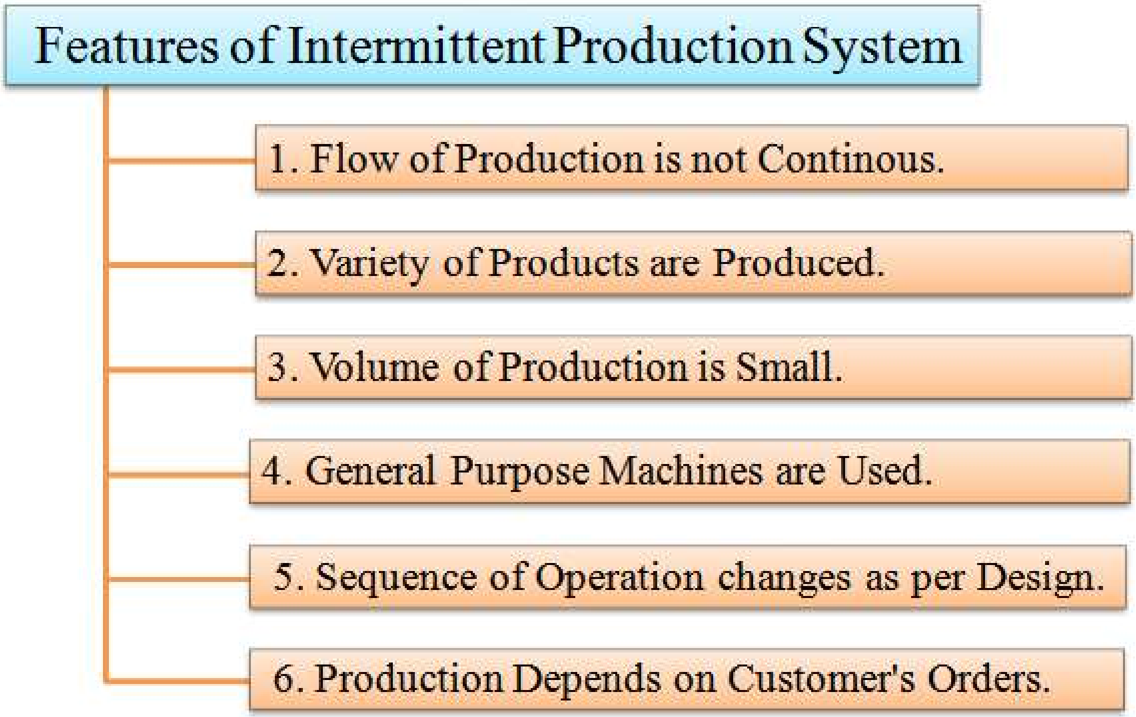


**Fig 2.3 Features of Intermittent System**

The types of intermittent production system include:

1. Project production flows,
2. Jobbing production flows, and
3. Batch production flows.

**Continuous production system**

Continuous means something that operates constantly without any irregularities or frequent halts.

In the continuous production system, goods are produced constantly as per demand forecast. Goods are produced on a large scale for stocking and selling. They are not produced on customer's orders. Here, the inputs and outputs are standardized along with the production process and sequence.

Following chart highlights the concept of a continuous production system.

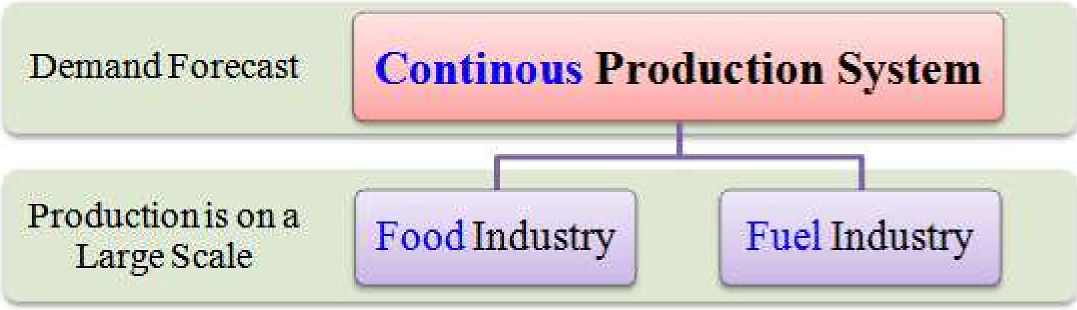


**Fig 2.4 Continuous Production System**

Following are examples on the continuous production system. Please refer above chart while reading examples given below.

1. The production system of a food industry is purely based on the demand forecast. Here, a large-scale production of food takes place. It is also a continuous production.
2. Similarly, the production and processing system of a fuel industry is also purely based on, demand forecast. Crude oil and other raw sources are processed continuously on a large scale to yield usable form of fuel and compensate global energy demand.

The features of a continuous production system are depicted below.

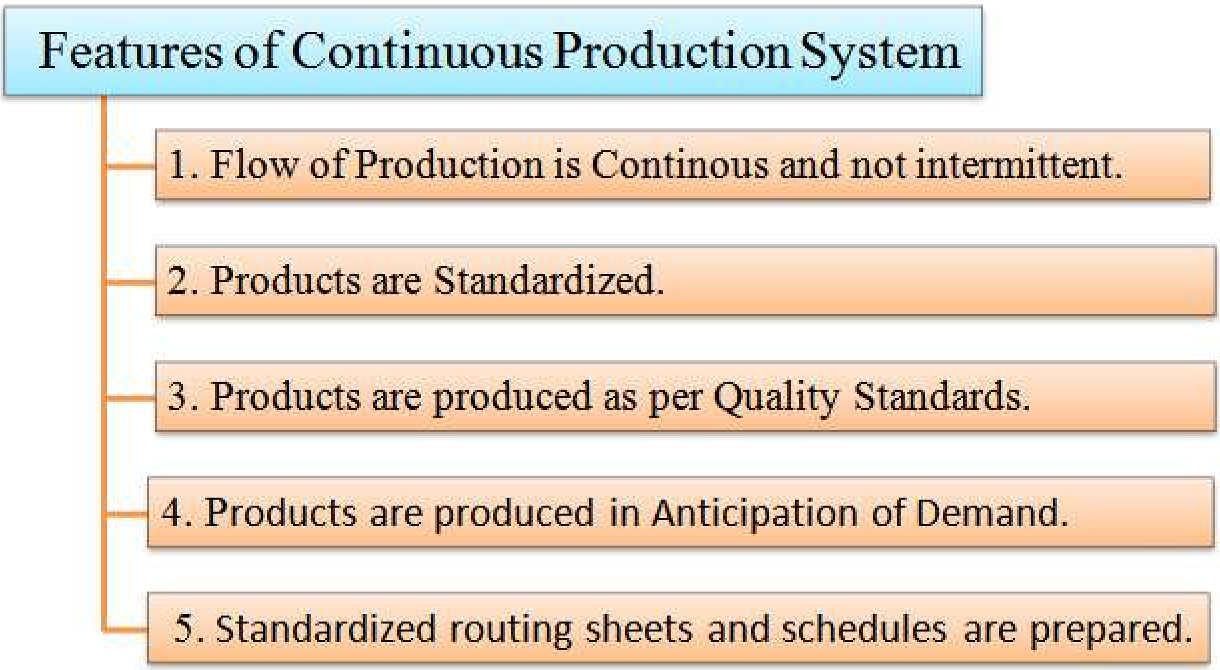


**Fig 2.5 Features of Continuous Production System**

The characteristics of a continuous production system are listed as follows:

1. The flow of production is continuous. It is not intermittent.
2. The products are standardized.
3. The products are produced on predetermined quality standards.
4. The products are produced in anticipation of demand.
5. Standardized routing sheets and schedules are prepared.

The types of continuous production system include:

1. Mass production flows, and
2. Process production flows.

**Advantages**

Following are the advantages of job shop production:

1. Because of general purpose machines and facilities variety of products can be produced.
2. Operators will become more skilled and competent, as each job gives them learning opportunities.
3. Full potential of operators can be utilized.
4. Opportunity exists for creative methods and innovative ideas.

**Limitations**

Following are the limitations of job shop production:

1. Higher cost due to frequent set up changes.
2. Higher level of inventory at all levels and hence higher inventory cost.
3. Production planning is complicated.
4. Larger space requirements.

## 2.3 BATCH PRODUCTION SYSTEM

Batch production is defined by American Production and Inventory Control Society (APICS) *"as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing."* It is characterized by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

**Characteristics**

Batch production system is used under the following circumstances:

1. When there is shorter production runs.

2. When plant and machinery are flexible.

3. When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.

4. When manufacturing lead time and cost are lower as compared to job order production.

**Advantages**

Following are the advantages of batch production:

1. Better utilization of plant and machinery.

2. Promotes functional specialization.

3. Cost per unit is lower as compared to job order production.

4. Lower investment in plant and machinery.

5. Flexibility to accommodate and process number of products.

6. Job satisfaction exists for operators.

**Limitations**

Following are the limitations of batch production:

1. Material handling is complex because of irregular and longer flows.

2. Production planning and control is complex.

3. Work in process inventory is higher compared to continuous production.

4. Higher set up costs due to frequent changes in set up.

## 2.4 MASS PRODUCTION SYSTEM

Manufacture of discrete parts or assemblies using a continuous process are called mass production.

This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardisation exists and all outputs follow the same path.

**Characteristics**

Mass production is used under the following circumstances:

1. Standardisation of product and process sequence.

2. Dedicated special purpose machines having higher production capacities and output rates.

3. Large volume of products.

4. Shorter cycle time of production.

5. Lower in process inventory.

6. Perfectly balanced production lines.

7. Flow of materials, components and parts is continuous and without any back tracking.

8. Production planning and control is easy.

9. Material handling can be completely automatic.

**Advantages**

Following are the advantages of mass production:

1. Higher rate of production with reduced cycle time.

2. Higher capacity utilisation due to line balancing.

3. Less skilled operators are required.

4. Low process inventory.

5. Manufacturing cost per unit is low.

**Limitations**

Following are the limitations of mass production:

1. Breakdown of one machine will stop an entire production line.

2. Line layout needs major change with the changes in the product design.

3. High investment in production facilities.

4. The cycle time is determined by the slowest operation.

**Continuous Production**

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

**Characteristics**

Continuous production is used under the following circumstances:

1. Dedicated plant and equipment with zero flexibility.

2. Material handling is fully automated.

3. Process follows a predetermined sequence of operations.

4. Component materials cannot be readily identified with final product.

5. Planning and scheduling is a routine action.

**Advantages**

Following are the advantages of continuous production:

1. Standardization of product and process sequence.

2. Higher rate of production with reduced cycle time.

3. Higher capacity utilization due to line balancing.

4. Manpower is not required for material handling as it is completely automatic.

5. Person with limited skills can be used on the production line.

6. Unit cost is lower due to high volume of production.

**Limitations**

Following are the limitations of continuous production:

1. Flexibility to accommodate and process number of products does not exist.

2. Very high investment for setting flow lines.

3. Product differentiation is limited.

## 2.5 CASE STUDY

M.S Manufactures would like to develop a new plant for their operations. The various operations and the movements of products between the departments are listed below.

| Department Code | Department Description | Grind | Paint | Drill | Rework | Glaze | Ship & Receive |
|---|---|---|---|---|---|---|---|
| 1 | Blow and Mould | 1000 | | 5000 | | 3000 | 3000 |
| 2 | Heat Treat | 2000 | 2000 | | | | 3000 |
| 3 | Neck | | 2000 | | | 2000 | |
| 4 | Package | 1000 | | 4000 | | | 5000 |
| 5 | Grind | | 2000 | | | | |
| 6 | Paint | | | | | 2000 | |
| 7 | Drill | | | | 1000 | | |
| 8 | Rework | | | | | | 1000 |
| 9 | Glaze | | | | | | |
| 10 | Receive | | | | | | |

You are required to suggest them where they can locate different departments.

## 2.6 NOTES

## 2.7 SUMMARY

In this unit we have discussed about various types of Production system. We have gained a deep insight about batch production, mass production, continuous production and intermittent production system.

## 2.8 KEY WORDS

Batch Production, Continuous production, intermittent production, mass production

## 2.9 SELF ASSESSMENT QUESTIONS

1. Explain different types of production system

2. Differentiate between batch and mass production

3. Discuss the advantages of continuous production system

## 2.10 REFERENCES

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4. Production Management – Manoj Kumar Sarkar

# UNIT –3 : WORLD CLASS MANUFACTURING PRODUCTION STRATEGY

**Structure:**

## 3.0 OBJECTIVES

After studying this unit, you should be able to;

- Explain the meaning of world class manufacturing system
- Examine the scope of global procurement
- Describe capacity planning

## 3.1 INTRODUCTION

The term "world-class manufacturer" is popularly used to denote a standard of excellence: the best of the best manufacturers at the international level. It came into prominence following the 1986 publication of *World Class Manufacturing: The Lessons of Simplicity Applied* by Richard J. Schonberger, which was his follow-up to *Japanese Management Techniques: Nine Hidden Lessons in Simplicity.*

World marketplace events during the 1970s and 1980s caused competition to grow to such an intense level that many firms were forced to re-examine their concept of manufacturing strategy, especially in terms of the **tradeoffs** among the four competitive priorities: cost, quality, delivery/service, and flexibility. Managers began to realize that they no longer had to make these tradeoffs but could instead compete on several competencies.

## 3.2 WORLD CLASS MANUFACTURING SYSTEM

Some of those excited by the concept describe it as capturing the breadth and the essence of the fundamental changes taking place in larger industrial enterprises, with their overriding goal and underlying mindset of continual and rapid improvement. Others describe it as the culmination of the relentless pursuit of competitive excellence. Richard Schonberger states that the emphasis on world-class manufacturing may someday be chronicled as the third major event in the history of manufacturing management, following the use of standard methods and times espoused by Frederick Taylor and Frank Gilbreth, and the findings of the Hawthorne experiments at Western Electric, which held that motivation, to a significant degree, comes from recognition. For simplicity's sake, we will describe a world-class manufacturer as a company that is able to compete effectively in a global market.

Clearly, there are some demands placed on individuals and organizations that desire world-class status. Peter Stonebreaker and Keong Leong presented a hierarchy of steps, appearing as five levels, that lead to world-class operations (see Figure 1). This series of steps will be used to describe the characteristics of world-class manufacturers.


**Figure 3.1 The Journey to World-Class Manufacturing**

**Level one : Business and operations strategy**

All world-class manufacturers have an explicit, formal manufacturing mission. Within this mission is the operating goal to become world class. They use competitive information to establish organizational goals and objectives, which they communicate to all members of the enterprise. They regularly assess the appropriateness of these objectives to attaining and maintaining world-class status.

World-class manufacturing requires an overall willingness to establish closer connections with everyone, from suppliers to workers. It requires an unwavering commitment to self-analysis and improvement. It requires an aggressive approach to technology that can turn visionary strategies into reality. All of these must be reflected in the firm's business and operations strategy if world-class status is to be attained.

**Level two : Organisation design, Human resources, Technology, and Performance Measurement**

The following sections discuss how organization design, human resources, technology, and performance measurement factor into an organization's effort to become a world-class manufacturer.

**Organisation Design**

World-class manufacturers integrate all elements of the manufacturing system in such a way that the needs and wants of its customers are satisfied in an effective, timely manner. This requires the commitment and the expenditure of efforts and resources by all elements within the system to ensure their proper integration. This commitment extends to outside elements as well, as the world-class manufacturer encourages and motivates its suppliers and vendors to become co-equals with the other elements of the manufacturing system.

World-class manufacturers work to eliminate organizational barriers to communication and to organize the firm in such a way that the core values needed to reach world-class status take precedence. In fact, most companies that have succeeded in implementing many of the world-class tools—such as just-in-time production (JIT), total quality management (TQM), manufacturing resource planning (MRP II) and total productive maintenance (TPM)—already had the core values well in place. Companies that are already world class are able to quickly absorb other world-class manufacturing concepts as they are developed and publicized.

**Human resources**

World-class manufacturers recognize that employee involvement and empowerment are critical to achieving continuous improvement in all elements of the manufacturing system. The continuity of organizational development and renewal comes primarily through the involvement of the employee. World-class companies invest comparatively more in their relationships with their workers, providing significantly more training than their competitors. An *Industry Week* survey found that firms approaching world-class status were three to five times more likely to report "highly effective" human-resources programs than other firms. Some analysts note that combining lean manufacturing principles with employee participation can help firms become world-class manufacturers.

**Technology**

A great deal of emphasis is placed on technology, equipment, and processes by those trying to attain world-class status. World-class manufacturers view technology as a strategic tool for achieving and maintaining their world-class status. A high priority is placed on the discovery, development, and timely implementation of the most relevant technology available and the identification and support of those who can communicate and implement this technology. The most highly competitive firms have made significantly more progress than others in implementing TQM, reengineering, simultaneous engineering, group technology, computer-assisted manufacturing (CAM), material resources planning (MRP), and the use of local area networks (LANs).

**Performance Measurement**

World-class manufacturers recognize the importance of measurement in defining the goals and performance expectations for their organization. They routinely adopt or develop the appropriate performance measurements needed to interpret and quantitatively describe the criteria used to measure the effectiveness of their manufacturing system and its interrelated components.

Use of the proper measurements allows world-class manufacturers to assess their performance against themselves (internal benchmarking), their competitors (competitive benchmarking), and against other world-class manufacturing firms that are not competitors (generic and functional benchmarking). World-class status is achieved through a relentless commitment to continuous improvement, which cannot be achieved without measurement.

### Level Three: Informance Systems, Management Direxction, and Operations Capabilites

The following sections discuss how information systems, management direction, and operations capabilities factor into an organization's effort to become a world-class manufacturer.

#### Informantion Systems

World-class manufacturers require world-class information systems for collecting, processing, and disseminating data and for providing the feedback mechanism that is necessary for meeting their objectives. Information systems are fully integrated into the business processes of firms that adhere to continuous improvement and TQM strategies. Capturing and analyzing customer feedback and designing, manufacturing, and delivering world-class quality products and services is rooted in superior information systems. Richard Schonberger states that functions within a world-class firm all have a common language and signaling system. World-class firms embrace computerized maintenance management and computer-integrated manufacturing. Additionally, organizational commitment to continuous improvement is supported by the strategic use of information systems.

#### Management Direction.

Management is responsible for directing the manufacturing organization's journey to world-class status and for creating an organizational culture committed to all that is necessary for achieving continuous improvement. Corporate culture and values are the foundation for superior manufacturing, which in turn reflects and is reflected by the caliber of corporate management. This implies that personal commitment, involvement, and a sense of direction by management are critical to the success of world-class firms.

The manufacturing excellence needed for world-class status is nurtured by direction from superior management, which must penetrate the manufacturing function, viewing and managing it as an integral, indivisible part of the firm. It cannot tolerate mediocrity or even average manufacturing performance.

Management must seek to describe and understand the interdependency of the multiple elements of their manufacturing system, to discover new relationships, to explore the consequences of alternative decisions, and communicate unambiguously within the organization and with the firm's customers and suppliers. Stimulating and accommodating continuous change forces management to experiment and assess outcomes. They must be able to translate knowledge acquired in this way into some sort of direction, framework, or model that leads to improved operational decision making, while incorporating a learning process into their fundamental operating philosophy. The objective of world-class status tests management's ability to learn, adapt, and innovate faster in the face of an intensely competitive global market.

**Operations Capabilities**

World-class manufacturers are concerned with whether their operations systems have the ability to meet design specifications, rather than with evaluating the quality and quantity of products after the fact. In order to attain world-class status, the manufacturing firm has to be given the proper resources. With these resources, the firm must have the capability to produce the right quantity, the right quality, at the right time (often just in time), and at the right price. The proper technology must be on hand or readily attainable. In addition, the firm must have the necessary managerial capabilities to compete successfully on a global basis. For many firms, the necessary operational capability involves the ability to provide customers with a large degree of flexibility of either product or volume, or exceptional response time to orders, changes in orders, or new product development.

Beyond the firm itself, operations capability implies a superior interactive relationship with all vendors and suppliers. World-class firms have extensively implemented JIT, are heavily involved with programs that contractually commit suppliers to annual cost cuts, and are making efforts to involve the supplier early in the new product development process.

**Level Four: Quality**

World-class manufacturers place an emphasis on quality. Firms in this category are usually in an advanced state of TQM implementation, continually seeking to enhance their business. All quality costs (prevention costs, appraisal costs, and cost of defects—both internal and external) are evaluated and held to the lowest reasonable sum. "Zero defects" is the goal of the world-class manufacturer. In order to achieve zero defects, the world-class firm is educated in and has fully implemented statistical quality control (SQC), sometimes called statistical process control (SPC) or quality at the source. Hence, quality is maintained and elevated through quality planning, quality control, and quality improvement. In conjunction with this effort to improve processes and products, world-class firms utilize an activity called benchmarking. This involves comparing the firm's performance, either overall or in a functional area, with that of other world-class organizations. The use of TQM techniques, according to some analysts, is the most striking differentiator between world-class and non-world-class firms. Quality has also been found to be the most important competitive differentiator in the eyes of the customer.

**Level Five: Customer Service**

World-class manufacturers instill within their organization and constantly reinforce the idea that all who are a part of the organization must know their customers and must seek to satisfy the wants and needs of not only the customers, but also all other stakeholders. The goal of satisfaction is pursued in regards to the product, order processing, delivery, quick response to changes, and service after the sale. After all, the goal of continuous improvement is to improve processes and add value to products and services in such a way as to increase customer satisfaction and loyalty and ensure long-term profitability.

**Level Six: World - Class Manufacturing**

While world-class manufacturing may be difficult for manufacturers to define, many say they know it when they see it. Whatever it is, it must be from the customer's vantage point. An *Industry Week* survey found that, among factories approaching world-class status, a higher percentage were likely to belong to public companies; have corporate parents with revenues greater than $1 billion; participate in an automotive industry value chain; and employ 250 or more people at the location. These firms reported large cost reductions over the previous three years, as well as increased revenues, higher capacity utilization, higher sales per employee, and returns on invested capital (ROIC) that exceeded that of other manufacturers. Daniel F. Baldwin states that truly world-class firms are always examining their business processes and continuously seeking solutions to improve in key areas, such as lead time reduction, cost cutting, exceeding customer expectations, streamlining processes, shortening time to market for new products, and managing the global operation.

World-class manufacturers are the ones that possess the knowledge and technology to provide products and services of continually improving quality. It is what separates practitioners of the new paradigm from the industrialist dinosaurs

**Key characteristics of the World Class Manufacturing concept**

The ***Cost Deployment*** pillar is of particular interest because it differs from the typical XPS (see this post to learn what is "typical"). Cost Deployment is a seven-step accounting technique for assigning actual costs to each loss and waste that happens in a factory. This way, the prioritization of which loss to attack first can be made with economical reasoning. An additional advantage of Cost Deployment is that all improvement work in the organization is assigned an equivalent saving potential. This motivates further improvements, and is the best argument for convincing remaining skeptics and cynics. To do proper Cost Deployment you need to team up persons from accounting, finance and operations.

Another key characteristic of the WCM concept is that change always starts with a ***model area***. The model areas are pilots for the implementation of the principles. For example, the plant typically chooses the worst performing machine as a model machine for the Autonomous

Maintenance pillar. Through a dedicated project, using WCM tools and techniques, this model machine is “brought back to basic condition” and made the best performing machine in the plant. The learning points and good practices are thereafter shared with the rest of the plant. This is however a challenging way to implement an XPS; you risk making “islands of excellence” that do little good for the overall performance of the plant. I guess that’s where cost deployment comes in again and ensures that practices are spread.

A third interesting notion in WCM is the “***concept of zero***”. A manager in Brazil has stated: “You can’t discuss with zero; once you suggest another target, you’ll get into all kinds of unfruitful discussions”. The target of WCM is ***zero waste, zero defects, zero breakdowns*** and ***zero inventory***. The model areas should prove *achievement of zero* for several weeks before solutions are spread.

For Chrysler, the latest WCM strategy is a strong focus on ***education***. For that purpose Chrysler has built a *World Class Manufacturing Academy* (WCMA) in Warren, Michigan. The WCMA is a state-of-the-art training centre for all employees in Chrysler, making use of modern technology and the latest knowledge on practical training. Because 70 % of Chrysler’s work force work in fair proximity to the Academy, many plants can afford sending their employees to training in Warren. The idea is that the plants should use Cost Deployment to identify areas of improvements, and then send employees for specific training in needed tools and techniques—not just general training.

WCM is not a static never-changing improvement programme. In 2010, an ***Energy*** sub-pillar was introduced in the Environment pillar “to improve the ability to identify and implement measures to reduce waste and achieve greater energy efficiency”. Obviously, a production improvement programme can also contribute to greater good!

## 3.3 GLOBAL PROCUREMENT

“Global procurement enables firms to pursue the full potential of international sourcing by capitalising on the world’s best suppliers (Lysons and Farrington, 2006)”

Global procurement became a way for organisations to meet the challenges of new markets and global competitors. The concept discusses strategies for global procurement management and their strengths and weaknesses. It also reviews recent business evidence and success factors to help practitioners make better and more informed decisions.

### Global Procurement Definition

Global procurement involves the co-ordination and integration of a highly complex network of common items and materials, processes, designs, technologies and suppliers across worldwide purchasing, engineering and operation locations.

**Global sourcing** is the practice of sourcing from the global market for goods and services across geopolitical boundaries. Global sourcing often aims to exploit global efficiencies in the delivery of a product or service. These efficiencies include low cost skilled labor, low cost raw material and other economic factors like tax breaks and low trade tariffs. A large number of Information Technology projects and Services, including IS Applications and Mobile Apps and database services are outsourced globally to countries like Pakistan and India for more economical pricing.

Common examples of globally sourced products or services include: labor-intensive manufactured products produced using low-cost Chinese labor, call centers staffed with low-cost English speaking workers in the Philippines and Pakistan and India, and IT work performed by low-cost programmers in India and Pakistan and Eastern Europe. While these examples are examples of Low-cost country sourcing, global sourcing is not limited to low-cost countries.

Majority of companies today strive to harness the potential of global sourcing in reducing cost. Hence it is commonly found that global sourcing initiatives and programs form an integral part of the strategic sourcing plan and procurement strategy of many multinational companies.

Global sourcing is often associated with a centralized procurement strategy for a multinational, wherein a central buying organization seeks economies of scale through corporate-wide standardization and benchmarking. A definition focused on this aspect of global sourcing is: "proactively integrating and coordinating common items and materials, processes, designs, technologies, and suppliers across worldwide purchasing, engineering, and operating locations.

The global sourcing of goods and services has advantages and disadvantages that can go beyond low cost. Some advantages of global sourcing, beyond low cost, include: learning how to do business in a potential market, tapping into skills or resources unavailable domestically, developing alternate supplier/vendor sources to stimulate competition, and increasing total supply capacity. Some key disadvantages of global sourcing can include: hidden costs associated with different cultures and time zones, exposure to financial and political risks in countries with (often) emerging economies, increased risk of the loss of intellectual property, and increased monitoring costs relative to domestic supply. For manufactured goods, some key disadvantages include long lead times, the risk of port shutdowns interrupting supply, and the difficulty of monitoring product quality. (With regard to quality in the food industry.

International procurement organizations (or IPOs) may be an element of the global sourcing strategy for a firm. These procurement organizations take primary responsibility for identifying and developing key suppliers across sourcing categories and help satisfy periodic sourcing requirements of the parent organization. Such setups help provide focus in country-based sourcing efforts. Particularly in the case of large and complex countries, such as China, where a range of sub-markets exist and suppliers span the entire value chain of a product/commodity, such IPOs provide essential on-the-ground information.

Over time, these IPOs may grow up to be complete procurement organizations in their own right, with fully engaged category experts and quality assurance teams. It is therefore important for firms to clearly define an integration and scale-up plan for the IPO.

## 3.4 CAPACITY PLANNING

Capacity Planning is the long-term strategic decision which determines a company's capability to supply products or services. In this section we explore the components of capacity planning and differentiate between utilization and capacity. Capacity planning is usually undertaken using sophisticated computer software and we explain the process which enables integrated capacity planning to be undertaken.

The production system design planning considers input requirements, conversion process and output. After considering the forecast and long-term planning organization should undertake capacity planning.

Capacity is defined as the ability to achieve, store or produce. For an organization, capacity would be the ability of a given system to produce output within the specific time period. In operations, management capacity is referred as an amount of the input resources available to produce relative output over period of time.

In general, terms capacity is referred as maximum production capacity, which can be attained within a normal working schedule.

Capacity planning is essential to be determining optimum utilization of resource and plays an important role decision-making process, for example, extension of existing operations, modification to product lines, starting new products, etc.

**Strategic Capacity Planning**

A technique used to identify and measure overall capacity of production is referred to as strategic capacity planning. Strategic capacity planning is utilized for capital intensive resource like plant, machinery, labor, etc.

Strategic capacity planning is essential as it helps the organization in meeting the future requirements of the organization. Planning ensures that operating cost are maintained at a minimum possible level without affecting the quality. It ensures the organization remain competitive and can achieve the long-term growth plan.

### Capacity Planning Classification

Capacity planning based on the timeline is classified into three main categories long range, medium range and short range.

**Long Term Capacity:** Long range capacity of an organization is dependent on various other capacities like design capacity, production capacity, sustainable capacity and effective capacity. Design capacity is the maximum output possible as indicated by equipment manufacturer under ideal working condition.

Production capacity is the maximum output possible from equipment under normal working condition or day. Sustainable capacity is the maximum production level achievable in realistic work condition and considering normal machine breakdown, maintenance, etc.

Effective capacity is the optimum production level under pre-defined job and work-schedules, normal machine breakdown, maintenance, etc.

**Medium Term Capacity**: The strategic capacity planning undertaken by organization for 2 to 3 years of a time frame is referred to as medium term capacity planning.

**Short Term Capacity**: The strategic planning undertaken by organization for a daily weekly or quarterly time frame is referred to as short term capacity planning.

### Goal of Capacity Planning

The ultimate goal of capacity planning is to meet the current and future level of the requirement at a minimal wastage. The three types of capacity planning based on goal are lead capacity planning, lag strategy planning and match strategy planning.

### Factors Affecting Capacity Planning

Effective capacity planning is dependent upon factors like production facility (layout, design, and location), product line or matrix, production technology, human capital (job design, compensation), operational structure (scheduling, quality assurance) and external structure ( policy, safety regulations)

### Forecasting v/s Capacity Planning

There would be a scenario where capacity planning done on a basis of forecasting may not exactly match. For example, there could be a scenario where demand is more than production capacity; in this situation, a company needs to fulfill its requirement by buying from outside. If demand is equal to production capacity; company is in a position to use its production capacity to the fullest. If the demand is less than the production capacity, company can choose to reduce the production or share it output with both

## 3.5 NOTES

## 3.6 SUMMARY

In this unit we have discussed about world class manufacturing system. We have also discussed about global procurement. Light is also thrown upon capacity planning.

## 3.7 KEY WORDS

World Class Manufacturing

Global procurement

Capacity planning

## 3.8 SELF ASSESSMENT QUESTIONS

1. Explain the concept of world class manufacturing
2. Write a note on Global procurement
3. Describe capacity planning

## 3.9 REFERENCES


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# UNIT- 4 : ADVANCES IN PRODUCTION MANAGEMENT

**Structure:**

## 4.0 OBJECTIVES

After studying this unit, you should be able to;

- ♦ Explain automation
- ♦ Differentiate between NC and CNC machines
- ♦ Examine the scope of Operations Management.
- ♦ Describe a production system
- ♦ Differentiate between product and service
- ♦ Classify the production systems
- ♦ Picture the Evolution of Operations Management

## 4.1 INTRODUCTION

Whether you manufacture complex solutions or simple products, you need strong production control in order to build a competitive advantage. As the global marketplace continues to shrink profit margins and customers become more demanding, businesses.


**Fig 4.1 Production Architecture**

are looking for agile solutions that can provide the infrastructure they need to respond quickly and efficiently. Epic or offers a comprehensive solution for make-to-order, mixed-mode, make-to-stock, engineer to-order, and configure-to-order manufacturers; including light assembly features for distribution businesses. Modular in design, the production control suite of modules include Job Management, Lean Manufacturing, Manufacturing Execution System (MES), Quality Assurance, and Advanced Quality Management.

## 4.2 CAD/CAM

CAD/ CAM can be defined as for example computers to assist design and manufacturing activities when they are performed in an integrated manner and are not as islands of automation. What we did in our earlier lectures is more like a islands of automation. A computer based automation of a design process and computer based automation of some of the manufacturing activities more in a separate way but now we are looking more in a integrated manner. And it is also true that benefits of a CAD/ CAM would be much more when you do it in a much integrated manner. There are like organizations who use computers only for design process. Then there also organizations who use only for manufacturing processes then there are organizations who use them separately.

Then you also have a class of organizations who actually look it more from the integrated point of view. So by the word CAD/ CAM, one usually refers to this particular thing. But if you really look at the definition which is given for CAD/ CAM, particularly from various books which are published you may come across various definitions and domains. The reason is the subject has award over like 40, 30, 40 years and the definition is also continuously changing. For example a book which is written something like about 20, 25 years back there were certain CAD/ CAM technologies but if you really look at now there is a more integrated approach compared to what it used to be a few decades back. So I have put that CAD/ CAM is something which is greater than CAD plus CAM that’s what is the basic summary of the definition.

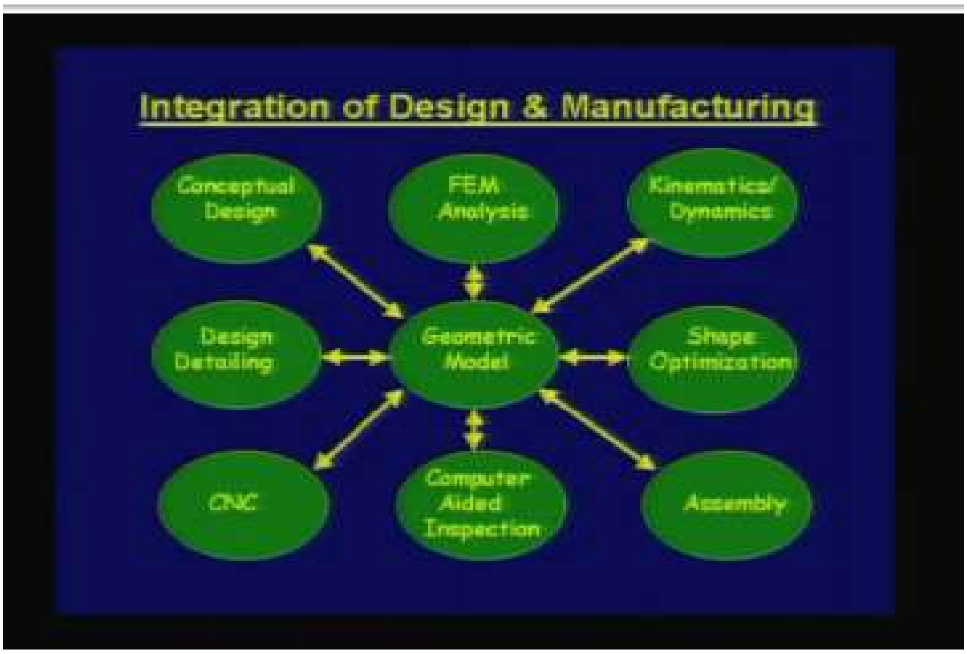


**Fig. 4.2 Integration of Design and Manufacturing**

Now this particular picture should give in a way an integrated framework for computer aided design and manufacture. If you look at for example what we discussed earlier is in our first lecture that computers can be used for the design process. They can be used at a conceptual design process and more so in a design detailing or analysis or configuration kind of a design and also in terms of carrying out analysis like finite element analysis. They can be applied for analysis like kinematic and dynamic analysis. So one can think of let's say using a CAD tools in this particular domain and restrict to only use of computer to this domain and call it is a CAD, that's very valid definition. And in the second lecture, we looked at particularly use of computers for manufacturing like CNC program generation or computer aided inspection. We also looked at computer aided assembly. So this can be considered as more of a computer aided manufacturing.

Shown here is only a set of activities. This is not complete design and manufacturing activity. Design and manufacturing activity overall involves many other activities which are not shown here. So this is just a representatives like. Now these activities which we call as a computer aided design and then computer aided manufacturing, they are all related with, they can be related using let's say a concept of geometric modeling. So this is called as a geometric modeling based integration of design and manufacturing. Now what is really happening in a typical product design and manufacturing process is somebody may start with a design, go for analysis tools, may come up with a optimization and finally arrive at let's say a design detailing.

During the design process, the geometry continuously evolves. So you start with nothing and at the end of a design, when you say that I have completed my design and I have documented that means one of the aspects of your design information is geometry, in fact key information is geometry.

So the geometric model continuously evolves as a part of a design process. You may have seen people who are using computer aided tools for example a designer sits in front of a computer then start with the design process and starts with let's say adding a few features like start with a simple, you can say start with a simple geometry and continuously modify this particular geometry as a part of the design process and during this particular process, you have to check for certain functional requirements. 2 You have to check whether the design geometry will do the indented functions satisfactorily or not.

So for those situations you use analysis tools and based on the feedback from the analysis, you modify your design and this is you can say an iterative process. It's like you cannot say that design is a sequential process, you start with a step one and end with a step 7 or step 8 where there are no iterations. It's an iterative process and that is what is usually done in this. Now the geometry evolves as a part of design. Now the same geometry is required at various stages of manufacturing. For example if I want to, suppose if I have a component which has to be manufactured on a CNC machine let's say it maybe a CNC machining center or it may be a CNC punch press or it may be a CNC arc welding machine. Now one of the inputs to generate the CNC program is geometry.

After all what is manufacturing. Manufacturing is like one of the ways of looking at is realizing the design geometry through various manufacturing processes.

So, since you are realizing the same geometry which has been designed by the designer so geometry forms one of the key inputs in any manufacturing. We also looked at computer aided inspection in our last lecture. So one way of or the major objective of any inspection process is to see that the manufactured geometry meets the design geometry within certain tolerances. That means there is not much deviation in the two. So you are again using the geometry which has been designed, you are getting a geometry which comes from the manufacturing like after a component is manufactured, I can measure it on a CMM and model the manufactured geometry and then compare with the design geometry which is available and see whether the part meets the, you can quality requirements or not.

So again geometry is an input and in assembly also we know that you make use of the geometric features of various parts to carry out the assembly process or even to automate the assembly process. When you say that there are two parts which are mating and they have a mating relationship. So this relationship is usually expressed in terms of some geometry.

For example you say that a solid shaft mates with a hollow shaft, you basically make use of the outer cylindrical surface of a solid shaft and inner cylindrical surface of a hollow shaft and say that these are the two mating surfaces. So, again you are making use of a geometry which is a part of, which comes as a part of a design. And so what we really look at here is this is, geometry evolves as a part of a design process and it is used by a manufacturing process.

Now if this is true then one should really like I have put the arrows how the geometry is basically modified or input from various activities. You see that the arrow has two directions, it is not necessary that design only gives a geometry and there is no modification.

It goes through modification like when I carry out a finite element analysis, I give a input geometry, carryout the analysis and I see that either it doesn't meet the strength requirements then I can go on change its geometry like change the section, so that now it has a better strength kind of a thing. So geometry is modified as a part of process.

It is true that in manufacturing activities also there is a feedback which is sent to geometric model for basically changing the geometry like I carryout let's say we discussed about what is called as a design for manufacture and design for assembly. So in DFM and DFA, what one is trying to do is that carryout the manufacturing operation either in real world or a virtual world then based on the feedback, you are actually trying to modify the geometry or suggesting some changes so that a component can be component can be manufactured in a more optimum manner.

So all the activities which pertain to design and 3 manufacturing, they take a geometry as a input or they return the modified geometry based on certain feedback. So when I am actually working in an environment like this, I can call it is a CAD/ CAM. So the CAD/ CAM is something more than pure computer aided design or computer aided manufacturing.

Now this type of framework is also used in many CAD/ CAM systems like when you use a software let's say a CAD software or a CAM software or whatever it is, you may have a software which actually can do only one of these functions like there are number of finite element analysis packages which can do stress analysis, heat transfer analysis or CFD analysis or electromagnetic analysis and the purpose of software is only to do analysis.

So it pertains to one aspect of a design. I may have a software which does only kinematic and dynamic analysis and nothing else or I can have which helps only in terms of helping in a conceptual design like I can use some innovation tools which are software based which can help me in conceptual design process. We also know that there are software packages which can do only a CNC program generation and nothing else.

Similarly you have software which specializes purely in assembly. Now when you say a CAD/ CAM, one approach is that you are putting together all these individual software's and trying to integrate in some manner that means you have a links from one to go for another. And this kind of framework is designed by the person or an organization which is trying to use all these software packages. A second way of looking is that if I have a software which has all these modules like I buy a single software that means under one umbrella, I should be able to do all these activities that is another approach.

## 4.3 COMPUTER INTEGRATED MANUFACTURING

Computer Integrated Manufacturing (CIM) encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated software packages. The data required for various functions are passed from one application software to another in a seamless manner.

For example, the product data is created during design. This data has to be transferred from the modeling software to manufacturing software without any loss of data. CIM uses a common database wherever feasible and communication technologies to integrate design, manufacturing and associated business functions that combine the automated segments of a factory or a manufacturing facility. CIM reduces the human component of manufacturing and thereby relieves the process of its slow, expensive and error-prone component. CIM stands for a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance.

Manufacturing engineers are required to achieve the following objectives to be competitive in a global context.

- Reduction in inventory
- Lower the cost of the product
- Reduce waste
- Improve quality
- Increase flexibility in manufacturing to achieve immediate and rapid response to:
- Product changes
- Production changes
- Process change
- Equipment change
- Change of personnel

CIM technology is an enabling technology to meet the above challenges to the manufacturing environment.

**EVOLUTION OF CIM:**

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts

Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. In the case of manufacture, CNC machines, DNC systems, FMC, FMS and the like provide tightly controlled automation systems. Similarly computer control has been implemented in several areas like manufacturing resource planning, accounting, sales, marketing and purchase. Yet the full potential of computerization could not be obtained unless all the segments of manufacturing are integrated, permitting the transfer of data across various functional modules. This realization led to the concept of computer integrated manufacturing. Thus the implementation of CIM required the development of whole lot of computer technologies related to hardware and software.

**DEFINITION OF CIM:**

CIM is defined differently by different users, and can be implemented in varying an increasing degree of complexity. For many companies, improving shop-floor communications is the primary goal. Others extend the degree of integration to encompass communication between engineering and manufacturing functions. The ultimate benefit of CIM is the improvement of communication and control of information flow to all aspects of an enterprise.

The computer and automated systems association of the society of Manufacturing Engineers (CASA/SEM) defines CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency.

CIM is recognized as Islands of Automation. They are

1. CAD/CAM/CAE/GT

2. Manufacturing Planning and Control.

3. Factory Automation

4. General Business Management

**CASA/SME's CIM Wheel is as shown in figure**

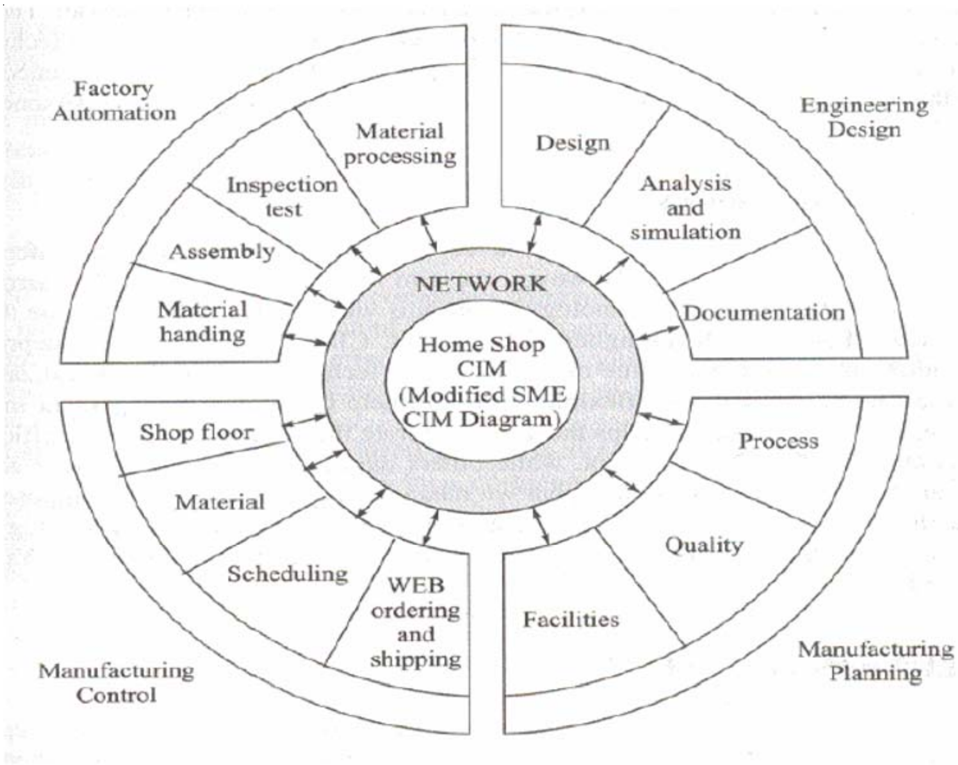


**Fig 4.3 CIM Wheel**

**ROLE OF THE ELEMENTS OF CIM SYSTEM**:

Nine major elements of a CIM system are in Figure 2 they are,

- Marketing
- Product Design
- Planning
- Purchase
- Manufacturing Engineering
- Factory Automation Hardware
- Warehousing
- Logistics and Supply Chain Management
- Finance
- Information Management


**Fig 4.4 Major Elements of CRM**

***i. Marketing:*** The need for a product is identified by the marketing division. The Specifications of the product, the projection of manufacturing quantities and the Strategy for marketing the product are also decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

**ii.** ***Product Design:*** The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer. Configuration management is an important activity in many designs. Complex designs are usually carried out by several teams working simultaneously, located often in different parts of the world. The design process is constrained by the costs that will be incurred in actual production and by the capabilities of the available production equipment and processes. The design process creates the database required to manufacture the part.

**iii.** ***Planning:*** The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc. In a CIM system, this planning process should be constrained by the production costs and by the production equipment and process capability, in order to generate an optimized plan.

**iv. *Purchase:*** The purchase departments is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture and assembly.

**v. *Manufacturing Engineering:*** Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity. This should include online dynamic scheduling and control based on the real time performance of the equipment and processes to assure continuous production activity. Often, the need to meet fluctuating market demand requires the manufacturing system flexible and agile.

**vi. *Factory Automation Hardware:*** Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS), Computer controlled robots, material handling systems, computer controlled assembly systems, flexibly automated inspection systems and so on.

**vii. *Warehousing:*** Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management assume great importance.

**viii. *Finance:*** Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

**ix. *Information Management:*** Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

## 4.4 NUMERICAL CONTROL MACHINES

Numerical control, popularly known as the NC is very commonly used in the machine tools. Numerical control is defined as the form of programmable automation, in which the process is controlled by the number, letters, and symbols. In case of the machine tools this programmable automation is used for the operation of the machines.

In other words, the numerical control machine is defined as the machined that is controlled by the set of instructions called as the program. In numerical control method the numbers form the basic program instructions for different types of jobs; hence the name numerical control is given to this type of programming. When the type of job changes, the program instructions of the job also change. It is easier to write the new instructions for each job, hence NC provides lots of flexibility in its use.

The NC technology can be applied to wide variety of operations like drafting, assembly, inspection, sheet metal working, etc. But it is more prominently used for various metal machining processes like turning, drilling, milling, shaping etc. Due to NC all the machining operations can be performed at the fast rate resulting in bulk manufacturing becoming quite cheaper.

**Brief History of the NC**

The invention of numerical control has been due to the pioneering works of John T. Parsons in the year 1940, when he tried to generate a curve automatically by milling cutters by providing coordinate motions. In the late 1940s Parsons conceived the method of using punched cards containing coordinate position system to control a machine tool. The machine directed to move in small increments and generate the desired finish. In the year, 1948, Parons demonstrated this concept to the US Air Force, who sponsored the series of project at laboratories of Massachusetts Institute of Technology (MIT). After lots of research MIT was able to demonstrate first NC prototype in the year 1952 and in the next year they were able to prove the potential applications of the NC.

Soon the machine tool manufacturers began their own efforts to introduce commercial NC units in the market. Meanwhile, the research continued as MIT, who were able to discover Automatically Programmed Tools, known asAPT language that could be used for programming the NC machines. The main aim of APT language was to provide the means to the programmer by which they can communicate the machining instructions to the machine tools in easier manner using English like statements. The APT language is still used in widely in the manufacturing industry and a number of modern programming languages are based on the concepts of APT.

**What is Numerical Control?**

Numerical control can be defined as a form of programmable automation in which process is controlled by numbers, letters and symbols.

In NC, the numbers form a programme of instructions designed for a particular workpart or job. When job changes the program of instruction changes. This capability to change a program for each new job gives NC its flexibility. Numerical control should be considered as a possible mode of controlling the operation for any production situation possessing the following characteristics :

Similar workparts in terms of raw material (e.g. metal shock for machining) The work parts are produced in various sizes and geometries. The workparts are produced in batches of small to medium size quantities. A sequence of similar processing steps is required to complete the operation on each workpiece. Many machining jobs meet these conditions. The machined workparts are metal, they are specified in many different sizes and shapes, and most machined parts produced in the industry today are made in small to medium size lots sizes. To produce each part a sequence of drilling operations may be required or a sequence of turning or milling operations. The suitability of NC for these kinds of jobs is the reason of tremendous growth of numerical control in metal working industry over the last 25 years.

**Basic components of NC system**

An operational numerical control system consists of the following three basic components:

1. Program of instructions.

2. Controller unit, also called machine tool unit.

3. Machine tool or other controlled process.

The program of instructions serves as input to the controller unit, which in turn commands the machine tool or other process to be controlled.

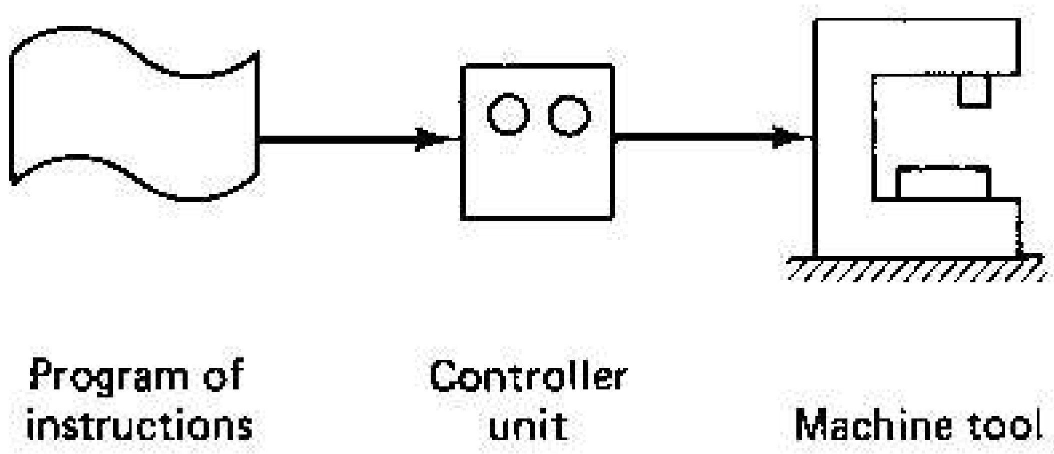


*Fig 4.5 Basic Components of NC System*

***Program of Instructions.***

The program of instructions is the detailed step by step set of instructions which tell the machine what to do. It is coded in numerical or symbolic form on some type of input medium that can be interpreted by the controller unit. The most common one is the 1-inch-wide punched tape. Over the years, other forms of input media have been used, including punched cards, magnetic tape, and even 35mm motion picture film.

There are two other methods of input to the NC system which should be mentioned. The first is by anual entry of instructional data to the controller unit. This is time consuming and is rarely used except as an auxiliary means of control or when one or a very limited no. of parts to be made. The second method of input is by means of a direct link with the computer. This is called direct numerical control, or DNC**.**

***Controller Unit***

The second basic component of NC system is the controller unit. This consists of electronics and hardware that read and interpret the program of instructions and convert it to mechanical actions of the machine tool. The typical elements of the controller unit include the tape reader, a data buffer, signal output channels to the machine tool, and the sequence controls to coodinate the overall operation of the foregoing elements.

The tape reader is an electrical-mechanical device for the winding and reading the punched tape containing the program of instructions. The signal output channels are connected to the servomotores and other controls in machine tools. Most N.C. tools today are provided with positive feedback controls for this purpose and are referred as ***closed loop systems.*** However there has been growth in the ***open loop systems*** which do not make use of feedback signals to the controller unit. The advocates of the open loop concept claim that the reliability of the system is great enough that the feedback controls are not needed.

***Machine Tool***

The third basic component of an NC system is the machine tool or other controlled process. It is part of the NC system which performs useful work. In the most common example of an NC system, one designed to perform machining operations, The machine tool consists of the worktable and spindle as well as the motors and controls necessary to drive them. It also includes the cutting tools, work fixtures and other auxiliary equipment needed in machining operation.

## 4.5 CNC MACHINES

**C**omputer **N**umeric **C**ontrol (C**NC**) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium (computer command module, usually located on the device, see picture right—>) as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Most NC today is **computer (or computerized) numerical control(CNC**), in which computers play an integral part of the control.

In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine by use of a post processor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools – drills, saws, etc. – modern machines often combine multiple tools into a single "cell". In other installations, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design

**Definition**

Computer Numerical Control (CNC) is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the workpiece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off.

In CNC machine the program is stored in the memory of the computer. The programmer can easily write the codes, and edit the programs as per the requirements. These programs can be used for different parts, and they don't have to be repeated again and again.

Compared to the NC machine, the CNC machine offers greater additional flexibility and computational capability. New systems can be incorporated into the CNC controller simply by reprogramming the unit. Because of its capacity and the flexibility the CNC machines are called as "soft-wired" NC.

**The benefits of CNC are**

(1) high accuracy in manufacturing,

(2) short production time,

(3) greater manufacturing flexibility,

(4) simpler fixturing,

(5) contour machining (2 to 5 -axis machining),

(6) reduced human error.

**What is CNC?**

CNC is the acronym for Computer Numerical Control. It is an outgrowth of the older term "NC", which stands for just "Numerical Control". It refers to the idea of controlling machine tools via computer. CNC Machines are robots of a sort. With the older "NC" term, a computer need not be involved. The machine might be controlled using, for example, punched tape.

NC, and later CNC, allowed for tremendous increases in productivity for machine tools because the machines could be run automatically without requiring constant attention from their operator. Before the advent of such automation, there was a lesser automation opportunity in the form of hydraulic tracer systems. Such systems used hydraulics to cause the cutting tools of a lathe or mill to follow a template. The taper attachments available for many manual lathes are not unlike the hydraulic tracer capability, it's just that the tracer is capable of more elaborate templates than simple tapers.

But the advent of first NC and then later CNC radically increased the amount of automation that was possible. CNC Machining is dominant method of machining materials these days, though manual machining is still quite common as well for one-offs, repair, and prototyping work.

The individuals that run CNC Machines on Shop Floors are called "CNC Operators," while those that write the programs to automate production are "CNC Programmers." CNC Machines execute what are called "Part Programs" which are written in a special language called "G-Code." A g-code part program may either be directly coded, or CAM Software may be used to convert a CAD drawing of the part into g-code.

**ELEMENTS OF A CNC**

A CNC system consists of three basic components

1 . Part program

2 . Machine Control Unit (MCU)

3 . Machine tool (lathe, drill press, milling machine etc)

**<u>Part Program</u>** The part program is a detailed set of commands to be followed by the machine tool. Each command specifies a position in the Cartesian coordinate system (x,y,z) or motion (workpiece travel or cutting tool travel), machining parameters and on/off function. Part programmers should be well versed with machine tools, machining processes, effects of process variables, and limitations of CNC controls. The part program is written manually or by using computer assisted language such as APT (Automated Programming Tool)

**The machine control unit (MCU)** is a microcomputer that stores the program and executes the commands into actions by the machine tool. The MCU consists of two main units: the data processing unit (DPU) and the control loops unit (CLU). The DPU software includes control system software, calculation algorithms, translation software that converts the part program into a usable format for the MCU, interpolation algorithm to achieve smooth motion of the cutter, editing of part program (in case of errors and changes). The DPU processes the data from the part program and provides it to the CLU which operates the drives attached to the machine leadscrews and receives feedback signals on the actual position and velocity of each one of the axes. A driver (dc motor) and a feedback device are attached to the leadscrew.

The CLU consists of the circuits for position and velocity control loops, deceleration and backlash take up, function controls such as spindle on/off

**Machine Tool**

The machine tool could be one of the following: lathe, milling machine, laser, plasma, coordinate measuring machine etc. Figure 3 shows that a right-hand coordinate system is used to describe the motions of a machine tool . There are three linear axes (x,y,z), three rotational axes (i,j,k), and other axes such as tilt (9) are possible. For example, a 5-axis machine implies any combination of x,y,z, i,j,k,and 6.

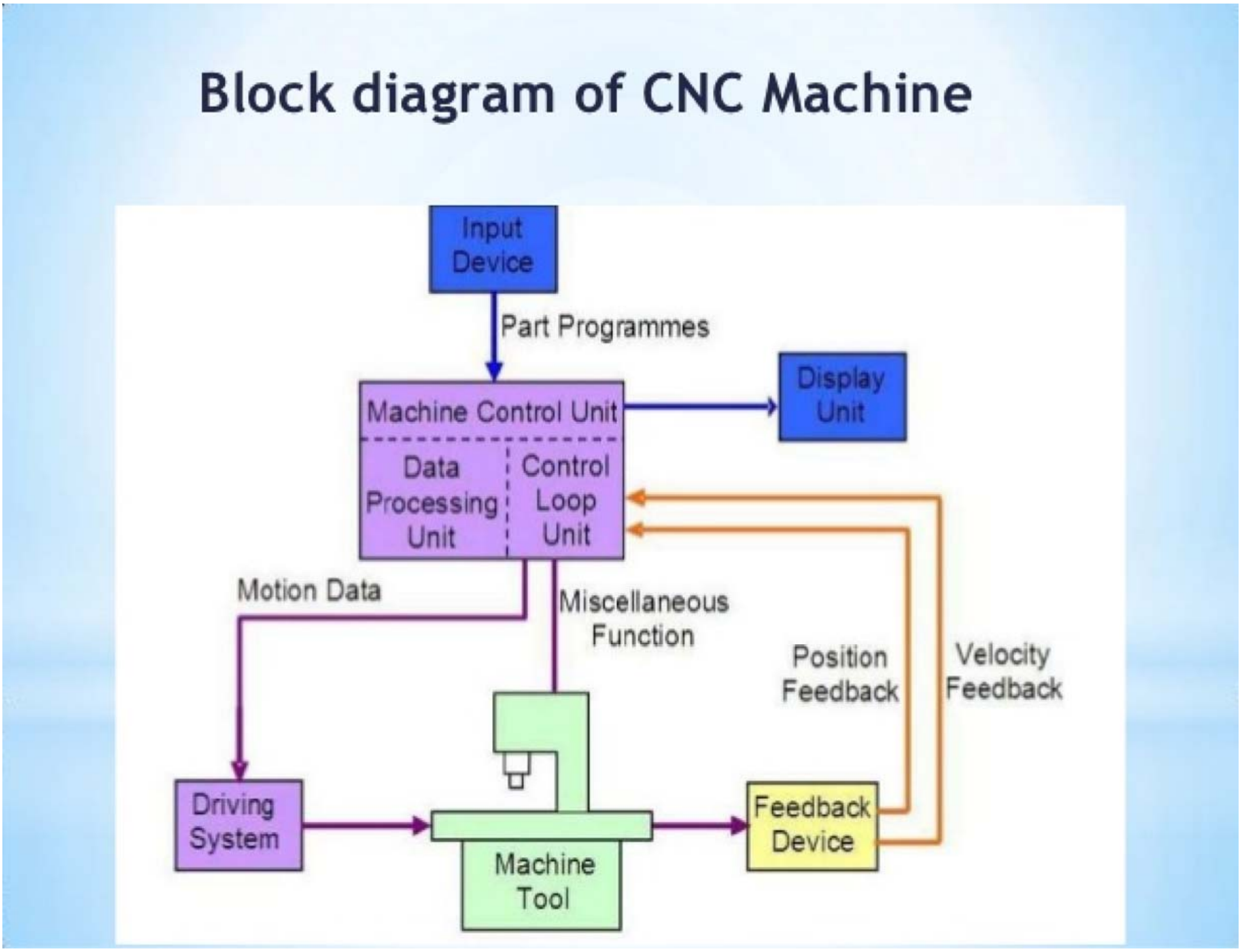


**Fig 4.6 Black Diagram of CNC Machine**

**Application of CNC:**

**Industries for removing metal:** The metal removing industries remove the metal from the raw material to give it the desired as per the requirements. These can be the automotive industries for making the shafts, gears, and many other parts. It can be manufacturing industries for making the various rounded, square, rectangular, threaded and other jobs. There are many other industries where the metal removal works are performed. All these metal removal works are performed by different machine tools like lathe, milling machine, drilling machine, boring machine, shaping machine, reamer, etc. Traditionally these machines are operated by the operators, but the CNC versions of all these machines are now used extensively. You can carryout almost all machining operations with the CNC machining centers. You can also carry out all the turning operations such as facing, boring, turning, grooving, knurling, and threading on your CNC turning centers. On your CNC grinders you can carry out the grinding of the internal diameter, outer diameter, and also the flat surfaces. The Contour Grinding technology enables you to grind surfaces of all shapes.

**Industries for Fabricating Metals:** In many industries thin plates like steel plates are required for various purposes, in fabrications industry the machining operations are performed on such plates. In these industries the CNC machines are used for various machining operations like shearing, flame or plasma cutting, punching, laser cutting, forming, and welding and many other applications. To bring the plates to their final shape CNC lasers and CNC plasma cutters are used commonly. To punch the holes in the plates of all sizes CNC turret punch presses are used. And if you want to bend the plate so as to give it a final shape, you can use CNC press brakes. In some cases the CNC back gages are coupled with the shearing machines, this enables controlling the length of the plate to be sheared as for different applications.

**Electrical Discharge Machining (EDM) Industry:** The EDM machines remove the metal by creating the sparks that burn the metal. There are two types of EDM with the CNC automation – Vertical EDM and Wire EDM. The Vertical EDM needs an electrode of the shape and size of the cavity that is be made in the job. Wire EDM is used to make the punch and die combinations for the dies set that are used in the industries where fabrication is done.

**Other Industries where CNC machines are used:** CNC machines are also used extensively in the wood working industries to perform various operations like routing (similar to milling) and drilling. CNC technology is also used in number of lettering and engraving systems. There are also CNC machines for the electrical industry such as CNC coil winders, and CNC terminal location and soldering machines

## 4.6 FLEXIBLE MANUFACTURING SYSTEMS (FMS)

### Introduction

In the middle of the 1960s, market competition became more intense.

During 1960 to 1970 *cost* was the primary concern. Later *quality* became a priority. As the market became more and more complex, *speed of delivery* became something customer also needed.

A new strategy was formulated: *Customizability*. The companies have to adapt to the environment in which they operate, to be more *flexible* in their operations and to satisfy different market segments (customizability).

Thus the innovation of FMS became related to the effort of gaining competitive advantage.

First of all, FMS is a manufacturing technology.

Secondly, FMS is a philosophy. "System" is the key word. Philosophically, FMS incorporates a system view of manufacturing. The buzz word for today's manufacturer is "agility". An agile manufacturer is one who is the fastest to the market, operates with the lowest total cost and has the greatest ability to "delight" its customers. FMS is simply one way that manufacturers are able to achieve this agility.

An MIT study on competitiveness pointed out that American companies spent twice as much on product innovation as they did on process innovation. Germans and Japanese did just the opposite.

In studying FMS, we need to keep in mind what Peter Drucker said: "We must become managers of technology not merely users of technology".

Since FMS is a technology, well adjusted to the environmental needs, we have to manage it successfully.

### 1. Flexibility concept. Different approaches

Today flexibility means to produce reasonably priced customized products of high quality that can be quickly delivered to customers.

Different approaches to flexibility and their meanings are shown Table 4.1

| Approach | Flexibility meaning |
|---|---|
| **Manufacturing** | The capability of producing different parts without major retooling<br><br>A measure of how fast the company converts its process (es) from making an old line of products to produce a new product<br><br>The ability to change a production schedule, to modify a part, or to handle multiple parts |
| **Operational** | The ability to efficiently produce highly customized and unique products |
| **Customer** | The ability to exploit various dimension of speed of delivery |
| **Strategic** | The ability of a company to offer a wide variety of products to its customers |
| **Capacity** | The ability to rapidly increase or decrease production levels or to shift capacity quickly from one product or service to another |

**Table 4.1 Flexibility Concept**

So, what is flexibility in manufacturing?

While variations abound in what specifically constitutes flexibility, there is a general consensus about the core elements. There are three levels of manufacturing flexibility.

(a) Basic flexibilities

- *Machine flexibility* - the ease with which a machine can process various operations
- *Material handling flexibility* - a measure of the ease with which different part types can be transported and properly positioned at the various machine tools in a system
- *Operation flexibility* - a measure of the ease with which alternative operation sequences can be used for processing a part type

(b) System flexibilities

- *Volume flexibility* - a measure of a system's capability to be operated profitably at different volumes of the existing part types
- *Expansion flexibility* - the ability to build a system and expand it incrementally
- *Routing flexibility* - a measure of the alternative paths that a part can effectively follow through a system for a given process plan
- *Process flexibility* - a measure of the volume of the set of part types that a system can produce without incurring any setup
- *Product flexibility* - the volume of the set of part types that can be manufactured in a system with minor setup

(c) Aggregate flexibilities

- *Program flexibility* - the ability of a system to run for reasonably long periods without external intervention
- *Production flexibility* - the volume of the set of part types that a system can produce without major investment in capital equipment
- *Market flexibility* - the ability of a system to efficiently adapt to changing market conditions

**2. Seeking benefits on flexibility**

Today's manufacturing strategy is to seek benefits from flexibility. This is only feasible when a production system is under complete control of FMS technology. Having in mind the *Process- Product Matrix* you may realize that for an industry it is possible to reach for high flexibility by making innovative technical and organizational efforts. See the Volvo's process structure that makes cars on movable pallets, rather than an assembly line. The process gains in flexibility. Also, the Volvo system has more flexibility because it uses multi-skill operators who are not paced by a mechanical line.

So we may search for benefits from flexibility on moving to the job shop structures.

Actually, the need is for *flexible processes* to permit rapid low cost switching from one product line to another. This is possible with *flexible workers* whose multiple skills would develop the ability to switch easily from one kind of task to another.

As main resources, flexible processes and flexible workers would create *flexible plants* as plants which can adapt to changes in real time, using movable equipment, knockdown walls and easily accessible and re-routable utilities.

### 3. FMS- an example of technology and an alternative layout

The idea of an FMS was proposed in England (1960s) under the name "System 24", a flexible machining system that could operate without human operators 24 hours a day under computer control. From the beginning the emphasis was on *automation* rather than the "reorganization of workflow".

Early FMSs were large and very complex, consisting of dozens of Computer Numerical Controlled machines (CNC) and sophisticate material handling systems. They were very automated, very expensive and controlled by incredibly complex software. There were only a limited number of industries that could afford investing in a traditional FMS as described above.

Currently, the trend in FMS is toward small versions of the traditional FMS, called flexible manufacturing cells (FMC).

Today two or more CNC machines are considered a *flexible cell* and two ore more cells are considered a flexible manufacturing system.

Thus, a **Flexible Manufacturing System** (FMS) consists of several machine tools along with part and tool handling devices such as robots, arranged so that it can handle any family of parts for which it has been designed and developed.

Different FMSs levels are:

Flexible Manufacturing Module (FMM). Example: a NC machine, a pallet changer and a part buffer;

Flexible Manufacturing (Assembly) Cell (F(M/A)C). Example: Four FMMs and an AGV (Automated Guided Vehicle);

Flexible Manufacturing Group (FMG). Example : Two FMCs, a FMM and two AGVs which will transport parts from a Part Loading area, through machines, to a Part Unloading Area;

Flexible Production Systems (FPS). Example: A FMG and a FAC, two AGVs, an Automated Tool Storage, and an Automated Part/assembly Storage;

Flexible Manufacturing Line (FML). Example: multiple stations in a line layout and AGVs.

### 4. Advantages and disadvantages of FMSs implementation

#### Advantages

- Faster, lower- cost changes from one part to another which will improve capital utilization

- Lower direct labor cost, due to the reduction in number of workers
- Reduced inventory, due to the planning and programming precision
- Consistent and better quality, due to the automated control
- Lower cost/unit of output, due to the greater productivity using the same number of workers
- Savings from the indirect labor, from reduced errors, rework, repairs and rejects

**Disadvantages**

- Limited ability to adapt to changes in product or product mix (ex. machines are of limited capacity and the tooling necessary for products, even of the same family, is not always feasible in a given FMS)
- Substantial pre-planning activity
- Expensive, costing millions of dollars
- Technological problems of exact component positioning and precise timing necessary to process a component
- Sophisticated manufacturing systems

## 4.7 WORK CENTERS

Work Centers are designed for specific roles and provide a central area for users to access key components within Financial and Supply Chain applications. They enable users to access various pages and perform daily tasks without leaving the Work Center, which reduces the time used when navigating through menus.

Work Centers are delivered as empty components. It is the responsibility of the system administrator from your organization, to design and create links so that users can view and access specific links and pages

Data in work centers is used for

**Scheduling:** Operating times and formulas are entered in the work center, so that the duration of an operation can be calculated.

**Costing:** Formulas are entered in the work center, so that the costs of an operation can be calculated. A work center is also assigned to a cost center.

**Capacity Planning: The** available capacity and formulas for calculating capacity requirements are entered in the work center.

Various default values for operations can be entered in the work center

## 4.8 ROBOTICS

Robotics is the branch of mechanical engineering, electrical engineering and computer science that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing.

These technologies deal with automated machines (robots for short) that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behavior, and or cognition. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics.

The concept of creating machines that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, it has been frequently assumed that robots will one day be able to mimic human behavior and manage tasks in a human-like fashion. Today, robotics is a rapidly growing field, as technological advances continue; researching, designing, and building new robots serve various practical purposes, whether domestically, commercially, or militarily

A robot has these essential characteristics:

- **Sensing** First of all your robot would have to be able to sense its surroundings. It would do this in ways that are not similar to the way that you sense your surroundings. Giving your robot sensors: light sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing and sonar sensors (ears), and taste sensors (tongue) will give your robot awareness of its environment.
- **Movement** A robot needs to be able to move around its environment. Whether rolling on wheels, walking on legs or propelling by thrusters a robot needs to be able to move. To count as a robot either the whole robot moves, like the Sojourner or just parts of the robot moves, like the Canada Arm.
- **Energy** A robot needs to be able to power itself. A robot might be solar powered, electrically powered, battery powered. The way your robot gets its energy will depend on what your robot needs to do.
- **Intelligence** A robot needs some kind of "smarts." This is where programming enters the pictures. A programmer is the person who gives the robot its 'smarts.' The robot will have to have some way to receive the program so that it knows what it is to do

Basic structure of robots is very much similar to humans. How do humans sense? For example a human sees something and sends neural signals to the brain via neurons and reacts accordingly. The development of all these senses artificially is achieved through 'Sensors'.

Sensors are the transducers which receive the physical changes of the environment and convert them into electrical or electronic signals. These analog signals are converted into digital by using analog-to-digital convertors. Control system functions as a brain in robotic systems.

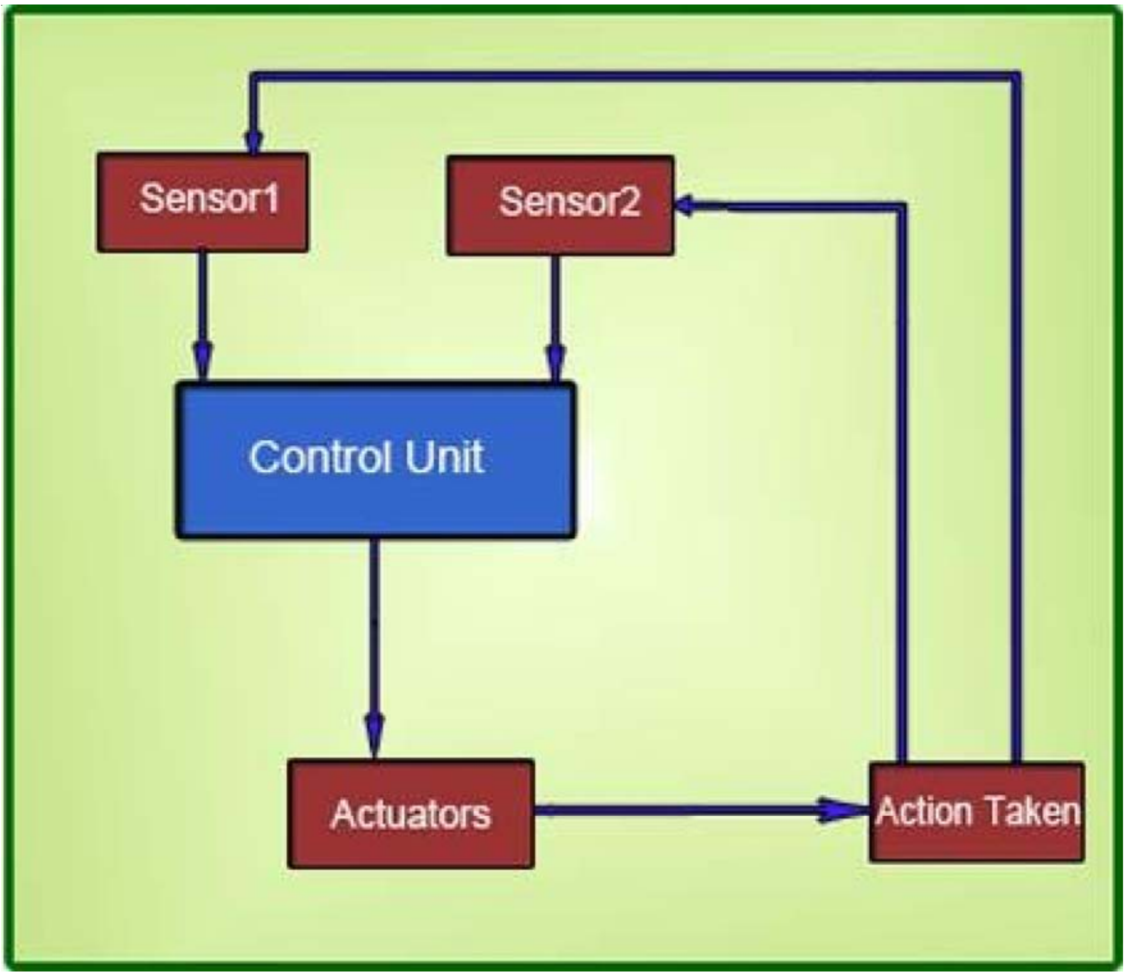


**Fig 4.7 Basic Structure of Robot**

PID controller is a popular method for controlling robots. Point of the control system is to get robot actuators do what one wishes to. An encoder on actuator, basically a sensor, determines what all is changing. Program that one writes, defines final results and actuators make changes. Other sensor senses environment, providing robot a better sense of working.

Among different components, actuators are the most important for robotic automation. This component helps in conversion of stored energy in movement. Usually, these are the electric motors, although compressed air and chemical actuators are also available for use. Stepper motor rotates in controllable motions and are commanded by controllers. Ultrasonic motor uses fast vibrating piezo-ceramic element for causing motion. With the help of compressed air, air muscles work exactly like human muscles, contracting and expanding.

Robots are made from an assortment of materials and are driven in many ways too. These can be constructed from sturdy, heavy steel or light weighted plastics. Surgical robots and Robotic arms have uncomplicated rotational joints. These are driven by hydraulics and electrical motors along with longitudinal joints that are moved with rotating screws. Some mobile robots have various wheels that can operate on various planes while others can walk on different terrains with multiple legs. You can find robots with sensing mechanisms like cameras operating as eyes and touch sensors for feeling the environment.

**History of Robotics and Early Robots**

Idea of robots have appeared all through human civilization, from robots of ancient world, to the contemporary humanoid robots and automated tools for weave production improvement for industrial revolution. While it is not clear of how many designs were attempted in past but humans have always dreamt of the automated machines.

Word robot was invented by Czech playwright in one of his plays. Author named Isaac Asimov made this idea even popular by science fiction. With invention of computers in 1950s, robots became complex. Unimate, first ever industrial robot was invented in 1962 for performing repetitive tasks. Stanford institute of research introduced Shakey, first ever automatic mobile robot. Robot toys like HERO series and RB5X series came to the fore in 1980s. Since then innovations have made them complex, leading to Sony Aibo, Lego Mind storms and Furby.

**Interesting Robots developed lately**

Socialization of the robots has been important research area lately. Researchers have been trying to provide robots with the social skills so that they can become much better with assistance at offices, schools, homes and other places. TR35 innovator, Andrea Thomaz invented robots that can grasp tasks from the human instructions with use of verbal instructions, expressions and gestures. University of Carnegie Mellon invented a robot that guides interactions with the help of eye contacts for suggesting its time for speaking.

Researchers at Californian University invented machine learning programs that allow robotic head to build up better face expressions. By checking itself out in a mirror, this type of robot can study the way in which its body parts move and can develop new expressions.

## 4.9 NOTES

## 4.10 SUMMARY

In this unit we have studied about latest trends in production management. We have seen NC and CNC machines and have learnt how these machines help in precision engineering. Today computers have marked their presence in every field, hence the operations management.

## 4.11 KEYWORD

**FMS, Robotics, CIM, CAD/CAM, NC CNC,**

## 4.12 SELF ASSESSMENT QUESTIONS

1. Outline the advancement in Production Management
2. What is FMS? What are its advantages?
3. Give a brief note on NC machines
4. How CNC machines are more convenient than NC Machines?

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# MODULE - II
# PRODUCTION PLANNING

## UNIT - 5 : PRODUCT AND PROCESS DESIGN

**Structure:**

## 5.0 OBJECTIVES

**After studying this unit, you should be able to;**

- Define product design
- Design a product for manufacturing and assembly
- Explain different types of layout
- Determine the best process based on the cost sheet

## 5.1 INTRODUCTION

Developing a new product is often a challenge for the production engineer. The marketing and the research team would come out with the quality and material specification of the product. However physically developing the product often poses challenge. The various parts of a product need to be manufactured or need to be purchased. Such parts shall so be designed that assembling would be feasible. The product design should suit the process capability of the machine. The design of the product and design of the process goes hand in hand in developing a product. For continuous production such as cement, the process should be determined first and the whole factory layout is determined based on the flow of the product.

## 5.2 MEANING AND DEFINITION OF PRODUCT DESIGN

Design is the conversion of knowledge and requirement into a form, convention and suitable for use for manufacture.

**Types of Design**

**1) Functional Design:** Functional design involves developing an idea into a tough model of the proposed products. This necessitates first making a rough sketch of the proposed products to give some idea of its shape and of the parts necessary to give some idea of its shape and of the parts necessary to accomplish its purpose. Then, the designer makes drifting room sketches of the individual parts in correct dimensions and then full sketches of proposed products. After this experimental models of the proposed products should be thoroughly tested to make sure that they will function properly for a certain period and under varying conditions.

2) **Aesthetic Design:** Before production on a commercial scale is undertaken, another type of design must be integrated with the functional design and it is aesthetic design or style or fashion design for market acceptability. The emphasis on styling has become a part of design of the proposed product. It should be appealing to the customers' eyes and inducing them to buy the product. It is not possible to improve the functional efficiency, , however, gives it a more attractive appearance and helps to increase sales.

3) **Production Design or Product Design:** Generally, the functional design is translated to production design to make it easy to manufacture. Product design means a design which may result in affecting the economies without affecting its functional efficiency. As soon as the product has been fully tested to determine whether it is functioning correctly, it must be checked to see if any design changes can be made that will affect economics but will not affect its functional efficiency. In carrying out production design, any special tools, jigs or fixtures needed in production should be noted and their designing should be carried out by the tool department.

4) **Packing Design:** Packing design should also be appealing to the consumers. Depending upon the size and the nature of the product, different packing materials can be used to suit the consumers'' needs and to maintain the chemicals properties of the product.

The product designer should use as far as possible standard parts or assemblies to reduce the cost of the production because standard parts in some cases may be purchased cheaper from outside firms specializing their manufacture. The product designer should also know about the possibility of simplification and diversification of product.

## 5.3 ELEMENTS IN PRODUCT DESIGN

The various elements involved in product design are:

**1) Research and Development:** The design of new product is done by the Research and development (R & D) department of organization with the help of many other departments.

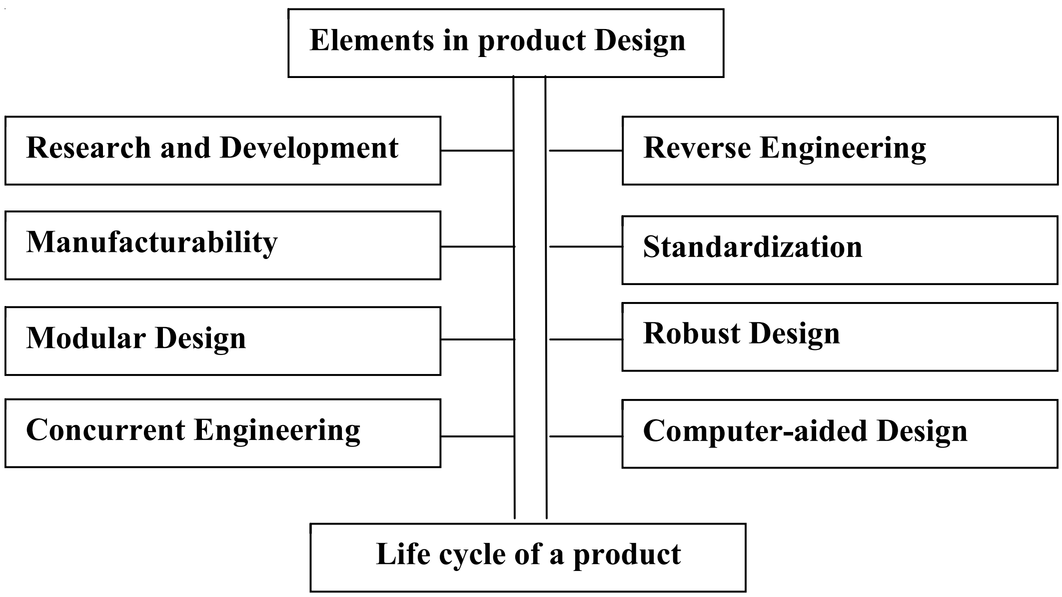



**Fig 5.1 Elements in Product Design**

2) **Reverse Engineering:** Reverse Engineering is the process of carefully dismantling an existing product (of a competitor) in order to understand the unique underlying concept. It helps in designing new products, which are better than those of the competitors. In the field of consumer's electronics, Sony Corp. is on the forefront in designing new innovative items such as the walkman, handy cam, digital cameras, etc. Many other companies have to follow the reverse engineering approach in order to break Sony's monopoly of new products in the shortest possible time.

3) **Manufacturability:** Manufacturability implies designing a product in such a way that is manufacturing/ assembling can be done easily. While designing a new product, the manufacturing capabilities (Such as existing machines, equipment, skills of workers, etc) of the organization have to be kept in mind. If the required capabilities do not exist, the management can consider enhancing the production capabilities by making mare investment.

4) **Standardization:** Standardization refers to less variety in the design of products, i.e., new products are designed such that there is no major variation from the existing productions. For example, all computers and typewriters have the same arrangement of keys in the keyboard because it has become a standard, consumers are used to. Although many other more efficient designs of keyboard keys are available, no company is willing to take the risk of deviating from this standard.

5) **Modular Design:** One of the significant aspects of the product design is modular design. Modular design is another type of standardization, which means designing a product in part or modules. The modules are subassemblies of different components and parts. It not only helps to realize a product of the organization, but also in realizing similar products in the future. Modular design directly affects the complexity and cost of the conversion process.

The modular design concept gives consumers a range of product options and, at the same time, offers considerable advantages in manufacturing and product design. Stabilizing the designs of the modules makes them easier to build. Problems are easier to diagnose, and the modules are easier to build. Production proficiency increases as personnel make refinements to and gain experience with the manufacturing processes for standardized sets of modules.

6) **Robust Design:** Robust design means designing a product that is operational in varying environmental conditions. For example, if you compare a car with a jeep (a four-wheel drive), the jeep is more robust in design as it can even by used efficiently on hilly areas with poor road conditions. The Japanese engineer Genichi Taguchi emphasized that it is easier to create a product with robust design rather than making changes in the environment to suit the product.

7) **Concurrent Engineering:** Concurrent engineering is the product design approach in which the design team includes personnel from the marketing department (to specify the customer requirements), production department (to suggest if production capability exists

for the design), materials department (to give inputs about material availability according to design specification), and finance department (to suggest financial feasibility of the design) in addition to the design department. This approach is radically opposite to the classical sequential product design approach in which the design process takes place in stages, moving from one department to the other. Concurrent engineering saves a lot of time unlike the sequential approach in which feedback between departments, at times leading to rejections of the suggested design at later stages, results in the wastages of a lot of time and effort.

**8) Computer-aided Design**: Computer-aided design (CAD) is a software which helps the designer to make the three dimensional design of a product on the computer and visualize the design from various angles.

In the earlier times, when CAD softwares were not available, design engineers had to make designs from various angles (say, front, back, side, top, bottom views of the product/ components) on paper charts by using rulers and other equipment, which was tedious and time consuming. Designs made on CAD can be seen at different workstations through internets simultaneously. Also, these can be transmitted to distant locations (for comments of experts, etc.) using the internet.

## 5.4 OBJECTIVES OF PRODUCT DESIGN

The objectives of designing the product may be summarized as follows:

1) The first objective of designing is to create attention in product for increasing the sale potentials.

2) To enlarge the importance of product from customers' point of view.

3) To make the product more effective and create more utility in the product for the consumer

4) To produce better quality at the lowest possible price.

## 5.5 FACTORS INFLUENCING PRODUCT DESIGN

The factors influencing product design or re-design are either from the customers' perspectives or from the organizational perspectives:

**1) Customer's Perspectives:** The product re-design should be as per the customers' requirements. The product alteration should be customer oriented. The aim of the product re-designs or the alteration or modification is to fulfil the customers' stated, implied and the latent needs. The customers' perspectives are normally in four different sectors which are as follows:

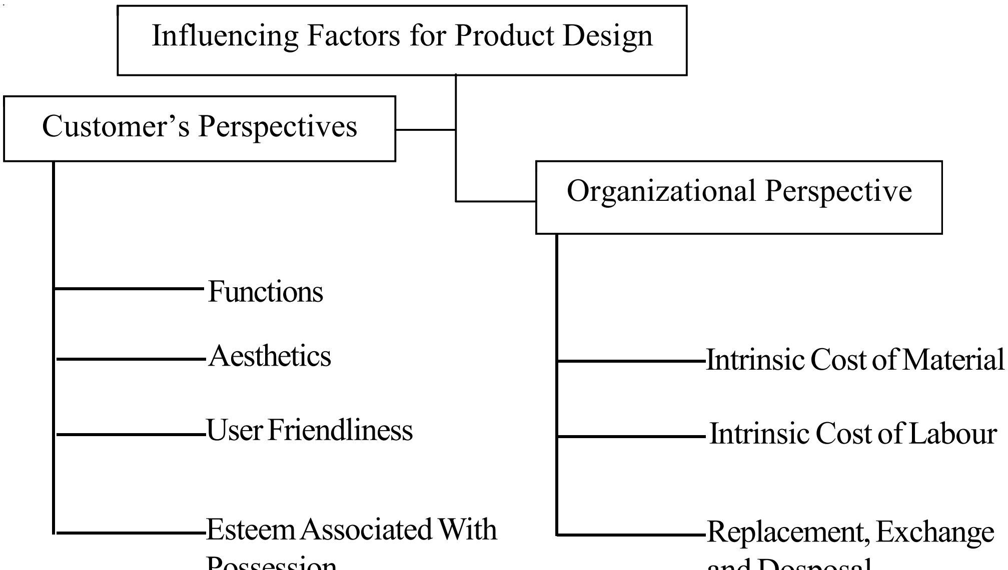



**Fig 5.2 Factors Influencing Product Design**

**i) Functions:** The product or the service should be fit for the use by the customer. The functions of the product or the service can be divided into two types of needs-the ‘musts’ and ‘wants’. The musts are the basic requirements for the product or service has to fulfil, and the wants are the desirable features of the product or service. The product or service which fulfils all the musts and the maximum number of wants is functionally the best product or the service.

**ii) Aesthetics:** The aesthetics or the external look of the product or service constitutes the basic requirement of any product or service to decide its market. The aesthetic is a marketing requirement across the products or services to be marked.

**iii) User Friendliness:** The User friendliness of the product or service decides its market share or the market leadership. Sometimes many of the good products or services fail to take-off in the marketplace if they are introduced before time, i.e., before the customer is ready to accept the products. The user friendliness or the ease of use, service and maintenance adds substantial value to the end-products or services.

**iv) Esteem Associated with Possession:** All the products or services in the market have two types of value-the use value and the esteem value. The products or services must fulfil the basic needs of customers to survive in the market. The products or services in the upper-end of the market have esteem value over and above the use value for gaining its market share. In this market segment, the customers want the products or services with special or additional distinguishing features for which they are ready to pay. The customers feel that the value added products or services would increase their social esteem or prestige because others in the society cannot afford such costly products. Therefore, these value-added products or services and the associated brand name become a status symbol in the society. The example could be possession of cars like 'Rolls-Royce'.

2) **Organizational Perspective:** The products or services manufactured and marketed by the organization have certain internal factors to be taken into consideration while undertaking the value analysis of the products or services. This is pertaining to the optimum utilization of the internal resources used for the production of the products or services by the organization. This will enable the organization to keep low its cost of production so that it can defend its profitability and offer the products or services at competitive rates than the competition thereby gaining higher market share:

i) **Intrinsic Cost of Material:** The main objective of value analysis is to reduce the material cost by the way of elimination of wastages, reduction in the material consumption and elimination or substitution of the non-value adding components in the products or services. The reduction in the cost of material can also come from the cheaper and better substitute parts and components in the products or services. As the material cost is normally 50% of the selling price of the products or services, a small reduction in the material cost is going to reduce the cost of production substantially.

ii) **Intrinsic Cost of Labour:** More important aspect than the cost of labour is the quality and the competency of labour. The intrinsic cost of labour is an important aspect of the value analysis of the products or services. This aspect of labour cost and productivity is handled effectively by management techniques such as work measurement, time study, motion study, and method study. These techniques bring down the intrinsic cost of labour with better quality of the products or services and better labour productivity.

iii) **Replacement, Exchange, and disposal:** The cost of replacement, exchange disposal or removal of personnel, machines or material due to the product design or re-design is an important aspect of the value analysis, which has to be looked into not only from the point of view of direct impact, but also from the point of view of the spinning of effects on the product, market, employees and the management. This is a major area which has to look into critically, otherwise it may spell a disaster to the organization or it may also bring to the organization.

## 5.6 ISSUES IN PRODUCT DESIGN

Designers must be careful to take into account a wide array of legal and ethical considerations. Moreover, if there is potential to harm the environment, then those issues also become important.

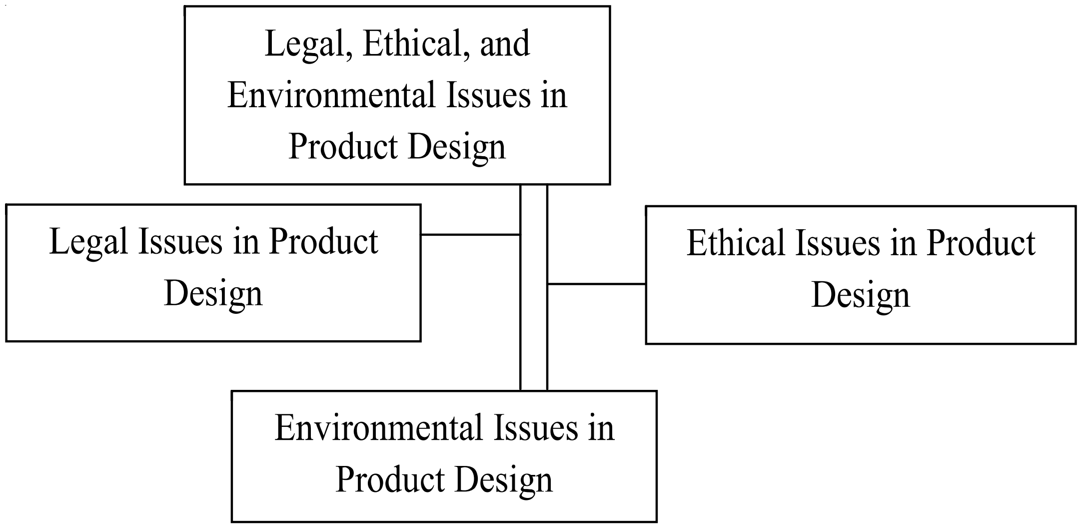



**Fig 5.3 Issues in Product Design**

**1) Legal Issues in Product Design:** The legal issues play a crucial role in the design process. They are as follows:

**i) Product Liability:** It refers to product does not provide the security that people have the right to expect. These are defects caused by the user, consumers personal, property, and moral damage,

## 5.7 PRODUCT DESIGN AND ANALYSIS

In any business venture, product design is the first step immediately after accepting the concept of product. Product design has direct bearing on plant layout and in process material flow. In the process of product design, one has to critically analyze different design features in the relevance to places of use, substitute materials and carefully plan the equipment alternatives for manufacturing the product. Therefore the purpose of product design and analysis is to determine and specify products that will be profitable to manufacturer and give human satisfaction.

The various aspects in product design are

- Design for function
- Design for making
- Design for selling

**Design for Function:** A product must perform its function which its customer expects it to do. If a part is designed by taking its functional features into account, then it will create satisfied customers and will further lead to having, ore repeat customers. The factors which are to be considered for functional design are strength and wearability of product and its components.

**Design for making:** A product design that solves the functional problem smoothly, but is impossible to manufacturing is of no use. Attention must be given to materials, components manufacture elements etc while designing product. Some critical factors such as hardness of material, size of fasteners are very important to consider while designing of product. Making use of standard parts is an important aspect of product design. Also operational convenience of the machineries must be taken into account at the design stage.

**Design for selling**: A product that functions well and easy to make but is wanted by no one is of waste. It makes no difference whether the product is a pen or car it has to sell itself to customers. The features like appearance and convenience, depending on customers' needs are to be considered. Product convenience can be improved using pre-determined motion-time systems.

So, Engineers, designers and psychologists should work together to design a better product for selling.

**Modules of product design and analysis:** Product design may be classified into design for new products (new product development) and design for modifications of existing products. Product design is a repetitive task. A careful analysis of product attributes would reduce obsolescence and extends the product's life. The following are various aspects of product design and analysis

- Process, planning and design
- Value engineering/Value analysis
- Standardization and simplification
- Make or buy decision
- Ergonomic considerations in product design
- Concurrent Engineering

Some other important design considerations are

**a) Standardization**: Standardization reduces the kinds, types and sizes of raw materials that have to be bought and cut down on manufacturing cost. We can cut set-up cost and use more specialized manufacturing tools.

b) **Modular Design**: Designers needs to resort to modular constructions. Products are to be made mostly out of easily detachable sub-assembly or sections. It makes easy for customers to replace of parts wherever needed.

**c) Form and functional design**: Product design deals with form and function. Form design deals with product shape. Functional design of product decides how it performs.

**d) Design and product cost**: While designing products, we should also consider product costs. Sometimes initial design cost may be more to produce than the market can bear. It needs redesigning so that it costs less to produce.

**e) Design for volume production**: Mass-produced items need to be designed so that they can be made at low cost. Precision of parts is very important for high volume products, sub-assembly , and parts are first designed so that they will perform. Then cost reduction and elimination are examined without effecting functional utility.

**f) Repair ability**: Easy repair is important design.

**g) Re design**: Each product's design must be continuously to be retained and to be changed if required.

**h) Miniaturization**: Make it smaller and lighter in weight concept is essential while designing product. Manufactured products /services must have market appeal and be reasonably easy to produce with quality and economy. It has been estimated that 70% of a manufactured product's cost is determined by its design.

## 5.8 PROCESS PLANNING AND DESIGN

**Selection of process:** Process selection decisions determine the type of productive process to be used and appropriate spam of process. For example, the managers of a fast-food restaurant may be required to decide whether to produce food strictly to customer order or to inventory. Managers should also decide whether to organize the process flow or low volume batch production process. All these decisions help in defining the type of process which will be used to make the product.

Process selection is sometimes viewed as low-level decisions. But on courtesy, process selection is strategic in nature and in of utmost importance process decisions affect quality, cost, delivery and flexibility of operations.

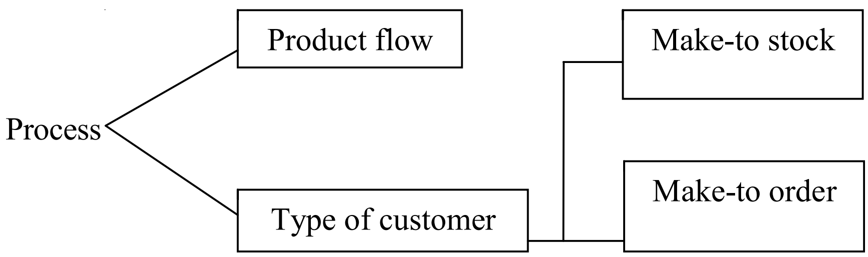



**Fig 5.4 Process Selection Decisions**

Process can be classified and selected according to product flow and type of customer order. The customer order is generally of two types

a) Make-to-stock: Make-to-stock aims to produce products in advance and helps to have ready stock. This applicable is for the products which has no specific customer at the time of manufacturing. Ex: Tooth paste, soap etc.,

b) Make-to-order: Make-to-order aims to manufacturing products only to orders. Ex: Crane, ship, Boiler etc.,

The following factors influences process selection

- Market Condition
- Capital requirement
- Labour
- Manufacturing skills
- Raw materials
- Technology

| | **Make-to-Stock** | **Make-to-order** |
|---|---|---|
| Line flow | Soap, paste, fertilizer, cement | Auto assembly, Railway coach, Dumpers |
| Intermittent flow | Medicine, fastener, furniture | Hospital, jewellery |
| Project | Real estate, Commercial paintings | Building, dam, Bridge |

**Table 5.1 Process Characteristics Matrix**

A good process selection requires a careful analysis of each of above factors through different studies. A market research study should be done to access potential market demand and conditions.

**Process Planning Design**

It is a complete determination of the specific technological process, steps and their sequences to be followed to produce products at the desired quality, quantity and cost. This task is generally managed by process Engineers.

The process Engineers should therefore:

- Determine the manufacturing method of product
- Establishing the sequence and type of operations required

- Selection of tools and equipments
- Analysis of manufacturing of product and facilities

The effect of process planning will be on cost, method of manufacturing, quality and production rates. The basic input of process planning classified into

a) Production information

b) Production system information

Production information includes product design, product volume, market environment and major technology selection.

Production information system includes resource availability and technology capacity.

Profit can be maximized if production cost reduced. Hence process Engineers should

- Be able to interpret product design, specification, tolerance on product design
- know functions and capabilities and limitations of available ones
- Be able to evaluate needs of new tools and equipments
- Be prepare best sequence of operations
- Be arrange necessary inspection equipment

Steps in process planning are listed below

a) Analyze the blue print part and the requirements of the part

b) Consult product design Engineers for their recommendations and suggestions

c) List the basic operations required to produce the part

d) List of specifications, tolerances, surface finishes to be achieved

e) Determine most practical and economical manufacturing method

f) Determine and list the tools and equipments required for operations

g) Device the best way to combine the operations and put them in sequence

h) Specify the gauging required for the process

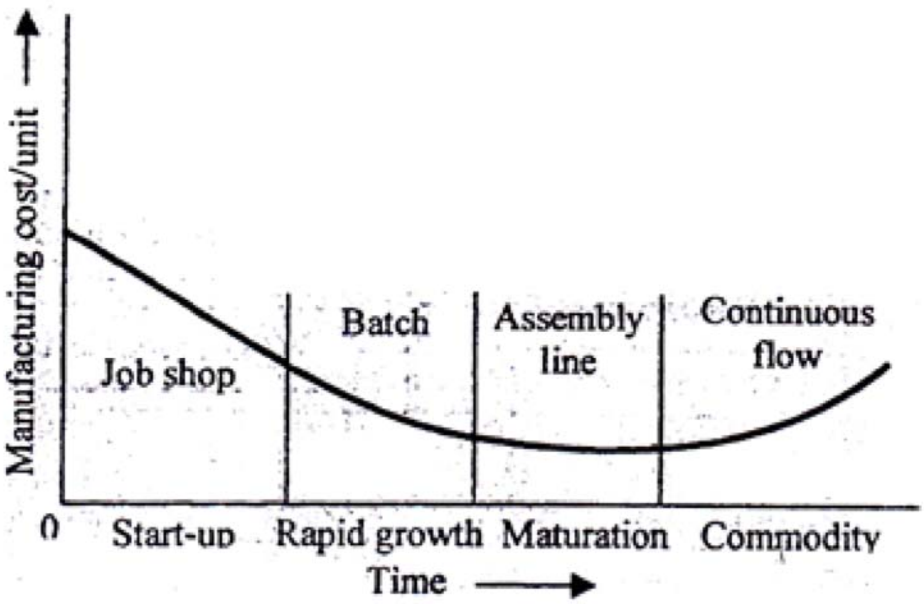
**Meaning of Process**

A process is a part of organizational activities that takes inputs and transforms them into outputs. The value of process generates is the difference between what the final product is worth to the customer and its initial value. The objective of the process is to provide the maximum overall value of the customer in the product.

For example, the component group of ECIL has product lines for electronic fuses, microwave components, printed circuit boards that are used internally, ceramic components and nickel cadmium batteries. Through the use of labour, manufacturing technologies, assembly, energy, etc, raw materials and components are transformed to the product of the company.

**Process Life Cycle**

Process technologies have life cycles related to product life cycles, as shown in figure 5.5 over time, unit manufacturing costs diminish or mature products.




From pr ughput volume, logy is typicall product survives to become a commodity. Throughput volumes and automation are low at start-up and high during maturation and decline. These changes require appropriately matching up the manufacturer's product process structures.

**Meaning of process design**

A process strategy is an organization approach to transforming resources into goods and services. The main objective of this strategy is to build such production process that meets customer requirements and specifications. The process strategies guide the process design. Process strategies are also termed as process design.

The new products are not realities until they are manufactured. Process design is necessary to manufacture new products. Process design is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations that are to be used, the machines and equipments necessary and the quantities in which each is required.

In other words, process design means the complete definition and description of specific steps in the production process and the linkages among the steps that will enable the production system to produce products of the desired quality, in the required quantity, at the time, customers want them and the budgeted cost.

The sequences of operations in the manufacturing process are determined by;

1) The nature of the product.

2) The materials used.

3) The quantities being produced and

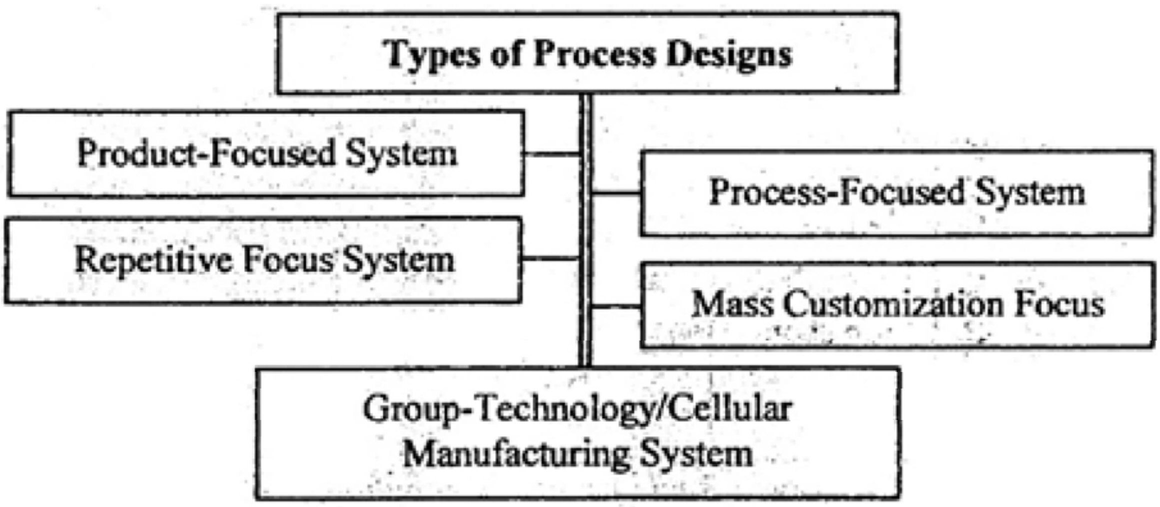
4) The existing physical layout of the plant.

## 5.9 TYPES OF PROCESS LAYOUT

The basic type of production system and the finished goods inventory policy to be used must be decided at the earliest stages of process planning. The common type of process designs are:

**PRODUCT-FOCUSED LAYOUT**

In this type of production processing, the production departments are organized according to the type of product/service being produced, all production operations required to produce a product/service are grouped into one production department or work centre.




assembling the components in the special configurations of the custom product.

Physical facilities are organized around the nature of the processes, and personnel are specialized by generic process type. For example, in a machine shop we might expect to find milling machine department, lathe department, drill departments, and so on. The flow of the item being processed in such productive system is dictated by individual product requirements, so the routes through the system are variable.

The nature of the demand on the productive system results in the intermittent demand for the system's facilities, and each component flows from one process to the next intermittently. Thus, the process-focused system with intermittent demand on process types must be flexible as enquired by the custom product, and each generic department and its facilities are used intermittently as needed by the custom orders.

Product-focused production is also known as line flow production or continuous production. In line flow production, the products tend to follow along direct linear paths and in continuous production the products tend to proceed through production department without stopping.

**Process-focused Layout**

This is a form of production system in which, production operations are grouped according to the type of process. In other words, all production operations having similar technological processes are grouped together to form a production department.

By contrast, the nature of the demand in the productive system that produces high-volume, standardized products results in continuous use of the facilities. Also, the material flow may be continuous, as in petroleum refining, or approaching continuous flow, as with automobile fabrication and assembly. Because of the high-volume requirements of such system can be justified as a productive system strategy. Processing is adapted completely to the product. Individual processes are physically arranged in the sequence required, and the entire system is integrated for a single purpose, like one giant machine. Thus, continues system have a product focus. Under these extreme conditions of high demand for standardized products, the process is integrated and high make use of mechanization and automation to achieve standardization and low cost. Inventories of standardized product may be an important element of production as well as marketing strategy.

Between the two extremes of process-focused (intermittent demand) and product-focused continuous demand) system, we have system that must deal with low-volume multiple-product situation usually involves a process-focused system but products are produced in batches. This allows certain economies of scale in comparison to the job shop system, which is designed to deal with custom product.

Process-focused systems are also known as intermittent production system or job shops batch production systems.

**Repetitive Focus Layout**

A repetitive process falls between the product and process focuses system. A repetitive processes use modules. Modules are parts or components previously prepared, often in a continuous process. The repetitive process line is the classic assembly line. Widely used in the assembly of virtually all automobiles and household appliances, it has more structure and consequently less flexibility than a process-focused facility.

Fast-food firms are an example of repetitive processing process using modules. This type of production allows more customizing than a continuous process; modules (e. g., meat, cheese, sauce, tomatoes, onions) are assembled to get a quasi-custom product, a cheeseburger. In this manner, the firm obtains both the economic advantages of the continuous model (where many of the modules are prepared) and the custom advantage of the low-volume, high-variety model.

**Mass customization Layout**

Mass customization was first identified in “Future Shock” by Tofter and later described in “Future Perfect” by Davis. Davis describes mass customization as the contradiction of mass production. Mass customization has different implications for different products and in different sectors. These are also different methods and strategies to achieve it. Some product can be tailored or customized at the retail outlet are dealer (Post-production customization) . Other products may adapt to the user, e.g., the intelligent systems, increasingly available in cars that adapt (transparently) to the style of driving (adaptive customization).

Mass customization is the rapid, low cost production of goods and services that fulfil increasingly unique customer easier. It is the new paradigm that replaces mass production, which is no longer suitable for today’s turbulent market, growing product variety, and opportunities for e-commerce Mass.

## 5.10 SOLVED PROBLEMS

1. Machines A and B are both capable of manufacturing a product. The comparison is as follows:

| | Machine A | Machine B |
|---|---|---|
| Investment | Rs.- 50.000/- | Rs. 80.000/- |
| Interest on capital invested | 15% per annum | 15% per annum |
| Hourly charges (Wages + Power) | Rs. 10/- | Rs.8/- |
| No. of pieces produced per hour | 5 | 8 |
| Annual operating hours | 2000 | 2000 |

(i) Which machine will have the lower cost per unit of output, if run for the whole year?

(ii) If only 4000 pieces are to be produced in a year, which machine would have the lower cost per piece?

(iii) Will your answer to (i) above vary if you are informed that 12.5% of the output of machine B gets rejected at the inspection stage. If so, what would be the new solution? (ICWA-Final June 1995)

**Solution**

| (i) Data | Machine A | Machine B |
|---|---|---|
| Annual interest charges | Rs. 50,000x $\frac{15}{100}$ =Rs.7,500 | Rs.80,000x $\frac{15}{100}$ =Rs.12,000 |
| Annual operating charges | Rs. 10 x 2,000 = Rs. 20,000 | Rs. 8 x 2,000 = Rs. 16,000 |
| Total annual charges | 7,500 + 20,000 = Rs. 27,500/- | 12,000 + 16,000 = Rs. 28,000/- |
| Annual production (units) for 2000 hours | 5x2000 = 10,000 nos | 8 x 2000 16,000 nos |
| Cost per unit | $\frac{27500}{10,000} = Rs.2.75$ | $\frac{28000}{16,000} = Rs.1.75$ |

Machine ‘B’ gives the lower cost per unit if run for the whole year (for 2000 hours).

(ii) If only 4000 pieces are to be produced in an year;

| Data | Machine A | Machine B |
|---|---|---|
| Operating hours required for producing 4000 nos | $\frac{4000}{5} = 800 hrs$ | $\frac{4000}{8} = 500 hrs$ |
| Operating charges | Rs. 10x800 = Rs. 8.000/- | Rs.8 x 500 =Rs4,000 |
| Interest charges | Rs,7,500/- | Rs,12,000/- |
| Total annual charges | 8,000 +7500 =Rs.15,500 | 4000+12000 =Rs16,000 |
| Cost per unit | $\frac{Rs.15{,}500}{4000}$ = Rs.3.875/- | $\frac{Rs.16{,}000}{4000}$ = Rs. 4/- |

Machine ‘A’ gives lower cost per unit

(iii) If 12.5% of output of Machine B is rejected, net annual production would be 14000 (16000X (100-12.5)/100). Then, unit cost of production on Machine B increases from Rs. l.75 to 2.00 still machine B continues to be cheaper, if used for 2000 hours in the year.

2. Methods P and Q are both capable of manufacturing a product. The cost details are as follows

| Data | Method P | Method |
|---|---|---|
| Fixture - cost - life | Rs.24,000/- 6 months | Rs. 16,000/- 4 month/- |
| Tooling - cost - life | Rs. 2,560/- 300 pieces | Rs. 4,800/- 500 pieces |
| Processing time per piece | 6 Minutes | 4 Minutes |

The annual requirement is 1500 nos. Operating cost per hour of the process is Rs.128 for both processes. Material cost is same in each case. Which method would you choose for production during a period of one year?

| **Data** | **Method P** | **Method Q** |
|---|---|---|
| Cost of manufacture per year<br>Fixture cost | Rs. 24,000 x 2<br>=Rs. 48.000/- | Rs. 16,000 x 3<br>= Rs. 48,000/- |

(2 No.s of fixtures are required per year in method P and 3 nos required in method Q)

| | | |
|---|---|---|
| Tooling cost | $2{,}560x\frac{1500}{300}$ | $4{,}800x\frac{1500}{500}$ |
| | =2560 x 5<br>=12,800 | =4800 x 3<br>= Rs. 14,400 |
| Operating hours to produce 1500 nos. | 1500 x 6/60<br>150 hours | 1500x4/60<br>100 Hours |
| Operating cost per year | Rs. 128x150<br>= Rs. 19,200/- | Rs. 128 x 100<br>= Rs. 12,800/- |
| Total manufacturing cost per year | Rs. 48,000 +<br>Rs. 12,800<br>Rs. 19,200 | Rs. 48,000 .<br>Rs. 14,400 .<br>Rs. 12,800 |
| | Rs. 80,000 | Rs. 75,200 |

The Total Cost is Rs 80.000 in Method P and 75.200 in Method Q

Since method Q is cheaper than method P, method 'Q' is the choice for production during the whole one year period.

## 5.6 NOTES

## 5.7 SUMMARY

In this unit we have discussed about product and process design. We have studied about different types of layouts. We have also solved few problems.

## 5.8 KEY WORDS

Product Design

Process Design

Product Focussed lay out

Process Focussed layout

## 5.9 SELF ASSESSMENT QUESTIONS

1. Discuss the various factors to be considered for product and process design

2. Explain the various types of layout

3. Calculate the break-even point for following:

Production Manager of a unit wants to know from what quantity he can use automatic machine as against semi-automatic machine.

| Data | Automatic | Semi-automatic |
|---|---|---|
| Time for the job | 2mts | 5 mts |
| Set up time | 2hrs | 1,5 hrs |
| Cost per hour | Rs.20 | Ra.12 |

4. Two alternative set-ups, A and B are available for the manufacture of a component on a particular machine, where the operating cost per hour is Rs. 20/-.

| | Set up A | Set up B |
|---|---|---|
| Component/set -up | 400 pieces | 3000 pieces |
| set –up cost | Rs.300/- | Rs.1500/- |
| Production rate /hour | 10 pieces | 15 pieces |

Which of these 4set-ups should be used for long range and economic production?

5. Three production processes B and C have the following cost structure:

| Process | Fixed cost /year | Variable cost/ unit |
|---|---|---|
| A | Rs. 1,25,000 | Rs. 2.50 |
| B | Rs. 85,000 | Rs. 4.00 |
| C | Rs. 75,000 | Rs. 5.00 |

(a) What is the most economic process for a volume of 12,000 units per year.

(b) How many units per year must be sold with each Process to have annual profits of Rs. 50,000, if the selling price is Rs.67- per unit.

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# UNIT - 6 : PLANT LOCATION AND LAYOUT

**Structure:**

## 6.0 OBJECTIVES

**After studying this unit, you should be able to;**

- Define plant location
- Explain factors affecting plant location
- Distinguish between different types of layouts

## 6.1 INTRODUCTION

Plant layout is the physical arrangement of industrial facilities. Plant layout is the method of allotting machine and equipment suitable for various productions and other necessary service involved in transformation process of a product with available space so as to perform various operations in most efficient and convenient manner providing output of high quality with minimum cost.

The plant is a space/place where men, material, money, equipment, information, capital technology (input resources) are brought together for manufacturing of product.

## 6.2 PLANT LOCATION

The problem of plant location starts when starting a new concern or during expansion of existing plant, Plant location means deciding suitable location area, place, etc where plant or factors will starts functioning.

## 6.3 FACTOR INFLUENCING PLANT LOCATION

Hardly any location is ideal or perfect. One has to strike a balance between various factors affecting plant location as discussed below.

1. **Nearness to raw material**: It will reduce the cost of transporting raw material from vendor place to plant especially those plants which consumes the raw materials in bulk. It is advisable to locate the plant close to raw materials source. The time consumed for transporting raw materials from large distance to plant will result delay in production hence with the view of above plant must be nearness to raw material source.

2. **Transport facilities**: Lot of money is spent in transporting both raw materials and finished goods. Depending on the size of raw material, a suitable method of transportation like road, rail, water or air is selected and accordingly plant location is decided cost of transportation should remain fairly small in proportion to total cost.

3. **Nearness to market:** Nearness to market reduces cost of transportation also reduces time required for transportation and reduces chances of getting damages for goods. Moreover plant near to market can catch more market share and can render quick service to customers.

4. **Availability of Labour:** Stable labour force of right kind of adequate size (no) and at reasonable rates with its proper attitude towards work are few factors which governs plant location to a major extent. The purpose of management is to face less boycotts, strike or lockouts to achieve lower labour cost/unit of production.

5. **Availability of Fuel and power :** Because of wide spread usage of electrical powers most cases, fuel like coal, oil etc has not remained a deciding factor for plant location still some industries like steel, petro refineries are located to near source of fuel (coal, oil) to cut downs transportation cost.

6. **Availability of Water;** Water is used for processing as in paper and chemical industries and is also required for drinking and sanitary purpose. Depending on nature of plant, water should be available is adequate quantity and will adequate quality.

7. **Climate conditions:** With development in field of heating, ventilation and air conditions, climate of region does not much problem of course, control of climatic condition needs money.

8. **Financial and other Aids;** Certain states governments give grants, aids, loans, feed money, on built-up shads to attract industries.

9. **Land:** Topography area, shape of site, cost, drainage and other facilities, the probability of floods earthquake (from past history) etc influences selections of plan location.

10. **Community attitude:** Success of an industry depends very much on the attitude of local people

11. **Presence of related industries.**

12. **Houses security facilities**

13. **Expansion opportunities**

14. **Local Bye-laws, Taxes, etc**

15. **Existence of hospitals, marketing centers and schools, banks.**

## 6.4 PLANT LAYOUT

Plant layout ensures steady, smooth and economical flow of martial for various production processes. A good plant layout results in comfort, safety, convenience efficiency, compactness and profit.

Development of a good layout depends on several factors like capacity, facility, manufacturing methods to material handling.

**Objectives of good plant layout**

♦ Material handling and transportation is minimized

- Minimize investment in equipment
- Minimize overall production
- Utilization of existing space more effectively
- Ensuring comfortness, convenience safety
- Compactness and steady flow of material with profit
- Flexibility of arrangement and operation
- Achieving higher productivity
- Working stations are suitably designed d
- Waiting time of semi-finished

**Principles of plant layout:**

A few sound principles of plant layout are as follows:

1. Integration: It means that the integration of production centers facilities like men, m/c raw materials etc in more logical and balanced manner.
2. Minimum movements and material handling: The number of movements of working and materials in optimum bulk rather than small.
3. Smooth and continuous flow: Bottle necking, congestion, back track should be removed.
4. Cubic space utilization: Besides using floor space of a room if ceiling height, space is used, more materials can be accommodated.
5. Space and improved environment: Workplace safety and good ventilation, lighting, dustless, noise less and odourless and hazard free operations will increases efficiency of manufacturing operations.
6. Flexibility: In automotive industries where models of production changes frequently, it is better to permit all possible flexibility in layout. The machinery arrangement should be in such a way that the changes in production process are accommodated at least cost.

## 6.5 TYPES OF LAYOUT

The layout of manufacturing system can be classified into 3 main categories

1. Line or product layout
2. Functional or process layout
3. Fixed position layout

4. Combined or group layout

**Line or product layout**: It implies that various operations on raw materials are performed in a sequence and the machines are arranged (placed) along product flow line i, e. machines are arranged in sequence in which raw materials will be operated upon. This type of layout is preferred for continuous production i, e. involves continues flow of in-process material towards finished stage. Their type of layout is used when m/c s and auxiliary services are locked according to the processing sequence of the product. The product layout is selected when volume of production is high such that separate production line to manufacture can be justified so as to achieve satisfactory (max) utilization of equipment.

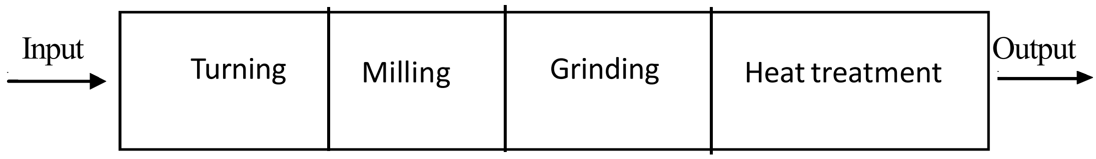


**Figure 6.1 Product Layout**

Example:

Input- Round rod

Turning – Turns out to exact dimensions

Milling-Cutting flutes on primitive of round surface

Grinding- Grained cutting edges to required cutting and lip angles

Heat treatment- To get required hardness of tool

Out Put- Drill bit

**Advantages of product layout:**

- Flow of material is in logical flow lines
- Less space requirement
- Automatic/lesser material handling
- Product completes in less time
- Operator need not be skilled
- Simple PPC system

**Limitations**

1. A breakdown of one m/c may lead to stoppage of machines in downstream line.
2. A change in product design requires major alternative layout.

3. Comparatively higher investment.
4. More specialized
5. In any case machine utilization is below level.

**Process/ Functional Layout:**

Process/ functional layout is characterized by keeping similar machines (m/c) or similar operations / services at one location (place) together. Here m/cs are arranged according to their functions. Process layout is normally used when production volume is less and not sufficient to justify to have a product layout. This type of layout is generally employed in industries engaged in job-order production and non repetitive kind of manufacturing activities.

| | | |
|---|---|---|
| Lathe | Milling | Grinding |
| | Heat treatment | Drilling |

**Fig 6.2 Process Layout**

**Advantages:**

1. Machines are better utilized
2. Less number of machines are required.
3. A high degree of flexibility in terms of allotment of work
4. Low investment.
5. The diversity of task offers more interesting and gives job affection to operator.

**Limitations:**

1. More material handling, cost is high.
2. More complex PPC system.
3. Production time is more
4. More material movement
5. In process inventory is high
6. Skilled operators are required.
7. Space and capital are tied up by work-in-process
8. More jobs will be in queue for production/ inspection.

**Combined / grouped layout:**

| | |
|---|---|
| Milling | Shaping |
| Drilling | Slotting |
| Grinding | Planning |

| | |
|---|---|
| Forging | Fitting |
| Welding | Turning |

**Fig 6.3 Group layout with two cells**

**Advantages:**

1. It increases standardization and reliability
2. Effective machine operation
3. Higher productivity, accruing, customer service.
4. Reduces planning work, setting time, down time, WIP, FG stock, Overall cost, movement of work.

**Limitations:**

This type of layout may not be feasible for all situations.

**Fixed Position layout:**

In this type of layout men, m/c, equipment, raw materials are moved to a place where all the manufacturing activities are carried out. Ship building, air craft manufacturing, big pressure, vessel manufacturing employs their kind of layout (other ex: Railways, Bridges, and Dams etc).

**Advantages:**

1. It involves easy movement of Material
2. Layout is simple and capable of frequent adjustment with respect to process and product.
3. It is possible to assign one or more skilled workers to a project from start to finish in order ensuring continuity of work.
4. A number of quite different projects can be taken with same layout.

**Limitations:**

1. Layout is suitable for only special cases
2. Higher equipment handling cost.

**Factor to be considered in layout planning:**

a) **Hazards**: Risks arising due to moving parts, projecting m/c element, suspended weight, and air pollution at production centre: other physiological and chemical risk and type of precautionary measurements needs to be taken to ensure the safety of personnel.

b) **Type of production:** Job batch, continuous process, assembly lines and involvement type of flow like single or multi flow line

c) **Types of a process:** Wet or dry, using heavy or height machines involving scrap, reprocessing etc.

**Characteristics of production and service centres**

a. **Sequence of operations: :** Dependence of one operation on anther, rigidity of sequence, reprocessing and its effect on flow being unidirectional or retraction.

b. **Integration of production**: single flow or multi-flow, relation of part of flow system one to other, co-ordination of sub assembly lines that feeds to major assembly lines.

c. **Types of product**: Its lot volume, physical and chemical characteristic, its design safety precaution, susceptibility to transportation, and difficulty connected to storage.

d. **Types of supervisions**: Centralized or decentralized, its affect on amount of work on process and m/c adjustment.

e. **Management policy**: plans for future operations, and expansion, changes in product design and diversity.

## 6.6 STEPS IN PLANNING A PLANT LAYOUT

The final product plant layout can be no better than data upon which it is based; hence assurance is required regarding collections of supporting data of plant layout

The following steps briefs planning of plant layout

1. Collection of the basic data
2. Analysis and co-ordination of the basic data
3. Determine the equipment required
4. Select general material handling plan
5. Preparation of layout planning charts

6. Plan the general flow pattern
7. Plan the individual work stations
8. Select specific material handling equipment
9. Establishment min with space for each operations
10. Analysis the space for storage requirement
11. Provide space for personal facility plan facility and services
12. Make flow diagram for production centre
13. Allocate production centre flow diagram for production centre
14. Construct master layout and check it
15. Install layout
16. Provide space provision for future expansion

**Methods of plant factory layout**

During different development stages of a layout the following methods may be used

A) Process flow chart

They show how different component parts assemble. so sequence of operations is considered in designing layout.

B) Material movement pattern:

The flow pattern of material in process is traced and layout is built around it

C) Layout analogues

They cover 2 dimensional cutouts or templates and 3 dimensional models.

(a) Templates: They are used to develop plant layout, they are 2 dimensional or bulk templates made up of cardboard. They made to scales and are placed outline plan of building. Templates/ cut outs shows the plan of various facilities and buildings. They show the actual floor space utilization. The template can be placed or attached to board by a sticking tap and hatch the surface or graph paper and thus being known as graphic techniques. This template have feasibility in use and can be invoked on graph paper from place to place in order to evaluate various feasible positions for different machines it is better to take photograph of each arrangement before shifting. The template saves time and money otherwise for each arrangement drawing preparation is needed. A two dimension template gives machine outline whereas block template gives boundary of maximum projected area. They visually represents advantages and limitations of plant layout.

Advantages of 2 dimensional template

- Less costly
- They can be readily interpreted
- Duplicate copies can be made

**Limitation:**

- Non technical persons find it difficult to grasp clear picture
- Over head facilities can't be visualized.

**Three dimensional Models:**

They are scale model of facility and more near to the real situations as besides length and breadth they also show height of facility also. 3D Models are mainly used to develop floor plans and elevations. Model can be made for production m/c, workers and material handling equipments. Models are much more effective when compared to drawing/ Templates especially multi-storey plant layout is to be prepared.

**Advantages:**

- Layout is easier for laymen to understand
- layout can be easily explained to mgt
- Models can be easily shifted and quickly studied
- They convey more or less real situations.

**Limitations:**

- They require more storage area
- They are expensive
- It is Difficult to take them to shop floor for reference purpose.

**Travel Chart**

As the name implies travel chart is a chart or record of the amount of travel by material in process while going from one m/c to other or from one department to other. The amount of travel depends upon the frequency of movements between section/ Department. A travel chart helps in improving existing layout. Using this technique the movement between Departments will be noted and such departments will be kept side by side.

**Load path matrix method:** This method aims at reducing the transportation of in-process inventory from section to section. Like travel chart it also helps deciding position of departments in relations to other. The ultimate purpose is to modify existing layout or preliminary plant layout made by other techniques. The department having less flow of materials or goods are placed close to each others.

## 6.7 SOLVED PROBLEMS

**Illustration 1:**

After evaluating two potential sites A and B comparing costs and finding them approximately equal from cost point of view, a manufacturer decided to evaluate the intangible factor for these two locations by point rating. Comparative rating assigned to major intangible location factors to determine the relative importance for each factor and the points assigned to each location alternative for each of the factors are given in the below table. Find out which location is better?

**Points Assigned to Alternative Location**

| Factors Rated | Maximum Possible points | Points assigned to location | |
|---|---|---|---|
| | | Location A | Location B |
| Future availability of fuel | 300 | 200 | 205 |
| Transportation flexibility and growth | 200 | 150 | 150 |
| Adequacy of water supply | 100 | 100 | 100 |
| Labour availability | 250 | 220 | 200 |
| Pollution regulation | 30 | 20 | 20 |
| Site topography | 50 | 40 | 30 |
| Living conditions | 150 | 100 | 125 |
| Total | 1080 | 830 | 875 |

Sol: From the table, it is seen that location B has a slight advantage over location A.

**Illustration 2.**

Potential location A, B and C have the cost structure shown for producing a product expected to sell at Rs. 100 per unit. Find the expected volume for each of the location where A, B and C would be most economical.

| Location | Fixed cost year | Variable cost per unit |
|---|---|---|
| A | Rs. 25, 000 | Rs. 50 |
| B | Rs. 50, 000 | Rs.25 |
| C | Rs. 80,000 | Rs. 15 |

Solution

From the above table, it is evident that location A has low fixed cost and variable cost is high. It is suitable where production volume is less. Location B has moderate fixed and variable cost. It is suitable where quantity required is moderate. Location C has high fixed cost, but the variable cost is less. It suited where high quantity is required. Let us find out what quantity of production, a particular location is preferred.

Let $Q_{AB}$ be the quantity at which both location A and B have same total cost. $Q_{AB}$ at each of location A & B are equated i.e.,

$$25{,}000 + 50\ Q_{AB} = 50{,}000 + 25\ Q_{AB}$$

$$50Q_{AB} - 25Q_{AB} = 50{,}000\text{-}25{,}000$$

$$25\ Q_{AB} = 25000/25$$

$$=1000 \text{ units}$$

Hence if quantity is less than 1000, location A is preferred.

To determine the break - even volume between location B and C, the total cost for producing the break-even quantity say $Q_{BC}$ at each of location B and C are equated i.e.,

$$50{,}000 + 25\ Q_{BC} = 80{,}000 + 15\ Q_{BC}$$

$$25\ Q_{BC} - 15\ Q_{BC} = 80{,}000 - 50{,}000$$

$$10Q_{BC} = 30{,}000 \text{ or } Q_{BC} = 3000 \text{ units.}$$

Hence if the quantity is between 1000 to 3000 location B is preferred and if the quantity is above 3000 the location C is preferred.

**Illustration 3**

Score have been assigned with higher values indicative of preferred conditions. Using these scores, develop a qualitative factor comparison for the four location

| **Related Factor** | **Assigned Weight** | **Scores for location** | | | |
|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** |
| Product cost | 0.35 | 50 | 40 | 60 | 30 |
| Raw material Supply | 0.25 | 70 | 80 | 80 | 60 |
| Labour availability | 0.20 | 60 | 70 | 60 | 50 |
| Cost of living | 0.05 | 80 | 70 | 40 | 80 |
| Environment | 0.05 | 50 | 60 | 70 | 90 |
| Market | 0.10 | 70 | 90 | 80 | 50 |
| Total | 1.00 | | | | |

**Solution**

| Related Factor | Scores for location | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Product cost | 50 X0.35=17.5 | 14.0 | 21.0 | 10.5 |
| Raw material Supply | 17.5 | 20.0 | 20.0 | 15.0 |
| Labour availability | 12.0 | 14.0 | 12.0 | 10.0 |
| Cost of living | 4.0 | 3.5 | 2.0 | 4.0 |
| Environment | 2.5 | 3.0 | 3.5 | 4.5 |
| Market | 7.0 | 9.0 | 8.0 | 5.0 |
| Total | 60.5 | 63.5 | 66.5 | 49.0 |

Location C is preferred because of the highest weight score .

**Illustration 4**

A company is to decide on the location of a new plant. It has narrowed down the choice to 3 locations A, B and C; data in respect of which is furnished below.

| | Locations | | |
|---|---|---|---|
| | A | B | C |
| Wages & Salaries | Rs.20,000/- | Rs.20,000/- | Rs.20,000/- |
| Power and Water supply expenses | Rs.20,000/- | Rs.30,000/- | Rs.25,000/- |
| Raw materials and other supplies | Rs.80,000/- | Rs.75,000/- | Rs.60.000/- |
| Total initial investment | Rs.2 lakhs | Rs.3 lakhs | Rs.2.5 lakhs |
| Distribution expenses | Rs.50,000/- | Rs.40,000/- | Rs.60,000/- |
| Miscellaneous expenses | Rs.40,000/- | Rs.25,000/- | Rs.30,000/- |
| Expected Sales per year | Rs.2,25,000/- | Rs.2,50,000/- | Rs.2,25,000/- |

*Solution*

| | *Locations* | | |
|---|---|---|---|
| | A | B | C |
| Sales Revenue | Rs.2,25,000/- | Rs.2,50,000/- | Rs.2,25,000/- |
| Total expenses | Rs.2,10,000/- | Rs.1,90,000/- | Rs.1,95,000/- |
| Profit | Rs.15,000/- | Rs.60,000/- | Rs.30.000/- |
| Initial investment | Rs.2 lakhs | Rs.3 lakhs | Rs.2.5 lakhs |
| Return on investment (RoI) | $\frac{15,000}{2,00,000} X 100$ = 7.5% | $\frac{60,000}{3,00,000} X 100$ 20% | $\frac{60,000}{3,00,000} X 100$ 12% |

Based on RoI criteria, location 'B' is the best location.

**Illustration 5**

1. A company has to select one location out of the five alternatives considered for a new plant. The annual operating costs and other intangible factors are given below for these five locations.

| *Factors* | *Location* | | | | |
|---|---|---|---|---|---|
| | *A* | B | *C* | *D* | *E* |
| *(a) Economic factors* | | | | | |
| Labour costs | Rs.1,20,000 | Rs.1,10,000 | Rs.1,60,000 | Rs.85,000 | Rs.75,000 |
| Transportation costs | Rs.10,000 | Rs.8,000 | Rs.7,000 | Rs. 12,000 | Rs. 14,000 |
| Local taxes | Rs. 17,000 | Rs.20,000 | Rs.25,000 | Rs.19,000 | Rs.17,000 |
| Cost of Power | Rs.21,000 | Rs.29,000 | Rs.25,000 | Rs.18,000 | Rs.23,000 |
| Other costs | Rs.16,000 | Rs. 11,000 | Rs. 12,000 | Rs.16,000 | Rs.18,000 |
| *(b) Intangible factors* | | | | | |
| Community attitude | Very good | Fair | Good | Fair | Very good |
| Labour availability | Good | Very good | Fair | Outstanding | Acceptable |
| Quality of transportation | Fair | Acceptable | Outstanding | Acceptable | Fair |
| Quality of life | Acceptable | Fair | Good | Very good | Outstanding |

(i) On the basis of annual operating costs, which site would you choose?

(ii) Devise a method of quantifying the intangible costs and integrate them with the cost data into the overall evaluation. Which is best now?

*Solution*

(i) On the basis of annual operating costs :

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Total operating cost | Rs.1,84,000/- | Rs.1,78,000/- | Rs.2,29,000/- | Rs.1,50,000/- | Rs.1,47,000/- |
| Rank | 4 | 3 | 5 | 2 | 1 |

Since the total annual operating costs is least at location E, location E is the best choice based on economic considerations only.

(ii) On the basis of overall evaluation including intangible factors and economic factors: To quantify the intangible factors, the qualitative factors are converted into quantitative factors using a five point rating scale as below:

| *Grade* | *Point* |
|---|---|
| Outstanding | 5 |
| Very good | 4 |
| Good | 3 |
| Fair | 2 |
| Acceptable | 1 |

The intangible factor's ratings are as below:

| *Factor* | *Rating for locations* | | | | |
|---|---|---|---|---|---|
| | *A* | B | C | *D* | *E* |
| Community attitude | 4 | 2 | 3 | 2 | 4 |
| Labour Availability | 3 | 4 | 2 | 5 | 1 |
| Quality of transportation | 2 | 1 | 5 | 1 | 2 |
| Quality of life | 1 | 2 | 3 | 4 | 5 |
| **Total rating** | **10** | **9** | **13** | **12** | **12** |
| Rank | 3 | 4 | 1 | 2 | 2 |

To combine the economic factor (operating cost) rating with intangible factor rating, let us allot highest rating of say 10 for the location which has the lowest annual operating cost. (i.e., for location E)

Hence the economic factor ratings are proportionately reduced from 10 as the operating cost increases.

Therefore Economic rating of location $A = \dfrac{10X\ 1,47,000}{1,84,000} = 7.98$

"do" $B = \dfrac{10X\ 1,47,000}{1,78,000} = 8.25$

"do" $C = \dfrac{10X\ 1,47,000}{2,29,000} = 6.41$

"do" $D = \dfrac{10X\ 1,47,000}{1,50,000} = 9.80$

$$\text{Total factor rating} = \begin{pmatrix}\text{Economics}\\ \text{factor rating}\end{pmatrix} + \begin{pmatrix}\text{Intangible}\\ \text{factor rating}\end{pmatrix}$$

| | Locations | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Total factor rating = | 7.98 + 10.00 = 17.98 | 8.25 + 9.00 = 17.25 | 6.41 + 13.00 = 19.41 | 9.80 + 12.00 = 21.80 | 10.00 + 12.00 = 22.00 |

Since the total factor rating for location E is the highest, Location E is the best choice.

## 6.8 NOTES

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## 6.9 SUMMARY

In this unit we have discussed about plant location and layout. We have studied about different types of layouts. We have also solved few problems.

## 6.10 KEY WORDS

Plant location

Plant layout

Breakeven point

## 6.11 SELF ASSESSMENT QUESTIONS

**1.** Define plant layout. What are factors affecting plant layout

**2.** Define Plant location. Explain factors to be considered while deciding plant location.

**3.** Location A would result in fixed costs of Rs 8,00,000, variable costs of Rs 63 per unit and revenues of Rs 68 per unit. Annual fixed costs at location B are Rs 8,00,000 with variable costs of Rs 32 per emit and revenue of Rs 68 per unit. Sales volume is estimated to be 25,000 units/year. Which location is most attractive?

**4.** Xyz co. wants to establish new plant in order to expand its business. The company considered some critical factors and also awarded the rating to each factor. The potential location A, B and C is also identified. The company has weighed each location on the scale of 1 to 10, 1 being worst and 10 being best and presented in below table using suitable method. Suggest xyz co. the best locations.

| Factors | Rating | Loc A | Loc B | Loc C |
|---|---|---|---|---|
| Proxy to market | 4 | 6 | 7 | 8 |
| Proxy to market | 4 | 6 | 6 | 4 |
| Available to power | 3 | 3 | 4 | 6 |
| Available to workforce | 1 | 1 | 2 | 3 |
| Tax factor | 2 | 2 | 3 | 5 |
| Social factor | 5 | 6 | 7 | 8 |

5. XYZ co. wants expand its business and hence they want to establish new plant. The company has made a survey and identified 3 potential locations ALB and C the co. has rated for both factors and locations and summarized below you are required to suggest best plant location.

| Factors | Rating | Weightage | LocA | LocB | LocC |
|---|---|---|---|---|---|
| A | 20 | 0.068 | 60 | 70 | 80 |
| B | 60 | 0.20 | 60 | 60 | 40 |
| C | 40 | 0.137 | 30 | 40 | 60 |
| D | 80 | 0.275 | 10 | 20 | 30 |
| E | 60 | 0.2 | 20 | 30 | 50 |
| F | 30 | 0.1 | 60 | 70 | 80 |
| Total | 290 | | | | |

## 6.12 REFERENCES

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# UNIT-7 : FORECASTING AND PRODUCTION PLANNING AND CONTROL

**Structure:**

## 7.0 OBJECTIVES

**After studying this unit, you should be able to;**

- Explain the types and use of forecasting
- Describe objectives of production planning and control
- Define aggregate planning

## 7.1 INTRODUCTION

A forecast is an estimation of an event which will happen in future. The event may be demand of a product, rainfall at a particular place, population of a country, growth of technology etc. The forecast value is not a deterministic quantity. Since, it is only an estimate based on past data related to particular event, proper care must be given in estimating it.

Production in manufacturing comprises a series of steps by which material is given in a new form to satisfy a predetermined objective, the change being brought about by the utilization of machines, tools, and labour. In a broad sense, production includes the mental work of designing, planning, controlling, recording and accounting as well as the physical manipulation of material.

Production planning and control can be viewed as the nervous system of the production operation. This function aims at efficient utilization of material resources, people and facilities in any undertaking through planning, coordination and controlling the production activities that transform the raw material into finished products or components as a most optimal manner. All the activities in the manufacturing or production cycle must be planned, coordinated, organized and controlled to its objectives.

## 7.2 FORECASTING

In industrial organization, forecasting is the first level activity in order to estimate the demand of a particular product to take decisions on material planning, scheduling, and type of production system to be implemented etc,

Hence, forecasting provides a basic for co-ordination of plans for activities in various parts of company. All the functional managers in any organization will take their decisions based on forecast value. So, it is vital information for organization. Due to these reasons proper care should be taken while estimating forecast values.

The business forecasting may be classified as follows

1) Technology forecast
2) Economic forecast

3) Demand forecast

**Technology forecast:** Technology is a combination of hardware and software. Hardware is a physical product while the software is the know-how, technique or procedure. Technology forecast deals with certain characteristics such as level of technical performance, rate of technological advances.

Technological forecast is a prediction of the future characteristics of useful manufacturer, products process, procedure or techniques. Based on the importance of this activity, Government of India has established a "Technological Information Forecasting and assessment Council" (TIFAC) under the ministry of science and technology to provide action oriented studies.

**Economic forecast:** Government agencies and other organization involve in collecting data and prediction of estimate on general business Environment. These will be useful to government agencies in predicting future tax revenues, level of inflation etc this will be useful for business circles to plan their future activities based on the level of business growth.

**Demand forecast:** The demand forecast gives expected level demand of goods/services. This is the basic input for business planning and control. Hence, the decision for all the functions of any corporate house are influenced by demand forecast.

Forecasting is required in business decisions in the following areas

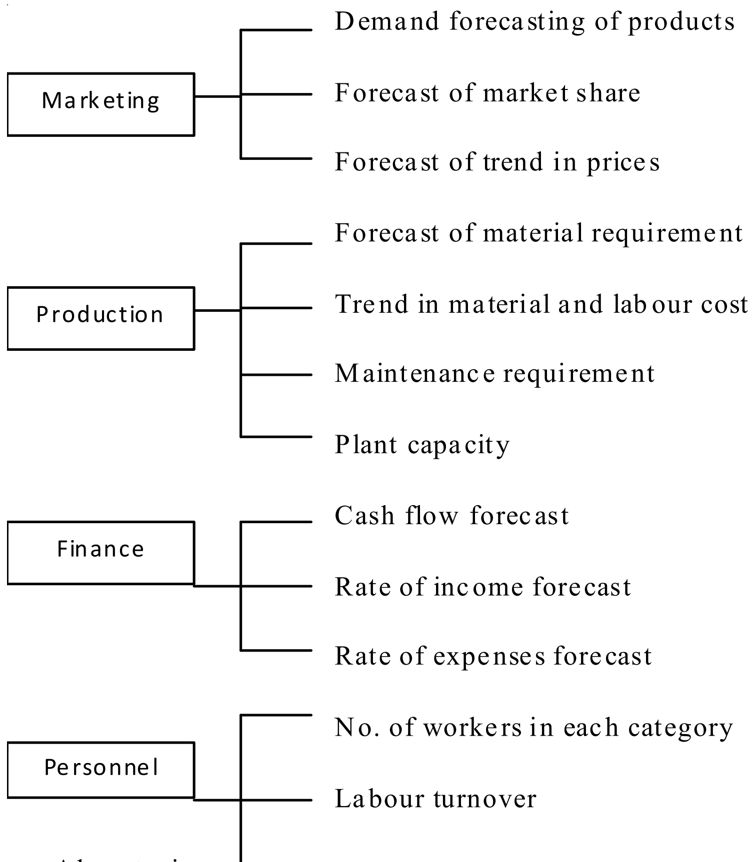



**Fig 7.1 Areas of Forecasting**

**Sources of Data:** The data for forecasting is very much vital. We must make sure that relevant data is collected before designing a particular model of forecast. The data may be obtained from company records, published records, journals, surveys, government publications, news papers etc,

Since forecasting is done on past data, we must be sure of past time period during which the data can be collected. If we consider the time period as large, the reliability of forecasting would be more. Hence suitable time period may be selected for collecting relevant data.

- Business cycle
- Random variation
- Customer's plan
- PLC
- Competitions efforts and prices
- Customer's confidence and attitude
- Quality
- Credit policy
- Design of goods and services
- Sales effort
- Advertising

**Purpose of forecasting:**

a) By knowing future demand of products, the management can take following decisions

- To expand the new unit
- To open the new unit
- To closedown existing or some requirements

b) To plan long-term financial requirements

c) To train personals so, that man power requirement can be meet in future

**Objectives of forecasting**

1) Long term objectives: To decide about,

a) Capacity of production b) Labour requirement c) Financial plan

2) Short term objectives:

i)Formulation of production policy

- Regular supply of materials
- Maximum utilization of manufacturing cost
- Availability of labour

i) Price policy formulation

ii) Proper sales control

iii) Arrangement of finance

## 7.3 METHODS OF FORECASTING

a) **Direct Survey Method:** In this method, the prospective consumers are approached and are asked why they intended to buy. Generally, sampling technique method are used for survey purpose, as it is impossible to approach all individual consumers. From a representative sample of customers, it is possible to predict with some degree of certainty, how population will respond.

b) **Indirect survey method:** In this method, attitude and behaviour of consumer is predicted through salesmen and dealers.

c) **Comparing with established product:** some times, the product under considerations is comparable to an existing product, so sales figures can be compared. If the new product is substitute for the competitors products, its acceptance will depend on advertisement programme and consumers loyalty to present product.

d) **Limited market trail:** To predict the acceptance of the product by potential consumers sometimes limited selling techniques is also adopted

**Forecasting for established product**

1) **Production method:** Based on historical data, future can be predicted to some extent. A line drawn based on information is projected to the forecast what would be the sales volume will be for future period. Projection method may use time series analysis, regression analysis etc,

2) **Related information method:** In this method a predictor which varies directly with sales volume is found. Ex: a birth rate may be used to predict baby foods

3) **Market research method:** Through critical analysis of marketing forces, changing pattern of socio economic pressures, political changes, we can predict future demands of product.

4) **Executive opinion method:** In this method, opinions of experts are invited about past sales. It does not involve huge volume of statistical data or complicated calculations. It

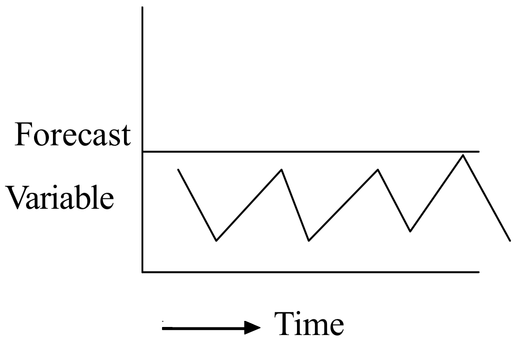
is simple and fast. However it suffers from two drawbacks one is it is not scientific decision and possibility of inaccuracy.

**5)** **Sales force composite method:** News of salesmen, traders, middlemen, are grouped and estimates are made accordingly. It reflects market trend. However it is not scientific. It may suffer from prejudge or bias opinion.

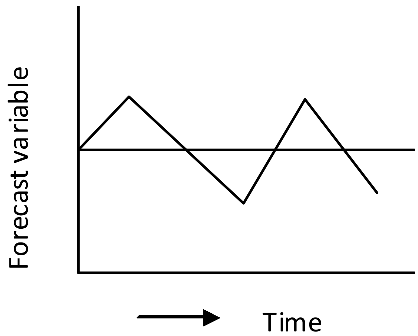
**Demand patterns:**

Forecasting is based on patterns of events in past. A pattern may solely exist as a function of time and such a pattern can be identified directly from historical data. Another pattern may consist of relationship between two or more variables. So it is important to understand the most common demand patterns.

**1)** **Historical or stationery pattern:** This exists when there is no trend in data and when the mean value does not change over time. Products with stable sales, number of defective items from production process are some of examples.

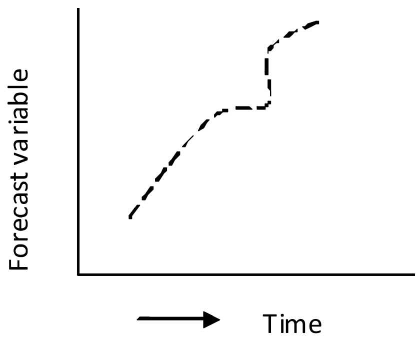



**2)** **Seasonal Demand pattern:** This demand pattern exists when series functions are according to source seasonal factor. The season may be months, quarters, weeks etc, Eg: Sales of refrigerators, sales of soft drink, sales of wool items etc,



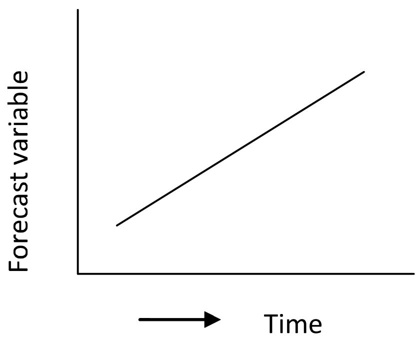

**3)** **Cyclical pattern:** In this type of pattern the length of single cycle is larger than a year. The cycle does not repeat at constant intervals of time. Ex: pries of some metals

Forecast variable




**4) Trend pattern:** This type of pattern exists when there an increase or decrease in the value of variables over a time. The examples are sales of many products, stock prices.

Forecast variable




**Time Series Analysis**

A time series is a set of observations made at different times. It gives measurement of phenomenon over a period of time. In modern business, the importance of time series analysis is very great. The analysis of time series examines these movements and changes describes and measures the fluctuations which shows the main characteristics of time series.

The purpose of time series analysis, therefore is to describe the part movement and fluctuations to analyze their causes and inter relationships to examine the casual factors operating in present and to explain what significance in present combination of casual factors has in relations with future

There are two types of movement operating in time series.

a) Long term/secular trend

b) Short term

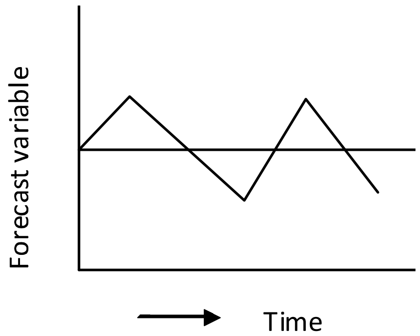
- Seasonal variations
- Cyclical variations
- Erratic variations

**The long term /secular trend:** Most series shows a definite trend. There exists a gradual increase or decline in the data, but there may be sudden changes here and there. The series exhibits a definite direction or these directions changes at constant rate. In such series there are long time raising and falling tendencies.

Ex: The population of India showing increasing trend. But production of cottage industries show declining trend.

**Seasonal variations:** These variations occur generally within 12 month period due to change in seasons. The growth and decline movements in a series within a year brought about by changing seasons are called seasonal variations. The short term fluctuations are regular up and down movements. The production and consumption of commodities vary due to change in seasons. The seasonal demand pattern exists when series fluctuations are according to seasonal factors.

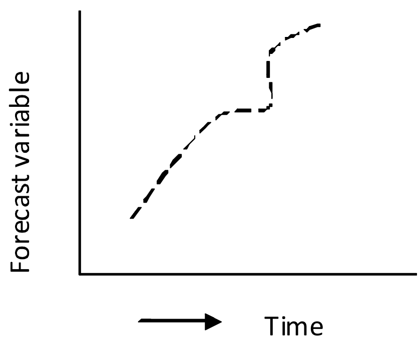
Ex: Sales of refrigerator, wool items, soft drinks etc,




**Cyclical fluctuation:** Cyclical movement consists of boom, recession, depression, recovery and then again boom i.e. cycle from property to depression and vice versa.

The cyclical demand pattern is as shown in figure. In this pattern the length of cycle is longer than a year. The cycle does not repeat at constant intervals of time.

Ex: Prices of some metals




**Irregular fluctuation**: These movements are accidental or residual and are due to wars, flood, drought, strikes and other calamities. Analysis of time series involves measurement and study of long and short time variations. The purpose is to discover any irregularities which characterize the movement of data through time

**Forecasting models /classification/methods of forecasting:**

The forecasting techniques can be classified into qualitative and quantitative techniques.

Qualitative technique uses subjective approaches and is very useful in cases of new products or where no data is available.

Quantitative techniques are based on historical data. These are more accurate and scientific.

Characteristics of methods of forecasting:

A. Qualitative forecasting techniques:

- Delphi method
- Market surveys and market research
- Nominal group testing
- Historical analysis
- Life cycle analysis
- Informal judgment

B. Quantitative forecasting method

I. Time series analysis

- Simple moving average
- Single exponential smoothing
- Double moving average
- Semi average method
- Trend projection
- Fourier series
- Box jenkin's methods

II. Casual methods

- Regression analysis
- Leading indicator
- Input-output models
- Simulation models

Selection of forecasting technique: Selection of forecasting depends on 3 factors

a) Decision making situation

b) Forecasting methods

c) Present situation

a) Decision making situation

- Time horizon
- Level of detail
- Number of items
- Control v/s planning

b) Forecasting methods

- Time horizon
- Pattern of data
- Type of model
- Cost of accuracy
- Ease of application

c) Present situation

- An item being forecast.
- Amount of historical Data available
- Time allowed for preparing forecast

## 7.4 PRODUCTION PLANNING AND CONTROL (PPC)

Production planning and control comprises the planning, routing, scheduling, dispatching and follow up function in the productive process, so organized that the movements of material, performance of machines and operations of labour, however sub-divided, are directed and coordinated as to quantity, quality, time and place. It is adopting a business principle the old adage of 'plan your work and work your plan'. The many systems which have been devised are merely tools or helps in accomplishing this purpose. The system which is finally adopted should be as simple and economical as possible and yet be effective in producing the product for delivery when promised, of the proper quality, and at the proper cost.

**According to Alford and Beatty,** "Production planning and control comprise the planning, routing scheduling, dispatching and follow up function in the productive process, as organized that the movements of material, performance of machines and operations of labour, however subdivided, are direct and coordinated as to quantity, quality time and place. It is adopting as business principle the old saying plan your work and work your plan".

**According to Charles A. Koepke,** " Production planning and control may be defined as the coordination of a series of functions according to a plan which will, economically utilize the plant facilities and regulate the orderly movement of goods through their entire manufacturing cycle, from the procurement of all materials to the shipping of finished goods at a predetermined rate".

**Scope of Production Planning and Control**

1) **Materials:** Planning for procurement of raw materials, components and spare parts in the right quantities and specifications at the right time from the right source at the right price. Purchasing, storage, inventory control, standardization, variety reduction, value analysis and inspection are the other activities associated with materials.

2) **Methods:** Choosing the best method of processing from several alternatives, it also includes determining the best sequence of operations (process plans) and planning for tooling, jigs and fixtures etc.

3) **Machines and Equipments:** Manufacturing methods are related to production facilities available in the production system. It involves facilities planning, capacity planning, allocation and utilization of plant and equipments, machines etc.

4) **Manpower:** Planning for manpower (labour, supervisory and managerial levels) having appropriate skills and expertise.

5) **Routing:** Determining the flow of work, material handling in the plant and sequence of operations or processing steps. This is related to considerations of appropriate shop layout and plant layout, temporary storage locations for raw materials, components and semi-finished goods and of materials handling systems.

6) **Estimating:** Establishing operation times leading to fixation of performance standards both for workers and machines.

7) **Loading and Scheduling:** Machine loading is allocation of jobs to machines in conjunction with routing and with due consideration for capacity of machines and priority for jobs in order to utilize the machines to the maximum possible extent. Scheduling ensures that parts, sub-assemblies and finished products are completed as per the required delivery dates. It provides a timetable of manufacturing activities. It ensures a balanced load on all work centers and ensures even flow of work through the manufacturing facilities.

8) **Dispatching:** This is concerned either the execution of the planning functions. It gives necessary authority to start a particular work, which has already been planned under routing and scheduling functions. Dispatching is the release of orders and instructions for the starting of production in accordance with the route-sheets and schedule charts.

9) **Expediting:** Means chasing, follow up or processing, which is done after the dispatching function. It keeps a close liaison with scheduling in order to provide an efficient feedback and prompt review of targets and schedules.

10) **Inspection:** This function is related to maintenance of quality in production and of evaluating the efficiency of process, methods and labour so that improvements can be made to achieve the quality standards set by product design.

11) **Evaluating:** The objective of evaluation is to improve performance. Performance of machines, process and labour is evaluated to improve the same.

12) **Cost Control:** Manufacturing cost is controlled by wastage reduction, value analysis inventory control and efficient utilization of all resources.

**Objectives of Production Planning and Control**

The following are the main objectives of the Production planning and control:

1) **Nature of the Inputs:** To manufacture a product, different types of inputs are used. The quality of the product depends upon the nature of the inputs used. Hence the planning is done to determine the nature of various types of inputs which is a complicated process.

2) **Quantity of Inputs:** To achieve a level of production, determination of quantity of the inputs and their composition is very important. A product can be prepared only when there is an estimate of the required composition of inputs is not proper, the desired product will not be ready.

3) **Proper coordination:** It ensures the proper coordination among the workforce, machines and equipments. This leads to avoidance of wastages and smooth flow of production.

4) **Better Control:** Production planning is the method of control. For a better control, planning is precondition. Only then, one can compare the performance and calculate the deviations which lead control of the production.

5) **Ensures Uninterrupted Production:** The planning of materials ensures the regular supply of raw materials and other components. The regular flow of materials and supplies are helpful in the uninterrupted production.

6) **Capacity Utilization:** There is a need to use the available resources effectively. It helpful in bringing down various costs of Production.

7) **Timely delivery:** If there is good production planning and control, there will be timely production and the finished product will be rushed to the market in time. This also ensures the better relationship with the customers.

## 7.5 BASIC FUNCTIONS OF PRODUCTION PLANNING AND CONTROL

Figure 7.2 shows the various functions or elements of production planning and control.

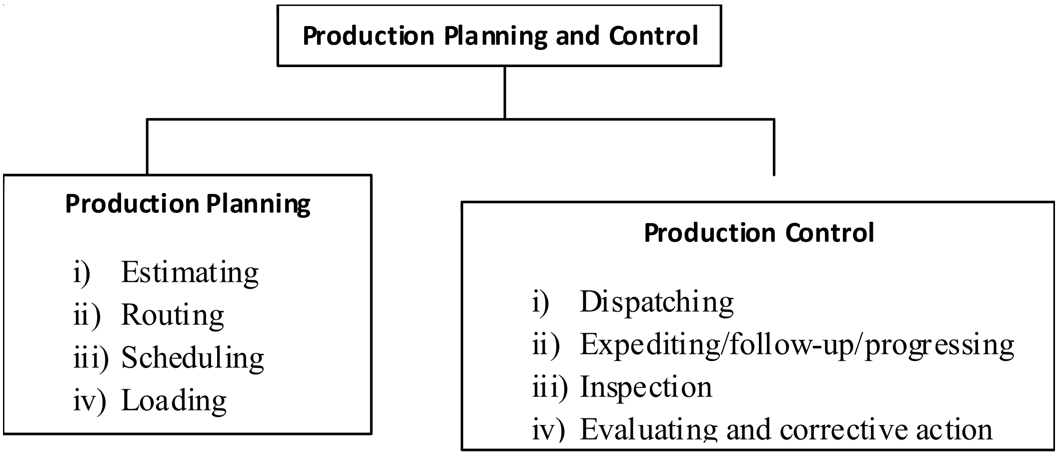



**Figure 7.2: Functions of Production Planning and Control**

**Production Planning Functions**

The main functions of production planning are:

1) **Estimating:** Involves deciding the quantity of products to be produced and cost involved in it on the basis of sales forecast.

   Estimating manpower, machine capacity and materials required (bill of material is the basis) to meet the planned production targets are the key activities before budgeting for resources (eg- production budget is the basis for materials budget, capital equipment budget and manpower budget).

2) **Routing:** This is the process of determining the sequence operations to be performed in the production process. Routing determines what work must be done, where and how?

Routing information is provided by product or process engineering function and it is useful to prepare machine loading charts schedules.

3) **Scheduling:** Involves fixing priorities for each job and determining the starting time and finishing time for each operation, the starting dates and finishing dates for each part, sub-assembly and final assembly. Scheduling lays down a time-table for production, indicating the total time required for the manufacture of a product and also the time required for carrying out the operation for each part on each machine on equipment.

4) **Loading:** Facility loading means loading of facility or work centre and deciding which jobs to be assigned to which work centre or machine. Loading is the process of converting operation schedules into practice. Machine loading is the process of

assigning specific jobs to machines, men or work centers based on relative priorities and capacity utilization. A machine –loading chart (Gantt chart) is prepared showing the planned utilization of men and machine by allocating the jobs to machines or workers as per priority sequencing established at the time of scheduling. Loading ensures maximum possible utilization of productive facilities and avoids bottlenecks in production.

It is important to avoid either over loading or under loading the facilities, work centers or machines to ensure maximum utilization of resources.

**Production Control Functions**

**1) Dispatching:** Dispatching may be defined as setting production activities in motion through the release of orders (Work order, shop order) and instruction in accordance with the previously planned time schedules and routings.

**2) Expediting/Follow-up/Progressing**: Expediting or progressing ensures that, the work is carried out as per the plan and delivery schedules are met.

**3) Inspection:** Inspection is the process of examining an object for identification or checking it for verification of quality and quantity in any of its characteristics. It is an important tool for ascertaining and controlling the quality of a product.

Inspection is an appraisal activity that compares good or services to a standard. Inspection can occur at three points:

i) Before production,

ii) During Production, and

iii) After production

**Production Control**

Production Control is defined as the design and use of systematic procedure for establishing plans and controlling all the elements of activity. Production Control includes

- A Complete Plan
- A follow up procedure for determining how closely the plan is followed

**Objectives of Production Control**

- Provision of Raw material, machinery, manpower.
- To organize production schedule in conformance with demand forecast.
- The max utilization of resources
- Achieving higher productivity

- Minimizing production cost and delivery time
- Determination of economic production run and reducing set up cost.
- Proper co-ordination of operation of various departments
- Ensure the quality of product/process using QC technique
- Production Control helps in product design and development

**System Record Progress/Work accomplishment**

Progress charts work normally employed for this purpose they compare work progress against a prescribed target, and when the point accomplishment is not as per predetermined level corrective actions can be taken and such paints needs attention and investigation.

The chart construction may be of following forms:

1. Bar chart

2. Curve chart

3. Gantt chart

1. Bar chart: Consists of a number of bars. Each bar has its length proportional to activity duration. A bar chart is generally used to point out and analyze interrelated data which otherwise difficult to read.

2. Curve Chart: It is a graph between two variables, material along x and days on y axis. As the day pass, the no. of items produced are marked over the graph. When all such points are joined they indicate the production trend.

Both bar and curve chart indicates past data. They are not readily available to current situation

**Gantt chart:**

Gantt chart was developed by Henry.L Gantt. It is frequently used keep track of multiple machinery schedule or project activities schedules. Gantt chart was actually modified bar char, wherein load is marked against time scale with one horizontal bar or line allotted to each machine.

**A Gantt chart displays following:**

a. Plans for future

b. Progress on present operations

c. Past achievement till date

d. Relationship among several variable

e. It focuses the attention on cases or situation where likely to delay the operation.

**Follow-up or expediting:**

The manufacturing activities of a factory is said to be in control when the actual performance is as per planned performance. Follow-up or expediting regulates the progress of materials and components through production process. Follow-up serves as a catalytic agent to use the various separate and unrelated production activities into unified whole that means the progress.

**Advantages of Production Planning and Control**

**1. Higher Productivity:** The Productivity can be improved by taking care of production methods and time.

**2. Removal of Hurdles:** Any possible hurdles coming in the way of smooth and continuous production can be eliminated well in time through production planning and control.

**3. Better Quality:** The efficient method of production planning and control helps in the improvement of quality of products.

**4. Consumer Satisfaction:** Better quality of products improves consumer satisfactions. This further enhances the goodwill of the organization.

**5. Saving in Cost:** The production planning and control use scientific methods to determine the quantity of batch to be produced and minimize the losses and wastages in production process. This results in saving the cost of production.

**6. Increase in Production:** Production planning and control ensures minimized production times, smooth and continuous production process which result ultimately in increase in production.

**7. Optimum Utilization of Capabilities:** Production planning and control involves systematic function of men and machines. Strict production standards are followed which make it possible to utilize the capabilities well.

**8. Minimum Overtime:** The work is done according to the schedule thus reducing the possibility of overtime.

**9. Better Industrial Relations:** Employee-Employer relations improve with the efficient use of production planning and control. It helps in buildings the morale of employees.

**10. Better Profitability:** With all the above advantages, the profitability of a concern will surely increase.

**Disadvantages of Production Planning and Control**

1. **Assumptions:** Production planning and control function is based on certain assumption or forecasts of customers' demand, plant capacity, availability of materials, power, etc. If these assumptions go wrong, PPC becomes ineffective.

2. **Rigidity in Employees Behaviour:** Employees may resist changes in production levels set as per production plans if such plans are rigid.

3. **Time Consuming Process:** The production planning process is time consuming when it is necessary to carry-out routing and scheduling functions for large and complex products consisting of a large number of parts going into the product.

4. **External Environmental Factors:** Productions planning and control function become extremely difficult when the environmental factors change very rapidly such as technology, customers' taste regarding fashion or style of products needed, government policy and controls, change frequently, stoppages of power supply by electricity boards due to power cuts, break in supply chain due to natural calamities such as foods, earthquakes, war, etc.

5. **Costly Process:** The implementation of production planning and control is costly.

## 7.6 AGGREGATE PLANNING

Aggregate planning is the process of development, analyzing, and maintaining a preliminary, approximate schedule of the overall operations of an organization. The aggregate plan generally contains targeted sales forecasts, production levels, inventory levels, and customer backlogs. This longer-term perspective on resource use can help minimize short-term requirements changes with a resulting cost saving.

In simple terms, aggregate planning is an attempt to balance capacity and demand in such a way that costs are minimized. The term "aggregate" is used because planning at this level includes all resources "in the aggregate"; e.g., as a product line or family. Aggregate resources could be total number of workers, hours of machine time, or tonnes of raw materials. Aggregate units of output could include gallons, feet, pounds of output, as well as aggregate units appearing in service industries such as hours of service delivered, number of patients seen, etc.

Aggregate planning does not distinguish among sizes, colours, features, and so forth. **For Example**, with automobile manufacturing, aggregate planning would consider the total number of cars planned for not the individual models, colours or options. When units in aggregation are difficult to determine (**e.g.,** when the variation in output is extreme) equivalent units could be based on value, cost, worker hours or some similar measure.

Aggregate planning is considered to be intermediate-term (as opposed to long or short-term) in nature. Hence, most aggregate cover a period of three to eighteen months. Aggregate plans serve as foundation for future short-range type planning, such as production scheduling, sequencing and loading. The master production Schedule (MPS) used in material Requirements planning (MRP) has been described as the aggregate plan "disaggregated".

**Need Aggregate Planning**

There are several inevitable reasons for every organization, whether engaged in product manufacturing or service delivery, to plan aggregate production. The following among them merit some attention:

1) **Demand fluctuations:** Organizations hardly experience a stable or even demand. Several sectors of the manufacturing and service industry experience a significant upswing in demand during certain periods. The demand for garments in India is high during August-October due to the festive season. Meeting surges in demand requires some prior planning.

2) **Capacity fluctuations:** While demand fluctuations happen on account of seasonality, there are fluctuations in capacity too. Moreover, schedule and unscheduled plant shutdowns have a significant impact on capacity availability.

3) **Difficulty Level in Altering Production Rates:** Production are complex and varying the rate of production from one level to another required material, capacity and other resources are available for the incremental plan.

4) **Benefits of Multi-period Planning:** It is known that planning just for a period with no consideration of potential events in the near future amounts to a knee jerk reaction that any attempt to reach optimal and cost saving decisions.

5) **Effective Utilization of Facility's Capacity:** The aggregate Plan should utilise the facility's capacity in an efficient manner and the usage should be consistent with the organization's strategy. Capacity under-utilization may lead to wastage of resources.

**Aggregate Planning Process**

The process consists of four basic considerations as follows:

1) **Concept of aggregation:** Aggregation starts with a meaningful measure of output. In a Single product output organization, there is no problem with the output measure. Many organizations have multiple products and it is difficult to find a common factor of measure of output.

**For example,** steel producer can plan in terms of tonnes of steel, gallons of paint in case of paint industry. Service organizations such as transport system may use passengers miles as a common measure, health care facilities may use the patient visits and educational institutes may use student to faculty contact ratio in terms of hours as a reasonable measure.

A group of products or services that have similar demand requirements and common processing, labour and material requirements is called a product Family. Therefore, a firm can aggregates its products or services into a set of relatively broad families, avoiding too much detail at the planning stage.

**For example,** consider the Bicycle manufacture that has aggregated all products into two families: mountain bikes and road bikes. This approach aids production planning for the assembly lines in the plants.

2) **Goals for Aggregate Planning:** Goals for aggregate planning there are number of goals to be satisfied:

1) it has to provide all the overall levels of output, inventory and backlogs dictated by the business plan

2) Proper utilization of the plant capacity. It should not be underutilized because it is waste of resources. It is better to operate at a near full capacity

3) The aggregate plan should be consistent with the company's goals and policies regarding its employees. A firm may-like to have employee stability or hire and layoff strategy. Other firms change employees freely as the output level is varied throughput the aggregate planning horizon.

## 7.7 NOTES

## 7.8 SUMMARY

In this unit we have discussed about various methods of forecasting. We have studied about production planning and control. We have discussed about aggregate planning.

## 7.9 KEY WORDS

Plant location

Plant layout

Breakeven point

## 7.10 SELF ASSESSMENT QUESTIONS

1. Explain the concept of aggregate planning
2. Define production, planning and control. Explain its purpose and objectives.
3. Discuss the different methods of forecasting

## 7.11 REFERENCES

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# UNIT - 8: MATERIALS MANAGEMENT

**Structure:**

## 8.0 OBJECTIVES

After studying this unit, you should be able to,

- Define purchase and explain its functions
- Design a product for manufacturing and assembly
- Explain different types of layout
- Determine the best process based on the cost sheet

## 8.1 INTRODUCTION

Material management involves the major functions like purchasing, inventory management, vendor rating and stores management. Purchasing means procuring materials, supplies machinery and service needed for production and maintenance of the organization. The purchasing function is a liaison agency which operates between the factory organization and the outside vender on all matters of procurement. Normally mass production industries rely upon a continuous flow of right materials and hence, it demands an efficient purchasing division. The purchasing department occupies a vital and unique position in the organization.

## 8.2 PURCHASING

The importance of purchase function varies with the nature and size of industry. In small scale factories, this function is performed by work manager. In large scale organizations, where large quantities of materials are consumed, the buying function is given to a separate department under highly competent executive designated as chief buyer, or purchase manager.

The cost of product or selling price of product depends upon direct and indirect material cost and hence careful buying will helps in reducing product cost. The purchasing is delicate activities and the person employed should be sincere, honest and intelligent.

**Objectives of purchasing department:**

A. To procure right material.

B. To procure material in right quantity

C. To procure material of right quality.

D. To procure from right and reliable source or vender

E. To procure material economically.

**Duties of Purchase officer:**

1. To organize and direct the purchase department for efficient working.

2. To mantling the standard of quality of product by selecting right quality of material during purchasing
3. To represent his concern with other concerns during purchasing contacts.
4. Shop should maintain the reputation of the concern for integrity and fair dealing with other while negotiating the prices.
5. He should maintain the reputation of the concern for integrity and fair dealing with others while negotiating the price.
6. To suggest" make or buy decision" for a material request by various shops.
7. To spend money on purchase carefully and wisely.
8. To act as an executive of firm, especially in preparation of purchasing budget.

**Methods of purchase:**

Various method of purchasing may be listed as fallows

A. Purchasing strictly by requirement
B. Purchasing for a specified period
C. Market purchasing
D. Contract purchasing
E. Central purchasing organization.
F. Through directorate general of supplies

**Activates, Duties and function of purchasing department:**

1. To purchase right type and right quality of goods at cheapest price.
2. To purchase goods of right quantities in right time
3. To see that delivers of goods are received within time
4. To purchase material only on proper authorised requisitions
5. To ensure that goods are received in accordance with orders placed in respect of quality, quantity and specification.
6. To study market conditions and enter into rate contract to ensure price reduction and quick suppleness of goods.
7. To study various source of supplies to decide upon most convenient suppliers.
8. Development of alternate supply sources.
9. Maintaining list of approved vender.
10. To keep the list of article required for organization up to date with quantities

11. To prepare specifications, to obtain quotation and compare these quotation to place the orders.
12. To look that suppliers payment are made according to purchase order terms and conditions.
13. To place the purchase order of requisitioned goods with right suppliers.
14. To purchase directly small items

## 8.3 PURCHASING PROCEDURE

For a medium industry following purchasing procedure is generally adopted

1. After receiving purchase requisition form, exact quantity and specification of material to be purchased is decided.
2. Prepare a list of suppliers who deal with business of material to be purchased.
3. If the material to be purchased in of small amount and required urgently, it may be purchased locally.
4. If necessary, prepare and issue NIT (Notice inviting tender) to concerned suppliers, mentioning different terms, conditions, date and time of opening tenders.
5. Open the tender at prescribed time on prescribed date.
6. Preparation a comparative statement of rate, tenders and conditions mentioned in the tenders and then study them
7. If required, samples may be received from the firm have quoted lowest rates.

## 8.4 INVENTORY: AN ESSENTIAL REQUIREMENT

Inventory is a part and parcel of every facet of business life. Without it, no business activity can be performed, whether, it being a service organization like hospital, and banks etc. or manufacturing or trading organization Irrespective of the specific organisational setting, inventories are reflected by way of a conversion process of inputs to outputs. This is illustrated in Figure 8.1. In fact, inventory is maintained for flow of operations in the production process.

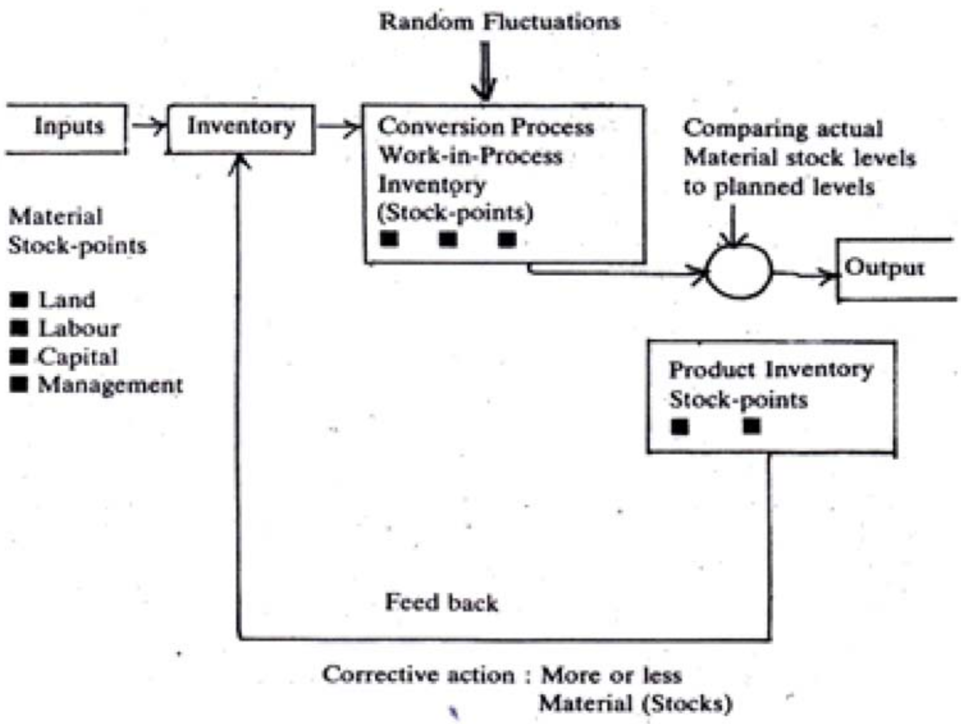


**Fig 8.1 The Material Conversion Process**

One can see that here may be stock-points at the input (raw material), conversion (Work-in process), and output (product) stages. Looking at the conversion process where inputs and outputs are based on the market situations of uncertainty, it becomes physically impossible and economically impractical for each stock item to arrive exactly where it is needed, it may be prohibitively expensive. This is the fundamental reason for carrying ht inventories. Thus, inventories play an essential and pervasive role in any organisation because they make it possible.

- To get right amount of stock at exact time of need to ensure continuous and smooth production.
- To avoid the physical impossibility and economical impracticability of getting right amount of stock at exact time of need.
- To order larger quantities of goods, materials or components from the suppliers at advantageous prices.
- To provide reasonable customer service through supplying most of the requirements from stock without delay.
- To maintain more stable operating or work force levels.
- To take advantage of shipping economics.

- To plan overall operations strategy through decoupling of successive stages in the chain of acquired goods, preparing products shipping to branch where houses and finally serving customers.
- To facilitate economic production runs.
- To facilitate the intermittent production of several products on the same facility.
- To provide means against hedging against future price and delivery uncertainties.
- To make effective use of available capital and/ or storage space.
- To achieve favourable return on investment.

**Objectives of Inventory**

As inventory is an essential part of any organization, it consists of many items running into thousands. Systematic management and control of inventory for all the items is a challenging job. Main objective of inventory control are:

- To maintain the overall investment in inventory at the lowest level, consistent with operating requirements.
- To supply the product, raw materials, sub-assembling, semi-finished goods, etc. to its users as per their requirements at right time and at right price.
- To keep inactive, waste, surplus, scrap and obsolete items at the minimum level.
- To minimize holding, replacement and shortage costs of inventories and maximise the efficiency in production and distribution
- To treat inventory as investment this is risky. For some items, investment may lead to higher retunes and for others less returns.

**Functions of inventory**

The basic function of inventory is to increase profitability through manufacturing and marketing support. Since zero inventory manufacturing-distribution system is not practical. It is important to remember that each rupee invested in inventory is geographical specialization, decoupling, blanching supply and demand and safety stock.

**1) Inventory investment alternative**

Inventory is a major area of asset deployment which should be required to provide a minimum return on investment. The marginal efficiency of capital (MEC) concept holds that a firm should invest in those alternatives that provide a greater return than capital cost to borrow.

**Geographical Specialization**

Another function of inventory is to allow geographical specialization of individual operating units. Due to factors of production such as power, raw material, water and labour the economical location for manufacturing is often a considerable distance at a simple warehouse/ plant to assemble in final product o to offer customers a single mixed product shipment. This also provides economics specialization between manufacturing and distribution units of an enterprise.

**2) Decoupling**

This function of inventory is to provide maximum efficiency of operations within a single facility. Decoupling is done by breaking operations apart so that one operations supply is independent of another's supply. This decupling function serves two purposes. First, inventories are needed to reduce the dependences among successive stages of operations so that break-downs, material shortage, or other reduction fluctuation at one stage do not cause later stages to shut down. Figure 8.2 illustrates this concept in an engineering firm. Since debursing packing could continue to operate from inventories should die casting and drilling be shut down or they can be decoupled from the production process that precedes them.

A second purpose of decoupling is to let one organization unit schedule its operations independently of another. For example, in an automobile organization, engine built up can be scheduled separately from seat assembly, and each can be decoupled from final automobile assembly operations through in process inventories.

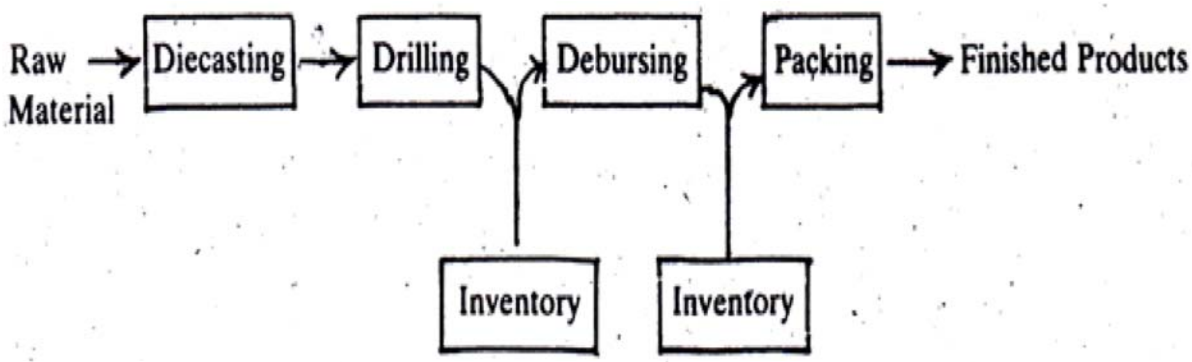


**Fig 8.2 Decoupling operations by using Inventory**

**3) Balancing supply and demand**

Balancing function concerns elapsed time between consumption and manufacturing. Balancing inventories exist to reconcile supply with demand. The most notable examples of balancing are seasonal production and year round consumption like sugar. Another example of year round production and seasonal consumption is woollen textiles. Inventories in a balancing capacity link the economics of manufacturing with variations of consumption. The balancing function of inventory requires investment in seasonal stocks which are expected to be fully liquidated within the season.

**4) Safety stock**

The safety stock or buffer stock function concerns short range variations in either demand or replacement. A great deal of inventory planning is devoted to determining the size of safety stocks. Safety stock provided protection against two types of uncertainty. The first of uncertainty is concerned with sales in excess of forecast during the replenishment period. The second type of uncertainly concern delays in replenishment.

The inventories committed to safety stocks represent the greatest potential for improved performance. Verities of technique are available to develop safety stocks which can be adjusted rapidly in the event of error of error or a change in policy.

## 8.5 CLASSIFICATION OF INVENTORY

Inventory may be classified into manufacturing, service and control aspects. This is exhibited in Figure 8.3 .

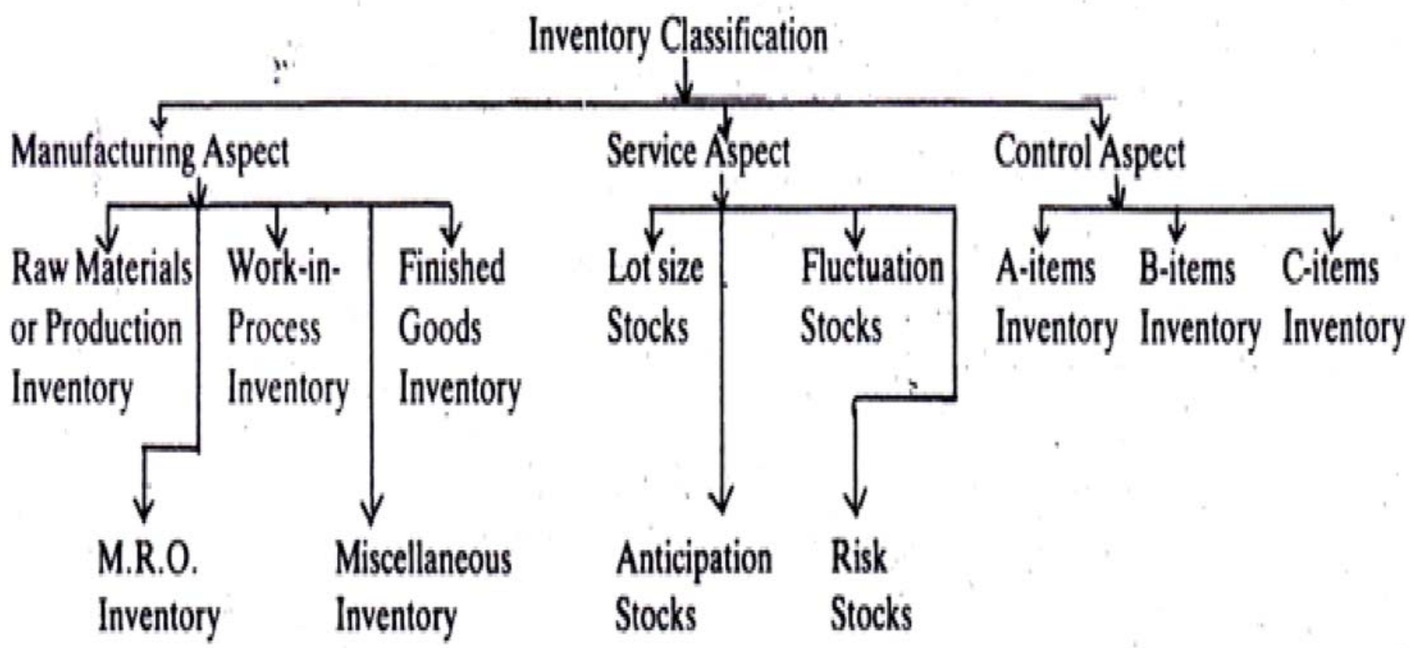


**Fig: 8.3 Types of Inventory**

1) **Manufacturing Inventory**

Inventory held by a manufacturing concern is mainly of five types:

**a) Productive inventory**

Items going into final product such as raw materials, components and sub assemblies are purchased from outside from production inventory.

**b) Work-in-Process inventory**

Under this all items in semi-finished form or product at different stages of production.

**c) Finished goods inventory**

This includes the product reedy for dispatch to users or to distributors.

d) **MRO Inventory**

They are the Maintenance, repairs and operating supplies like spare parts and consumable stores, which do not go into final product but are consumed in the production process.

E) **Miscellaneous inventory**

Items other than these mentioned above, such as scrap as scrap, obsolete and unsalable products arising from main production, stationary used in office and other items needed by office, factory and sales department, etc.

**2) Service Inventory**

This consists of four classes:

a. Lot size

This means purchasing in lots. This is resorted to

i) Reduce transportation and purchase costs

ii) Minimize handling and receiving costs

It would be uneconomical for a textile unit to buy cotton everyday rather than in bulk during the cotton season.

**b. Anticipation Stocks**

These are kept to meet predictable changes in demand or in availability of raw materials. The purchase of potatoes in the potato season for sale of roots preservation products throughout the year is an example of his kind.

**c. Fluctuation stocks**

These are carried to ensure reedy supplies to consumers or customer in the face of irregular fluctuations in their demands.

**d. Fisk stocks**

These are the items needed to ensure that there is no risk of complete breakdown of production. These are items with long lead time for supply but are vital and critical for production.

**3) Control of Inventory (ABC classification)**

A good tart in examining an inventory control system is to make ABC classification. It is known as ABC analysis which means the control will be always better if we start with ABC of inventory. This concept divided inventories into three grouping in terms of percentage of number of items and percentage of total value as given in figure 8.4

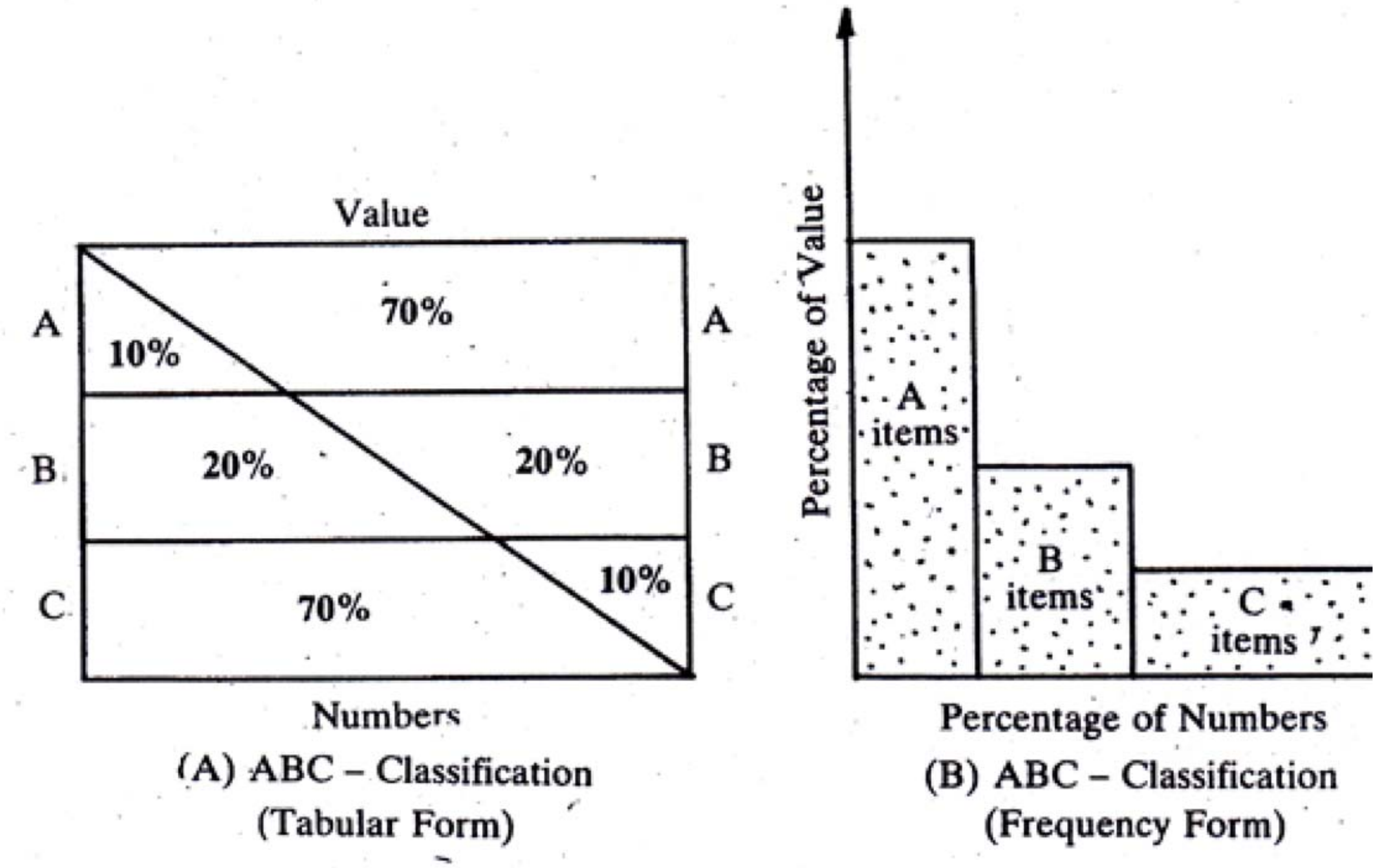


**Fig 8.4 ABC Classification of Inventory**

A-items group constitutes 10% of the total number of items and 70% of the total money value for all the items.

B-items group constitutes 20% of the total number of items and 20% of the total money value for all the items.

C- Items group is just opposite of A-items group. It constitutes 70% of the total number of items and 10% of the total values.

This classification provides clear cut indications for fixing priorities of control to the items. A class items must receive the attention frost in every respect of the control i.e. tight control, sound operating doctrine, attention to security etc.

ABC classification coupled with VED classification (vital, essential and Desirable) enhances the efficiency of control on inventories. It may be noted that ABC classification is based on the logic of proportionate value while VED classification is based on judgement, experience etc. As illustrated in Figure 8.5 total number of categories becomes nine.

| | V | E | D | TOTAL |
|---|---|---|---|---|
| A | 3 | 5 | 2 | 10 |
| B | 5 | 7 | 8 | 20 |
| C | 10 | 40 | 20 | 70 |
| TOTAL | 18 | 52 | 30 | 100 |

**Fig: 8.5 ABC/VED Classifications**

**Factor Affecting inventory**

The major problem of inventory control is to answer two questions, viz.,

(A) How much to order?

(B) When to order?

These are answered by developing a model. An inventory model is based on the consideration of the main aspects of inventory, Viz., the demand and the costs associated with this. Many factors related with these two main factors are discussed below:

**1) Economic Parameters**

These parameters usually include the following types.

**a) Purchase Price or production cost**

The cost or value of the item is the sum paid to the suppliers for the item received or the direct manufacturing cost if produced. It is normally equal to purchase price. When the market rice goes on fluctuating, planning of inventory is based on the average price mostly taken as a fixed price. The price factor is of special interest when price discount can be secured or when large production runs may result in a decrease in the production cost.

**b) Selling price**

In some inventory situation, the demand may be affected by the quantity stocked. In such cases, the inventory model is based on a profit maximization criterion which includes the revenue from selling the commodity. The unit selling price may be constant or variable depends upon whether quantity discount is allowed or not.

**c) Procurement costs**

These costs are those incurred by placing a purchase order. It is also known as ordering costs or incurred as set up costs related with the initial preparation of a production system in manufactured. These costs vary directly with each purchase order placed or with set up made and are usually assumed independent of the quality ordered or produced. Procurement costs include costs of administration (such as salaries of the person working for purchasing, tending, paper work, telephone calls, computers costs, postage etc.) transportation of items ordered, expediting and follow up, receiving and inspection of goods, processing payments etc. This cost is expressed as the cost per order or per set up.

**d) Carrying (or Holding) Costs**

The cost associated with carrying of stocks of items is called holding cost or storage cost or possession cost. Holding costs include handling cost, maintenance cost, wages of persons working for this, insurance, safety measures, warehouse rental, depreciation, theft, pilferage, obsolescence, interest on the money locked up, etc.

Considering all the above elements, the storage cost is expressed either as per unit of item held per unit of time or as a percentage of average rupee value of inventory held. The size of all these carrying costs usually increases or decreases in proportion to the amount of inventory that is carried.

**e) Shortage (or Stock out) Costs**

These are penalty costs incurred as a result of running out of stock when the commodity is needed. One form of these costs is known as back-order on the selling side (or backlog costs on the manufacturing side) when the unfilled demand can be satisfied at the later date i.e. customer waits till he gets the supply. Another form of these costs is known as lost sales costs on the selling side (or no backlogging on the manufacturing side) when the unfilled demand is lost or the customer does not wait for the supply and goes elsewhere (See Figure

8.6). These include the costs of production stoppage, overtime/idle time payments, expediting, special orders at higher price, idle machine, loss of goodwill, loss of opportunity to sell, loss of profitability etc.

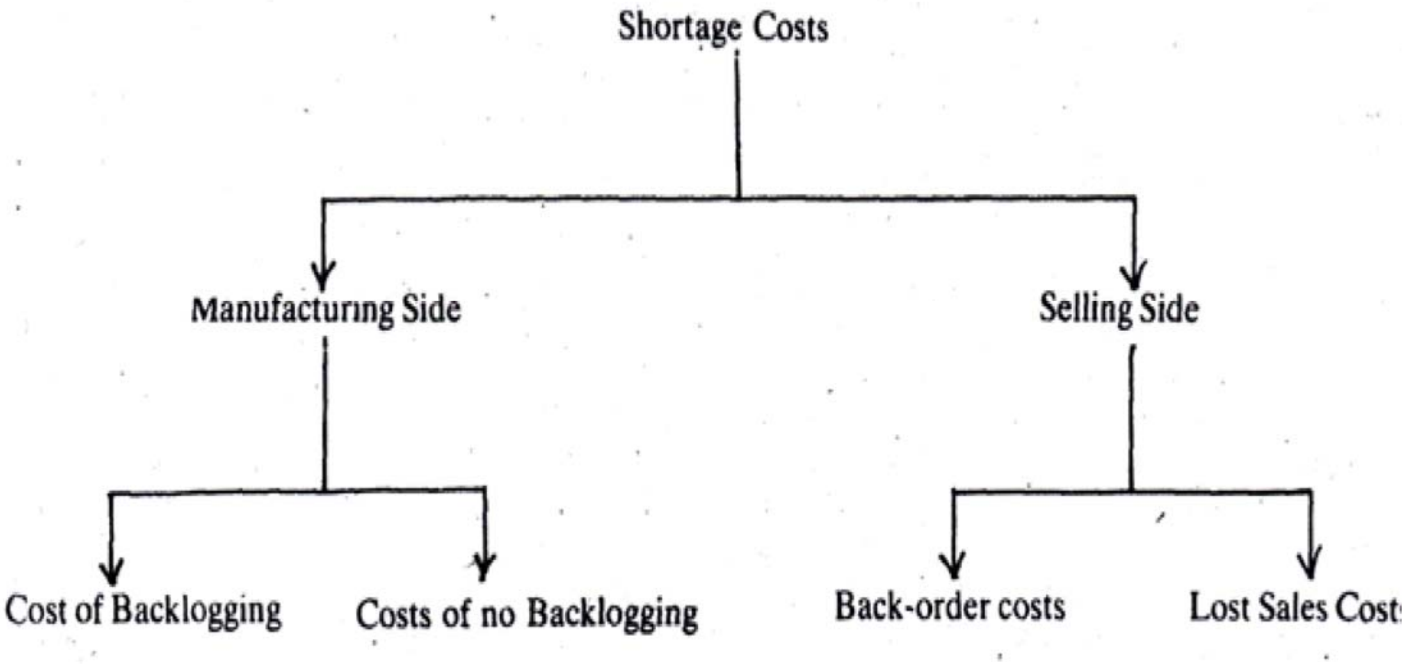


**Fig 8.6 : Nature of Shortage Costs**

**f) Cost of Operating the Information Processing System**

As stock levels change, someone must update records whether by hand or by computer. Where the inventory levels are not recorded daily, this operating cost is incurred in obtaining accurate physical counts of inventories. These operating costs are more fixed than variable over a wide quantity (volume) range.

**2) Demand**

The demand pattern of a commodity may be either deterministic or probabilistic. In the deterministic case, it is assumed that the quantities needed over subsequent periods of time are known with certainty. This may be expressed over equal periods of time in terms of known constant demands or in terms of known variable demands. The two cases are referred to as static and dynamic demands respectively. "

Probabilistic demand occurs when requirements over a certain period of time are not known with certainty but their pattern can be described by a known probability distribution. In this case, the probability distribution is said to be either stationary or non-stationary over time. These terms are equivalent to static and dynamic demands in the deterministic case.

The demand for a given period of time may be satisfied instantaneously at the beginning of the period or uniformly during that period. The effect of instantaneous and uniform demand reflects directly on the total cost of holding inventory.

**3) Ordering Cycle**

This is concerned with the time measurement of inventory situation. An ordering cycle may be identified by the time period between two successive placements of orders. The latter may be initiated in one of two ways.

**i) Continuous Review**

Where a record of the inventory level is updated continuously until a certain lower limit reached at which point a new order is placed. This s referred to sometimes as the two-bin system.

**ii) Periodic review**

Where orders are placed usually to equally spaced intervals of time

**4) Delivery Lag or Lead Time**

When the need of the materials is felt and an order is placed, it may be delivered instantaneously or it may require some time before delivery is effected, the time between the placement of the requisition for an item and its receipt for actual use is called delivery lag or lead time. In general, lead time has four components, viz. administrative lead time, suppliers lead time and inspection lead time can be fixed in nature, but suppliers lead time and transaction lead time can never be fixed. In general, the lead time may be deterministic or probabilistic.

**5) Time Horizon**

This is also known as the panning period over which inventors to be controlled. The planning period d may be finite or infinite. Mostly inventory planning in an enterprise is done on annual basis.

**6) Number of supply Echlons**

There may be several stocking points in the inventory system, these points are organised such that one point acts as a supply source for some other points. For example, the factory supplies the product to warehouse, and the warehouse supplies the retailers who, in turn, supplies to customer. Each level is called on Echlon. Mulit-echon inventories, as illustrated in figure 8.7 includes product stocked at the various levels in the distribution system.

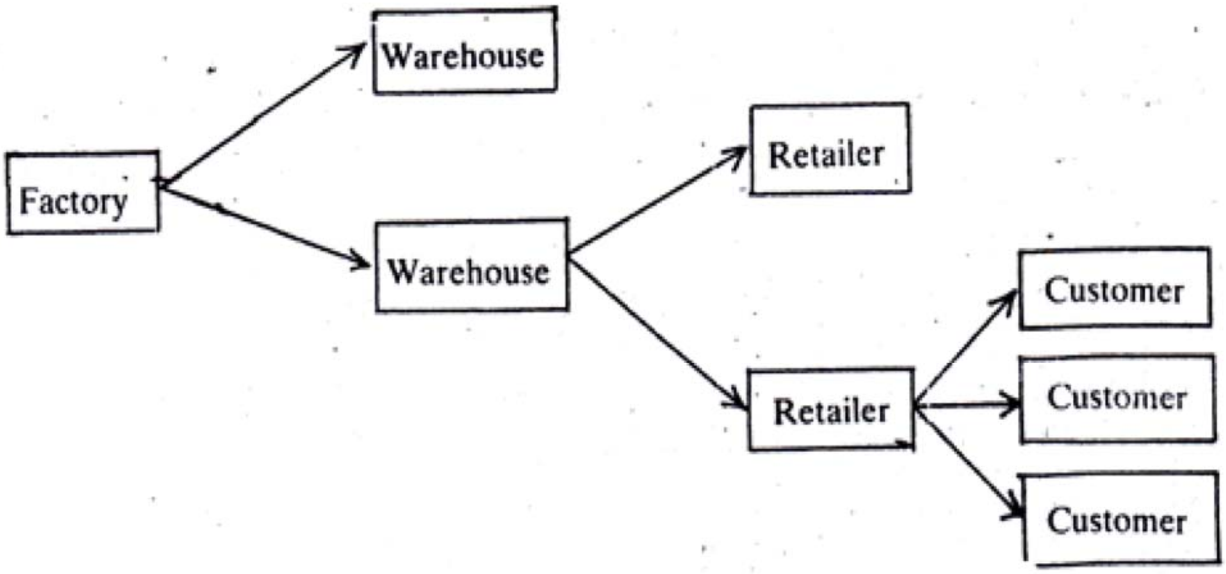


**Fig 8.7 Multi Echlon Supply Systems**

**7) Number of stages of inventory**

When Parts are stocked at more than one stage in the sequential production process they are called multi-stage inventories.

**Number of Items**

An inventory system involves, generally, more than one commodity. The number of items held in inventory effect the situation when these items compete for limited floor space or limited total capital.

**8) Availability of Items**

Sometimes supply position is badly affected due to various market situations which in turn affects the inventory position in an enterprise.

**9) Governments/ Company policy**

For items to be imported as well as for other items like explosive, highly inflammable and other essential items, the government has laid down some policy norms.

Similarly, a company may also lay down certain policies based on available capital etc. All these have effect on the level of inventories in any organisation.

## 8.6 INVENTORY MODELS

Inventory models with all the parameters know with certainty will be discussed below:

1) **The Economic order quantity Model (EOQ)** The concept of EOQ applies to items which are replenished periodically into inventory in lots covering several periods' needs. The EOQ concept is applicable under the following conditions.

a) The item is replenished in lots or batches, either by purchasing or by manufacturing.

b) Consumption of items (or Sales or usage rate) is uniform and continuous.

The model is described under the following situation:

i) Planning period is one year.

ii) Demand is deterministic and indicated by parameter D units per year.

iii) Cost of purchase or price of one unit is C.

iv) Cost of ordering (or Procurement cost or replenishment cost) is $C_0$ per unit per year.

v) Cost of holding stock (also known as inventory carrying cost) is $C_h$ unit per year expressed either in terms of cost per unit per period or in terms of percentage charges of the purchase price.

vi) Shortage cost (mostly it is back order cost) is Cs per unit per year.

vii) Lead time is L, expresses in units of time.

viii) Cycle period of replenishment is t.

ix) Order size is Q

Instantaneous supply case when shortages are not allowed will be discussed here. That is whatever is demanded, is supplied immediately after the lead time.

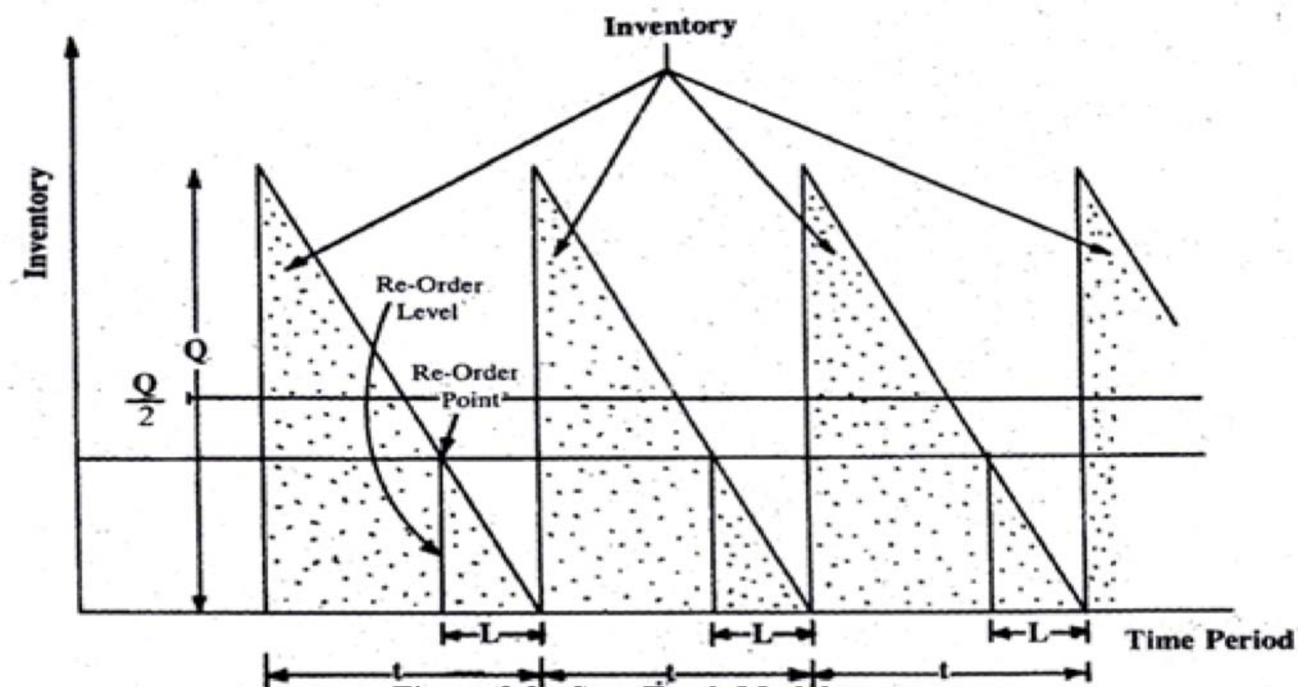


Figure 8.8 : Saw-Tooth Model

Since everything is so known and regular, there is no need of cushion or safety stock. Inventory will run out altogether just as the next lot is received. For this model, the various levels of inventories are fixed as follows:

Minimum level = Safety Stock (or Buffer Stock)

Maximum level= Minimum level plus Economic Order Quantity

Re-order level = Minimum level plus Consumption during lead time.

Since safety stock is not required for this case, safety stock is zero, i.e., minimum level is zero. Maximum inventory is the order size (or lot size). The average inventory per cycle = $^1/_2$ (Maximum level + Minimum level) where cycle is the intermittent pattern, in which inventory vary from maximum, to minimum and then back to maximum. The maximum inventory is Q, the average inventory per cycle is therefore

½ (Q+O) = Q/2.

Since average inventory during any cycle period is Q/2, the average inventory during one year is also Q/2. Average inventory is time independent.

The total relevant cost equation for this case will be:

Total annual relevant cost = Annual Purchase Cost + Annual Ordering Cost(OC) + Annual Carrying Cost (CC)

(TC) (PC)

$$= (\text{Price} \;/\; \text{Unit}) \begin{pmatrix} \text{Quantity} \\ \text{Purchased} \\ \text{per year} \end{pmatrix} + \begin{pmatrix} \text{Cost of} \\ \text{ordering} \\ \text{per order} \end{pmatrix} \begin{pmatrix} \text{Number} \\ \text{of orders} \\ \text{placed/yr} \end{pmatrix} + \begin{pmatrix} \text{Cost of} \\ \text{Carrying} \\ \text{one unit} \end{pmatrix} \begin{pmatrix} \text{Average} \\ \text{no of units} \\ \text{carried} \end{pmatrix}$$

-----(1)

Number of orders per year = Annual demand divided by the order size = D/Q Thus, equation (1) is written as:

$$TC = CD + C_0 \frac{D}{Q} + C_h \frac{Q}{2} \qquad \text{----- (2)}$$

The economic order quantity or optimal order size is that quantity which minimizes the total cost. Total cost is the sum of fixed cost and variable cost. Fixed cost (CD) is independent of order size while the variable cost is dependent on the order size Q. Since the fixed cost does not play any role in minimization or maximization process, only variable cost will be minimized here. For total cost to be minimum, the first order derivative of TC is zero, i.e.,

$$\frac{dTC}{dQ} = \frac{-C_o D}{Q^2} + \frac{C_h}{2} = 0 \qquad \text{----- (3)}$$

Or

$$\frac{C_o D}{Q} = \frac{C_h Q}{2}$$

$$= \sqrt{\frac{2C_o D}{C_h}}$$

Equation 5, may also be obtained from the figure 8.9

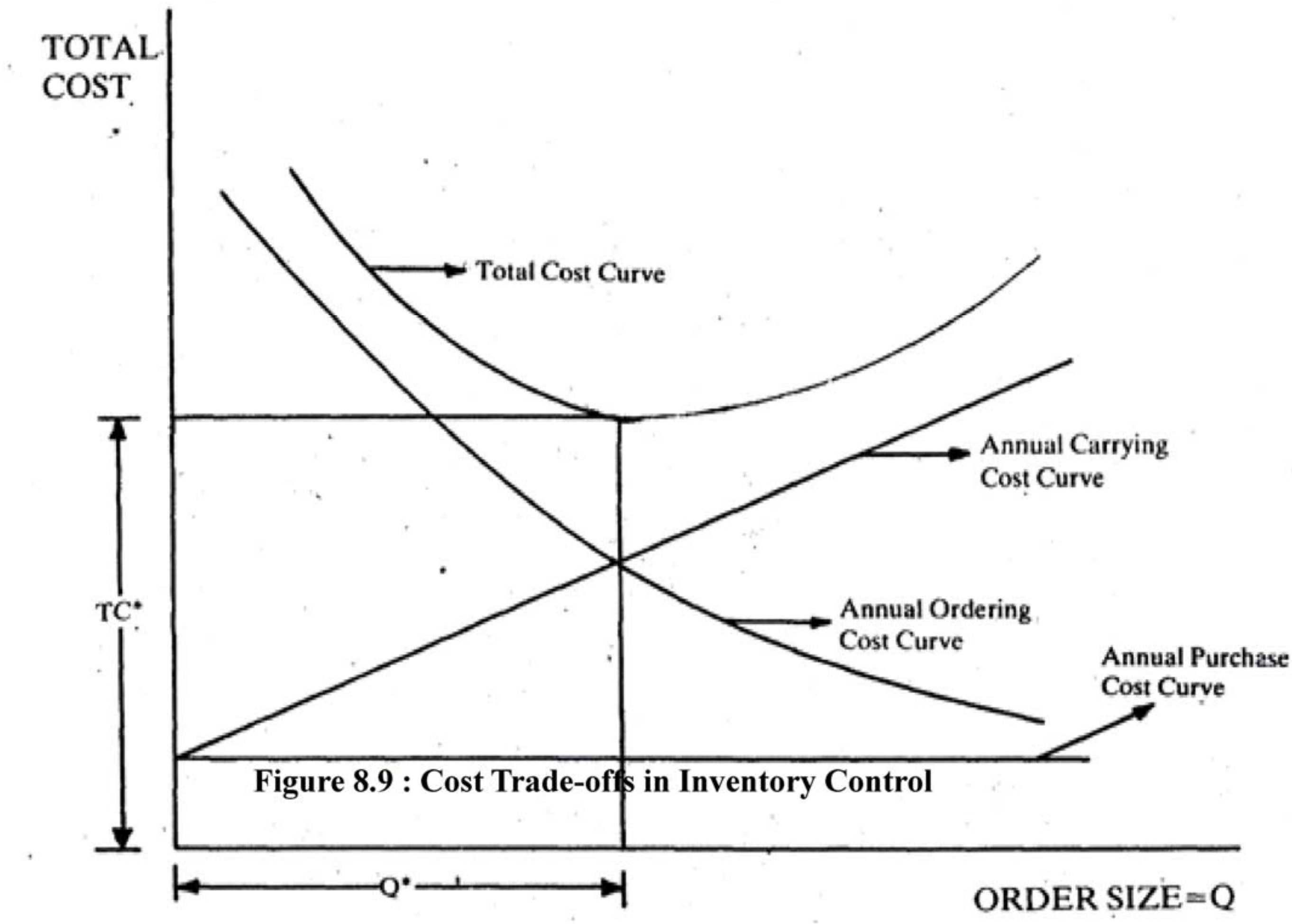


**Figure 8.9 : Cost Trade-offs in Inventory Control**

If we examine the total cost equation (2), the fixed cost and the variable costs relationships are as shown in Figure 8.9. The total cost curve has the lowest value just above the intersection of the two cost curves viz, ordering cost curve and carrying cost curve. At the intersection point. The two costs are equal, i.e., annual cost is equal to annual carrying cost.

From equation (4), one gets that

EOQ = Q* = Square root of two times of ordering cost multiplied by annual demand divided by carrying cost/per unit

$$\sqrt{\frac{2C_oD}{C_h}}$$

The cycle period t is given by $\dfrac{\text{Optimal Order Quantity}}{\text{Annual demand}}$

$$\text{or} \quad t^* = \frac{Q^*}{D} = \sqrt{\frac{2C_o}{C_hD}}$$

The total number of orders per year (=N) is the reciprocal of the cycle period i.e.

$$N = \frac{D}{Q^*} = \sqrt{\frac{C^hD}{2C_O}}$$

Total annual cost = TC = CD + $\sqrt{2C_oC_hD}$

Lead time consumption = (Lead time in yrs.) (Demand Rate per year)

Therefore, Minimum level = O, Maximum level = Q* .

Re-Order level (R.O.L) = LD

## 8.7 SOLVED PROBLEMS

**Example 1** :

A manufacturer uses 10,000 units of an item during the year. The ordering costs Rs. 25 per order and carrying costs as 12.5% of average inventory value. Find the optimal order size, number of orders per year and time period per order .

**Solution**

Here D = 10,000, $C_0$ = Rs. 25, $C_h$ = 12.5% of average inventory value/unit

$$Q^* = \sqrt{\frac{2X25X10{,}000}{0.125}} = 2000$$

**Cycle Period**

$$t^* = \sqrt{\frac{2X25}{(0.125)(10{,}000)}} = \frac{1}{5} \quad \text{yrs.= 73 days}$$

**No. of orders per year**

$$N = \frac{1}{t^*} = \quad 5$$

**Example 2 .**

Determine safety stock, reserve stock and buffer stock for the data given below,:

Normal usage= 100 per week

Lead time = 4 to 6 weeks

Minimum usage= 50 per week

Maximum usage= 150 per week

Re-order quantity = 600 nos

Also calculate the re-order level, minimum and maximum levels of inventory and also average inventory level

**Solution**

Buffer Stock = (Average Lead Time) X (Average Usage Rate)

= 5 x 100 = 500 nos.

Safety stock is for usage at normal rate during the extension of lead time.

Max extension of lead time = 6-5=1 week

Normal usage rate = 100 per week

Safety stock = (6-5) x 100 = 100 nos

Reserve stock is to meet the excess usage requirement during the normal lead time.

Excess usage requirement = 150 - 100 = 50 per week

Reserve stock = 5x50 = 250 nos

Re-order level = S.S.+ R.S. + B.S

= 100 + 250 + 500 = 850 nos.

Minimum inventory level = S.S.+ R.S. = 100 + 250 = 350 nos.

$$\text{Max inventory Level} = \frac{\text{(Minimum Inventory Level) + (Order Quantity)}}{2}$$

= 350 + 600 = 950 nos.

$$\text{Average inventory Level} = \frac{\text{Minimum Level +Maximum Level}}{2}$$

$$= \frac{350+950}{2} = 650$$

3 . A company uses 1200 units per month of an electronic component each costing Rs.2/-. Placing each order costs Rs.50/- and the carrying cost is 6% per year of the average inventory.

(i) Find EOQ.

(ii) If the company gets 5% discount if it places single order, should they accept the discount

(iii) Find break-even discount percentage which matches EOQ ordering.

**Solution**

Annual demand for the component (D) = 1200 x 12 = 14,400 nos.

Unit price of the component (P) = Rs.2/-

Ordering cost par order(C),= .Rs.50/-

Inventory carrying charges per year ($C_t$) = Rs 6%

(i) Determination of EOQ :

$$EOQ = \sqrt{\frac{2DC_0}{PC_1}} = \sqrt{\frac{2\ x\ 14{,}400\ x\ 50}{2\ x\ 0.06}} = 3464$$

No. of orders per year = $\frac{14{,}400}{3464} = 4.15 = 4$

Modified EOQ = $\frac{14{,}400}{4}$ =3600

Total cost for EOQ ordering = $(Cost\ of\ material\ /\ years) + (Ordering\ cost\ per\ year)$

$+ (Inventory\ carrying\ cost\ per\ year)$

$$T_{C(Disc)} = DP_1 + \frac{D}{Q_1}C_0 + \frac{Q_1}{2}P_1C_1$$

$$= 14{,}400x2 + \frac{14{,}400}{3600} X\ 50 + \frac{3600}{2} x\ 2x\ 0.06$$

= 28,000 + 200 + 216 = Rs.29,216/-

(ii) Decision regarding discount offer of 5%

Discounted unit price (P,) = 0.95 x 2 = Rs.1.90

$$\left.\begin{matrix} order\ qty\ to\ avail \\ discount\ (Q_1) \end{matrix}\right\} = 14{,}400 \text{ nos (i.e. single order per year)}$$

$$\left.\begin{matrix} Total\ \cos t\ under \\ discount\ offer \end{matrix}\right\} = T.C_{.(Disc)}$$

$$= 14{,}400 \times 1.90 + \frac{14{,}400}{14{,}400} \times 50 + \frac{14{,}400}{2} \times 1.90 \times 0.06$$

= 27,360 + 50 + 820.80 = Rs.28,230.80

Since, $T.C._{(Disc)} < T.C._{(EOQ)}$, the decision is to accept the discount offer of 5% on unit price.

## 8.8 CASE STUDY

M/s MSS Metals and Cproblems with their inventory management. They have excess stock of few items where as less stock of few other items. Getting an item at the crisis is costing them more. Hence they would like to adopt ABC analysis for inventory management. They could categorize all the items under eight different groups head based on the unit price and the average consumption pattern. They have also come out with an average monthly consumption and average price based on the consumption and unit price of various items in each group. The below table lists the groups and their consumption pattern and unit price. They would like to classify them as A,B or C. They have decided to adopt the criteria that items above 85 % of consumption value as A, Items that account for 10 per cent of consumption as B and items that account for 5 % of consumption value as C.

| Group | No. Of Items | Monthly Consumption | Price item (Rs) |
|---|---|---|---|
| I | 40 | 3000 | 9 |
| II | 20 | 270 | 100 |
| III | 100 | 1700 | 5 |
| IV | 200 | 1500 | 4 |
| V | 60 | 340 | 50 |
| VI | 300 | 2500 | 1 |
| VII | 250 | 2000 | 2 |
| VIII | 30 | 170 | 500 |

If you are hired as the material engineer, how do you classify them as A,B and C?

## 8.9 NOTES

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## 8.10 SUMMARY

In this unit we have discussed about various methods of forecasting. We have studied about production planning and control. We have discussed about aggregate planning.

## 8.11 KEY WORDS

- Material Management
- Inventory Management
- Safety Stock
- Inventory Models

## 8.12 SELF ASSESSMENT QUESTIONS

**1.** Explain the functions of purchasing

**2.** Differentiate between various models of inventory management

**3.** The ABC fun novelty company buys 80,000 shipping container per year. Price of each container is Rs 40/-. Cost of purchase is Rs 800 per order. Cost of holding one container is Rs 1/- per year. Bank rate of interest is 15% including a charge for taxes and insurance. Find

a. The economic order quantity and time between orders based on 220 working days per year.

b. The minimum variable cost per year

c. If the company had been following a policy of quarterly ordering, what would have been the increase in the variable cost?

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# MODULE - III
# MANUFACTURING AND CONTROL

## UNIT - 9: PRODUCTIVITY AND TIME STUDY

**Structure:**

## 9.0 OBJECTIVES

**After studying this unit, you should be able to:**

- Define productivity
- Explain the importance of productivity
- Describe work study
- Perform method study and work study in an organization
- Appreciate the use of learning curves

## 9.1 INTRODUCTION

The objective of managing the personnel is to obtain the highest productivity possible without sacrificing quality, service, or responsiveness. The operations manager uses job design techniques to structure the work so that it will be conducive to both the physical and behavioral needs of the human worker. Work measurement methods are used to determine the most efficient means of performing a given task, as well as to set reasonable standards for performing it.

A working knowledge of learning curves is also needed to allow the operations manager to anticipate the gains in efficiency that naturally arise as workers gain experience.

## 9.2 PRODUCTIVITY

Productivity refers to the output relative to the inputs. Technically, productivity signifies the ratio between the input and output with respect to given resources, i.e., the ratio of the outputs achieved from an activity to the inputs consumed to make those outputs.

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Labour} + \text{Capital} + \text{Materials} + \text{Energy} + \text{Information}}$$

This definition, while accurate, does not convey the central role that productivity and productivity improvements have in determining the competitiveness of the organization. Productivity is a multifaceted concept i.e., when more is produced with the same expenditure of resources, it may be termed as effectiveness; when the same amount is produced at less cost, it may be termed as efficiency. Thus the word productivity is broad enough to cover effectiveness and efficiency. It denotes the efficiency with which the various inputs are converted into goods and services and the effectiveness with which resources are used. Output per labour hour, often called labour efficiency, is perhaps the most common partial measure of productivity.

For example Good Day limited manufactures 20,000 components per month by employing 100 workers in one 8 hour shift. What is the productivity of the labour?

Productivity = Outputs / Inputs

Assuming the company works for 25 days

Productivity = 20,000 / 100 x 8 x 25

Therefore, productivity is 1 component per man-hour.

Productivity can be increased in the following ways

1. Increase production using the same or a smaller amount of resources
2. Reduced the amount of resources used while keeping the same production or increasing it
3. Allow the amount of resources used to increase as long as production increases more
4. Allow production to decrease as long as the amount of resources used decreases more

## 9.3 MEASUREMENT OF PRODUCTIVITY

The productivity can be measured in the following ways.

i) **Labour productivity:** The important function in any production set-up is the budgeted quantity of work must be achieved over a period of time. Labour productivity depends upon how labours are utilised. Labour productivity can be higher or lower depending on factors like availability of work load, material, working tools, availability of power, work efficiency, level of motivation, level of training, level of working condition (comfortable or poor) etc. Labour productivity can be measured in terms of hours or money.

$$\text{Labour productivity} = \frac{\text{Total output}}{\text{Labour input}}$$

$$\text{Labour productivity (in terms of hours)} = \frac{\text{Total quantity produced}}{\text{Actual man hours required to produce that quantity}}$$

Labour productivity (in terms of money) = Total cost (or sales value) of output produced

Amount in terms of rupees spent on workers

The productivity of labour can be increased by increasing efficiency of labour and reducing labour time.

**ii) Material productivity:** Production system converts raw material into finished product with the help of mechanical or chemical processes. Material productivity plays important role in cost of production. Material productivity depends upon how material is effectively utilised in its conversion into finished product. Material productivity depends upon percentage of rejection, creation of scrap, level of spoilage, obsolescence, work wastage etc. Material productivity is expressed as:

$$\text{Material productivity} = \frac{\text{Total output}}{\text{Material input}}$$

$$\text{Material productivity} = \frac{\text{Total quantity produced}}{\text{Total Material Cost}}$$

Material productivity can be increased by using skilled workers, adequate machine tools, good design of product etc.

**iii) Machine Productivity**: Production system converts raw material into finished product through mechanical or chemical process with the help of machines and equipments. Machine productivity depends upon availability of raw material, power, skill of workers, machine layout, quality of machine, maintenance, availability of spare parts.

$$\text{Machine productivity} = \frac{\text{Output in standard Hours}}{\text{No of Machine Hours Used}}$$

iv) **Capital productivity**: For any production set-up, facilities of machines, tools, land etc. are required which are assets of organisation. Capital is needed for such assets. As huge capital is locked in assets, their effective utilization is absolutely necessary. Capital productivity depends on how effectively assets are utilised. Therefore decision is necessary to take about replacement of fixed assets. Early replacement of fixed assets brings down maintenance cost but requires capital expenses. On the other hand, late replacement of fixed assets improves ratio of production to capital expenditure, but it increases maintenance cost. Therefore proper balance is necessary. Organaisations spend large amount (direct expenditure) for assets like direct material, direct wages, land, building, equipment etc. A production system incurs a lot of direct expenditure like salaries of manpower employed in planning, store keeping, record keeping, inspection etc. Indirect labour is also used for material movement, good housekeeping, cleaning etc. Indirect expenditure is incurred on indirect material like tools, oils, lubricant etc.

$$\text{Capital Productivity} = \frac{\text{Total Output}}{\text{Capital Input}}$$

**Problems**

1. Sriram, the local auto mechanic, finds that it usually takes him 2 hours to diagnose and fix a typical problem. What is his daily productivity (assume an 8 hour day)? Mr. Sriram believes he can purchase a small computer trouble-shooting device, which will allow him to find and fix a problem in the incredible (at least to his customers!) time of 1 hour. He will, however, have to spend an extra hour each morning adjusting the computerized diagnostic device. What will be the impact on his productivity if he purchases the device?

$$\text{Current productivity} = \frac{\text{8 hours per day}}{\text{2 hours per problem}} = \text{4 problems per day}$$

$$\text{Productivity with computer} = \frac{\text{7 hours per day}}{\text{1 hour per problem}} = \text{7 problems per day}$$

7 /4 =1.75

Productivity is improved by 75%

2. Satish, the Production Manager at Rahul Mills, can currently expect his operation to produce 1000 square mts of fabric for each ton of raw cotton. Each ton of raw cotton requires 5 labour hours to process. He believes that he can buy a better quality raw cotton, which will enable him to produce 1200 square mts per ton of raw cotton with the same labour hours. What will be the impact on productivity (measured in square yards per labour-hour) if he purchases the higher quality raw cotton?

$$\text{Current labour productivity} = \frac{\text{1000 sq yds}}{\text{1 ton*5 hours}} = \text{240 sq mts per hour}$$

$$\text{New labour productivity} = \frac{\text{1200 sq yds}}{\text{1 ton * 5 hours}} = \text{240 sq mts per hour}$$

Productivity improvement 20% = ( 240 - 200 ) / 200 = .2

Productivity is improved by 20%

3. Sarika is currently working a total of 12 hours per day to produce 240 dolls. She thinks that by changing the paint used for the facial features and fingernails that she can increase her rate to 360 dolls per day. Total material cost for each doll is approximately Rs 3.50; she has to invest Rs 20 in the necessary supplies (expendables) per day; energy costs are assumed to be only Rs 4.00 per day; and she thinks she should be making Rs 10 per hour

for her time. Viewing this from a total (multifactor) productivity perspective, what is her productivity at present and with the new paint?

| Currently | Using the new paint | |
|---|---|---|
| Labour | 12 hrs * Rs 10 = Rs 120 | 12 hrs * Rs 10 = Rs 120 |
| Material | 240 * Rs 3.50 = $840 | 360 * Rs 3.50 = Rs1260 |
| Supplies | = Rs 20 | = Rs 20 |
| Energy | = Rs 4 | = Rs 4 |
| Total Inputs | = Rs 984 | = Rs 1404 |
| Productivity | 240/984 = 0.24 | 360/1404 = .26 |

## 9.4 WORK STUDY

Work Measurement Study is a general term used to describe the systematic application of industrial engineering techniques to establish the work content and time it should take to complete a task or series of tasks.

Work measurement is a productivity improvement tool. Before improvements can be made, the current productivity level of an organization must be measured. This measurement is then used as a baseline to determine if improvement projects have resulted in genuine improvement.

Work measurement helps to uncover non-value added areas of waste, inconsistency, and non-standardization that exist in the workplace. Work measurement studies uncover ways to make work easier, and to produce products or services more quickly and economically.

Work is measured for four reasons:

1. To discover and eliminate lost or ineffective time.
2. To establish standard times for performance measurement.
3. To measure performance against realistic expectations.
4. To set operating goals and objectives.

Work measurement involves the use of engineered labour standards to measure and control the amount of time required to perform a specific task or tasks. While labour standards are most commonly associated with manufacturing or production environments, standards are used in many other types of settings including, but not limited to:

- Service or administrative,
- Warehousing and distribution,

- Retail,
- Janitorial,
- Medical and utilities.

Work Study has two major branches

1. Method Study
2. Time Study or Work Measurement

## 9.5 METHOD STUDY

**Concept and Definition:**

Method study is basically conducted to simplify the work or working methods and must go towards higher productivity. It is always desirable to perform the requisite function with desired goal minimum consumption of resources. Method signifies how a work is to be done i.e. description of how we consume resources in order to achieve our target?

**Methods are integral part of work accomplishment and signify:**

1. How well our methods utilize the limited available resources such as manpower, machines, materials and money.

2. How our methods physically affect production output of the unit.

3. The quality of output obtained by application of our methods.

Thus methods can determine the amount of input materials, time power and money consumed. So methods may be considered the core where one can attempt to reduce the consumption of resources thereby reducing cost per unit output through utilization of proper methods. The method design can decide the cost and quality of output produced.

**Method Study may be defined as:**

"A procedure for examining the various activities associated with the problem which ensures a systematic, objective and critical evaluation of the existing factors and in addition and imaginative approach while developing improvements".

**There are three aspects of its application:**

(1) Method study is concerned with broad investigation and improvement of a shop/section, the layout of equipment and machines and the movement of men and materials.

(2) Motion study is a more detailed investigation of the individual worker/ operator, layout of his machines, tools, jigs and fixtures and movement of his limbs when he performs his job. The ergonomics aspect i.e. study of environment, body postures, noise level and surroundings temperature also form part of investigation.

(3) Micro motion study i.e. much more detailed investigation of very rapid movements of the various limbs of the worker.

So, motion study is an analysis of the flow and processing of material and the movements of men through or at various work stations. Thus motion study analyses the human activities which make up an operation. Whereas method study or methods analysis has been defined as: "systematic procedure for the critical analysis of movements made by men, materials and machines in performing any work".

Now because by definition method study includes the study of all facets of human work and all factors affecting the work so motion study be considered as a part of method study.

**Scope of Method Study:**

**The task of work simplification and compatible work system design concerns the followings:**

(i) Layout of shop floor and working areas or work stations.

(ii) Working conditions i.e. ergonomics etc.

(iii) Handling distances (material movement)

(iv) Tooling and equipment used.

(v) Quality standards to be achieved.

(vi) Operators and operations in achieving the production targets.

(vii) Materials to be used.

(viii) Power required and available.

(ix) Work cycle time.

(x) Working processes.

**All these factors are related to method study and possible improvements may be:**

**(a) Short term:**

The improvements which can be introduced quickly and economically. These may be concerned with management and work force.

**(b) Long term:**

The improvements which are not acceptable to management at present and which require good investment. Improvement approach to method design is essential since a method describes how resource are to be used in order to convert them into desired output (final products) in order to accomplish the purpose through a network of facilities.

Operation and route sheets of production process contains in instructions that how a particular product/component can be manufactured. This usually contains the details about time required to perform the required operation.

The target is the minimization of production costs by affecting the consumer's acceptability by incorporating changes or by developing requisite resigns. But the design engineer will not be responsible for actual implementation of method designed by him. Likewise the Process Engineer will try to select best methods which have most economical sequence of operations by using most efficient infrastructure facilities (may be machines) with processing minimum time.

**Method Study Procedure**

The following general steps describe the procedure for making a method study.

1. Select the job – on which method study is to be applied.
2. Obtain information and record.
3. Examine the information critically.
4. Develop the most practical, economical and effective method by considering real limitations of the situation.
5. Install the new method as standard practice.
6. Maintain the standard practice by regular follow up.

Let us consider these steps in some detail.

**Selection of Job for Method Study**

Practically, any activity or a job is a potential project for improvement but as the work study engineer is to sell his ideas and maintain his existence in the organisation, he should always attempt to select those jobs for improvement which are unpopular among employees or are considered "dirty" by them.

By improving such jobs, he would earn goodwill from the employees as well as the management, and can expect their full cooperation for other studies in the future.

Considerations may be given to the following factors while selecting a job for method study

- Economic Factors
- Technical Factors
- Human Factors

**Economic Factors:**

If the economic importance of a job is small, it is not wise to start or continue a long study. Priorities should be given to those types of job which offer greater potential for cost reduction. Such jobs are easily identifiable, as they have

- High labour content, i.e. they consume more time
- Excessive machine or man idleness
- Higher frequency of occurrence, i.e. they have large demand
- Bottlenecks in production line
- Higher proportion of accidents
- Movement of material or men over long distance
- High scrap and reprocessing costs
- High payment of overtime bills.

**Technical Factors:** The method study engineer must have the necessary technical knowledge about the job to be studied. Only surface knowledge about the subject may not lead to the right solution to the real problem. To illustrate, consider that a particular machine tool in proving bottleneck. The output from this machine is not reaching the assembly line in the required quantity. Through a preliminary study, it is found that it is running at lower speed and feed than that recommended for the pair of work and tool material used. Just increase in speed or feed may not be the solution of this problem. It may be possible that the machine itself is not rigid enough to operate at higher speeds or take a deeper cut. Just increase in speed may increase the output but the quality of job may be seriously affected. Technical expertise in machine tools and metal cutting process would be essential to solve problem of this kind.

**Human Factors:** Emotional reaction of the workers to the method study and changes in method are important considerations. If the study of a particular job is suspected to cause unrest or ill feeling, it should not be undertaken, however useful it may be from the economic point of view. It is always better to take up first those jobs which are considered 'dirty', unsafe, unpleasant, boring, or highly fatiguing, and improvements brought about as a result of method study. This would possibly ensure cooperative from the workers for the other jobs as well.

After it is recognized that a problem exists, the first step is to properly formulate it. From the general statements like "Costs are too high", "Increase the production", "Reduce shop floor accidents", it is necessary to determine just what the real problem is. After it is ascertained that the problem merits consideration, it is decided whether this is the proper time to solve it, and how much time can be spent in solving it. The problem may then be defined broadly giving minimum constraints at this stage, as it will permit the use of imagination and creativity in finding a solution. It may sometimes be desirable to divide the complete problem into a couple of small problems and solve them.

**Different Types of method Study**

**Operation Process Chart:**

An operation process chart provides the chronological sequence of all operations and inspections that occur in a manufacturing or business process. It also shows materials used and the time taken by operator for different elements of work. Generally a process chart is made for full assembly, that is, it shows all the operations and inspections that occur from the arrival of raw material to the packaging of the finished product. A detailed chart is drawn is using these symbols.

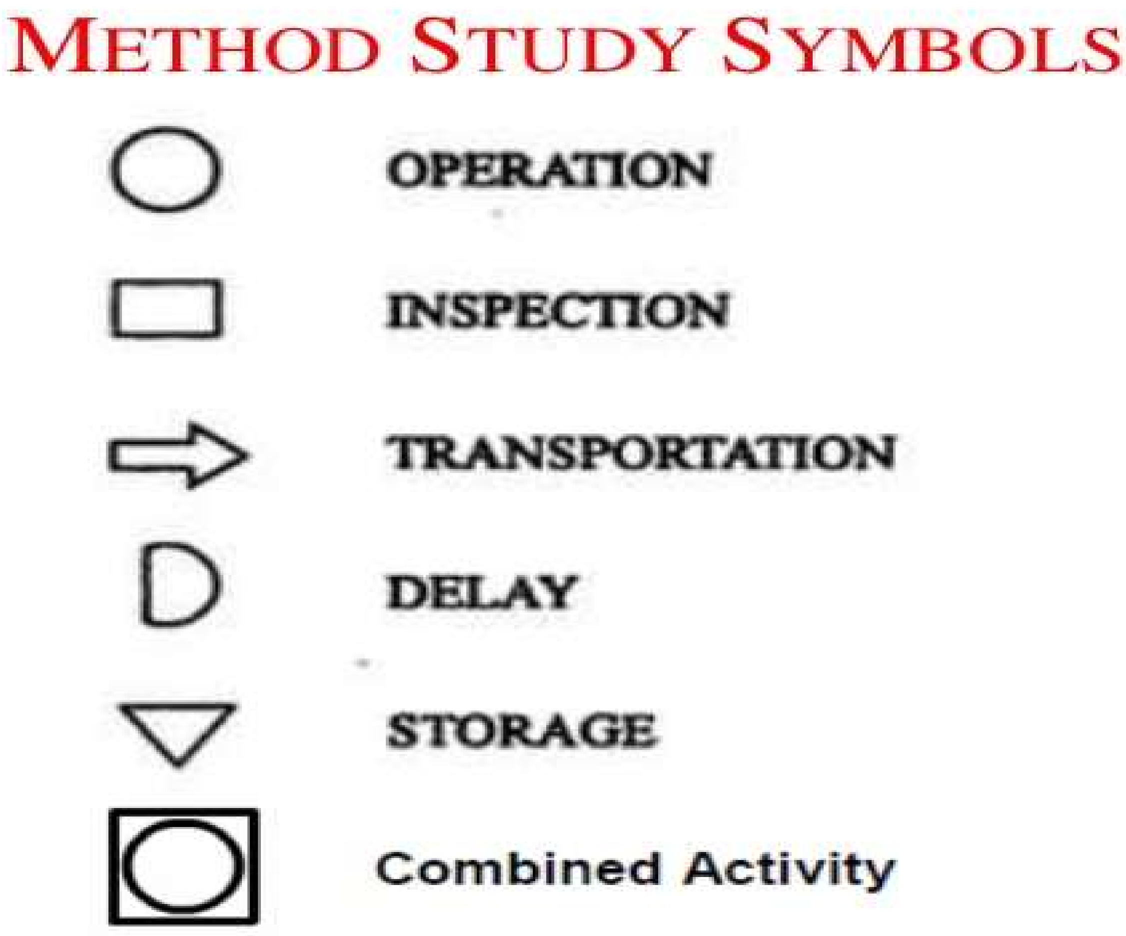



**Fig 9.1 Method Study Symbols**

**Flow Process Chart:**

A flow process chart is used for recording greater detail than is possible in an operation process chart. It is made for each component of an assembly rather than for the whole assembly.

A flow process chart shows a complete process in terms of all the elements of work. There are two main types of flow charts: product or material type , and the operator type . The product type records the details of the events that occur to a product or material, while the operator flow chart details how a person performs an operational sequence.

An important and valuable feature of this chart is its recording of non-productive hidden costs, such as delays, temporary storages, unnecessary inspections, and unnecessary long distances traveled. When the time spent on these non productive activities is highlighted, analyst can take steps to minimize it and thus reduce costs.

**Operator Process Chart :**

It is also called Left Hand – Right Hand chart and shows the activities of hands of the operator while performing a task. It uses four elements of hand work: Operation, Delay (Wait), Move and Hold. Its main advantage lies in highlighting un-productive elements such as unnecessary delay and hold so that analyst can take measures to eliminate or shorten them.

**Multiple Activity Chart:**

Worker-Machine process chart and gang process chart fall in the category of multiple activity charts. A worker-machine chart is used for recording and analyzing the working relationship between operator and machine on which he works. It is drawn to time scale. Analysis of the chart can help in better utilization of both worker and machine time. The possibility of one worker attending more than one machine is also sought from the use of this chart.

A gang process chart is similar to worker-machine chart, and is used when several workers operate one machine. The chart helps in exploring the possibility of reducing both the operator time and idle machine time.

**Simo Chart:**

A Simo chart is another Left-Hand Right-Hand chart with the difference that it is drawn to time scale and in terms of basic motions called therbligs. It is used when the work cycle is highly repetitive and of very short duration.

## 9.6 TIME STUDY

Time study is also called work measurement. It is essential for both planning and control of operations. According to British Standard Institute time study has been defined as *"The* application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

**Steps in Making Time Study**

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work. Steps in taking the time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Breakdown the operation into elements. An element is a instinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.
4. Measure the time by means of a stop watch taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, assess the operators effective speed of work relative to the observer's concept of 'normal' speed. This is called performance rating
6. Adjust the observed time by rating factor to obtain normal time for each element

**Computation of Normal Time**

Since all workers can not perform at same speed, one cannot take the observed time as the normal required to complete a task. The selected worker could be slow, normal or fast worker. Hence normal time to perform a work has to be considered here. The normal time required to perform a work can be computed by

Normal Time = Observed time X Rating factor of the observed worker

7. Add the suitable allowances to compensate for fatigue, personal needs, contingencies etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards wherever necessary.

**Computation of Standard Time**

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance. The various allowances are added to the normal time as applicable to get the standard time "Components standard time".

Standard time may be defined as the, amount of time required to complete a unit of work:

(*a*) Under existing working conditions,

(*b*) Using the specified method and machinery,

(*c*) By an operator, able to the work in a proper manner, and

(*d*) At a standard pace.

Thus basic constituents of standard time are:

1. Elemental (observed time).
2. Performance rating to compensate for difference in pace of working.
3. Relaxation allowance.
4. Interference and contingency allowance.
5. Policy allowance.

***Steps in time study***

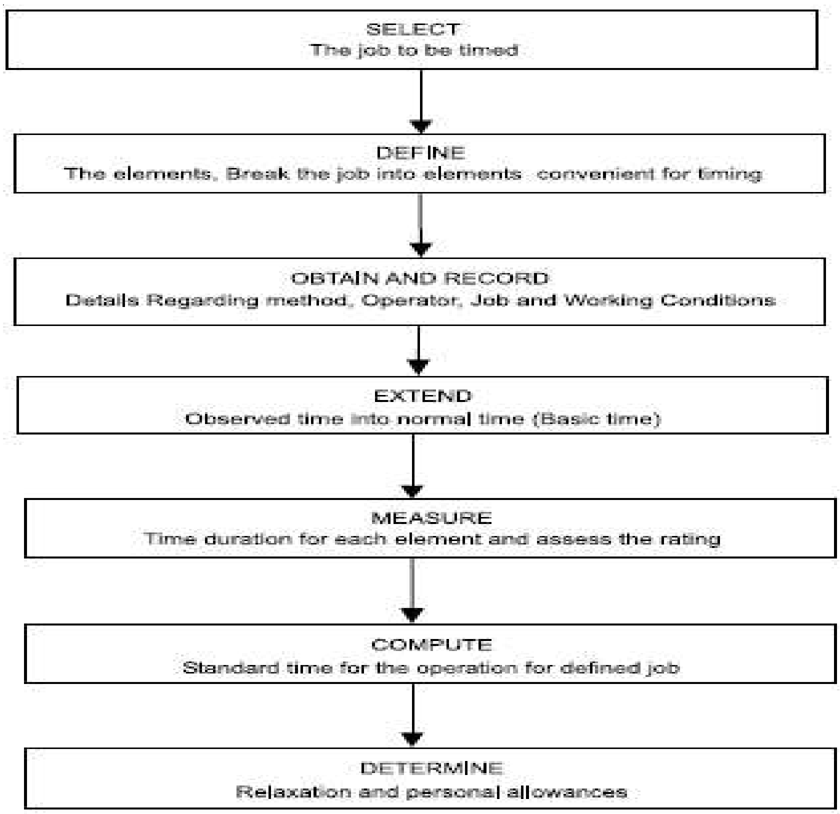
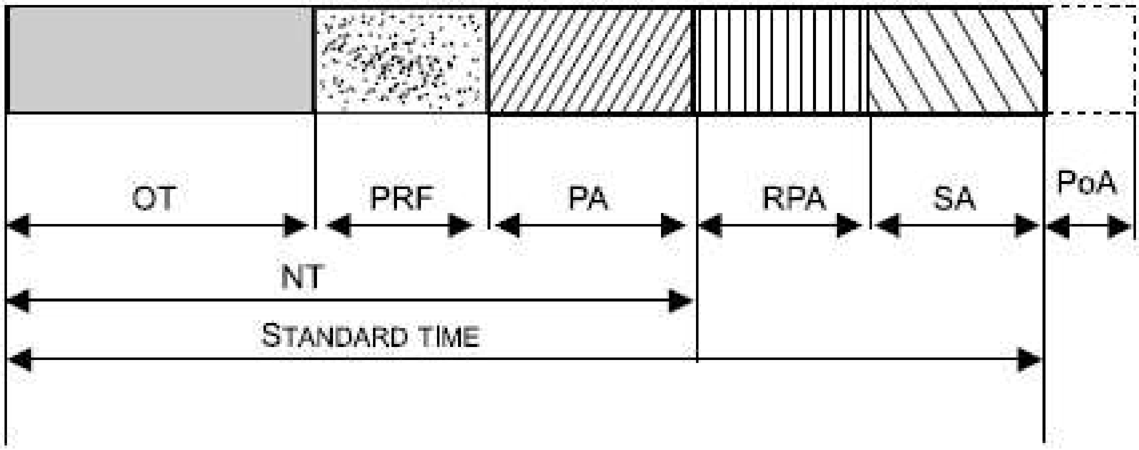



***Fig 9.2 Steps in Time Study***




| | | |
|---|---|---|
| OT | – | Observed Time |
| PRF | – | Performance Rating Factor |
| NT | – | Normal Time |
| PA | – | Process Allowances |
| RPA | – | Rest and Personal Allowances |
| SA | – | Special Allowances |
| PoA | – | Policy Allowances |

**Fig 9.3** ***Components standard time***

***Allowances***

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed.

Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorized as:

1. Relaxation allowance,
2. Interference allowance, and
3. Contingency allowance.

***RELAXATION ALLOWANCE***

Relaxation allowances are calculated so as to allow the worker to recover from fatigue. Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types: fixed allowances and variable allowances.

***Fixed allowances*** constitute:

***a. Personal needs allowance:***

It is intended to compensate the operator for the time necessary to leave, the workplace to attend to personal needs like drinking water, smoking, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5% for men, and 7% for women.

***b. Allowances for basic fatigue:***

This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

***VARIABLE ALLOWANCE***

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job. The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

***INTERFERENCE ALLOWANCE***

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs. Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

***CONTINGENCY ALLOWANCE***

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays. The precise measurement of which is uneconomical because of their infrequent or irregular occurrence.

This allowance provides for small unavoidable delays as well as for occasional minor extra work: Some of the examples calling for contingency allowance are:

- Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
- Power failures of small duration.

- Obtaining the necessary tools and gauges from central tool store. Contingency allowance should not exceed 5%.

***POLICY ALLOWANCE***

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances. The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, *e.g.*, work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

**Problem 1:**

Vishwas Guptha, a marketing surveyor, takes an average of 10 minutes to complete a particular questionnaire. Vishwas's performance rating (pace) is 110% and there is an allowance of 15%.

What is the Normal time for completing this questionnaire?

What is the Standard time for completing this questionnaire?

Normal time = (total time)(%working on this task)(rating)/(number of units produced)

$$= (10)(1.00)(1.10)/1 = 11 \text{ minutes}$$

$$\text{Standard time} = \frac{\text{Total Normal time}}{\text{1-Allowance factor}} = \frac{11}{1-0.15} = \frac{11}{.85} = 12.9 \text{ minutes}$$

**Problem 2:**

Tom Leonard, of Leonard, Spitz, and Wareham, takes 3 hours and 25 minutes to write an end of month report. Tom is rated at 95% (work pace is 95%) and the office has a personal time allowance of 8%. There is no delay time or fatigue time.

What is the Normal time for writing an end of month report?

What is the Standard time for writing an end of month report?

Normal time = (total time)(%working on this task)(rating)/(number of units produced)

$$= (205 \text{ minutes})(1.00)(0.95)/1 = 194.75 \text{ minutes}$$

$$\text{Standard time} = \frac{\text{Total Normal time}}{\text{1-Allowance factor}} = \frac{194.75}{1-0.08} = \frac{194.75}{.92} = 211.68 \text{ minutes}$$

**Problem 3:**

The two steps in preparing chocolate candy bars are molding and packaging. Personal fatigue and delay allowances are set at 15%. The molding machine operator is rated at 110% and the packer is rated at 80%. Observed times per batch are given below.

| | Observed Time in Minutes | | | |
|---|---|---|---|---|
| Task | 1 | 2 | 3 | 4 |
| Molding | 26 | 30 | 29 | 31 |
| Packing | 45 | 50 | 35 | 30 |

Determine the Normal and standard times for both tasks.

| | Observed Times in Minutes | | | |
|---|---|---|---|---|
| Task | 1 | 2 | 3 | 4 |
| Molding | 26 | 30 | 29 | 31 |
| Packing | 45 | 50 | 35 | 30 |

For Molding:

Average for the actual Molding cycle = 29 minutes per batch

Normal time = (total time)(% working)(rating)/(number of units produced)

= (29)(1.00)(1.10) / 1 = 31.9 minutes per batch

Standard time = (Normal time)/(1-Allowance)

= 31.90 /(1 – 0.15) = 37.5 minutes per batch

For Packing:

Average actual Packing time = 40 minutes

Normal time = (total time)(%working)(rating)/(number of units produced)

= (40)(1.00)(.80) = 32 minutes per batch

Standard time = (Normal time)/(1-Allowance)

= (32)/(1 – 0.15) = 37.6 minutes

**Problem 4:**

A work-study sample of a manufacturing activity conducted over a 40-hour period shows that a worker with an 85% rating produced 12 parts. The worker's idle time was 10% and the allowance factor was 12%

Find the Normal and Standard time for this activity.

Average actual time = 40 hours

Normal time = (total time)(%working)(rating)/(number of units produced)

= (40hrs)(0.90)(0.85)/(12) = 2.55 hours per part

Standard time = (Normal time)/(1-Allowance)

= 2.55 / 0.88 = 2.90 hours per part

**Problem 5:**

Jim and Bob recently time-studied a janitorial task. From a sample of 75 observations, they computed an average cycle time of 15 minutes with a standard deviation of 2 minutes. Was their sample large enough that one can be 99% confident that the standard time is within 5% of the true value?

To find the number of samples required:

$n = \left( \frac{z\sigma}{h - \bar{x}} \right)^2$ where $h$ is the accuracy desired and $z$ is the confidence level

$$n = \left( \frac{2.575 * 2}{0.05 * 15} \right)^2 = \left( \frac{5.15}{.75} \right)^2 = 47.15 \text{ or } 48 \text{ samples}$$

Therefore, the sample size of 75 is sufficient.

**Problem 6:**

Consider the following task broken down into 5 elements:

| | TMUs | Code in MTM Books |
|---|---|---|
| Reach to tool box | 14.2 | R12D |
| Grasp a tool | 3.5 | BG1 |
| Separate tool by pressing | 10.6 | AP2 |
| Turn tool | 3.5 | T45S |
| Move and focus eyes | 13.4 | M12B |

What is the total time for the Task?

| | TMUs | Code in MTM Books |
|---|---|---|
| Reach to tool box | 14.2 | R12D |
| Grasp a tool | 3.5 | BG1 |
| Separate tool by pressing | 10.6 | AP2 |
| Turn tool | 3.5 | T45S |
| Move and focus eyes | 13.4 | M12B |
| TOTAL | 45.2 | |

Remember: 1 TMU = .0006 minutes.

Translating to minutes: 45.2 TMUs * .0006 = .027 minutes

Translating to seconds: .027 minutes * 60 = 1.627 seconds

## 9.7 WORK MEASUREMENT

The fundamental purpose of work measurement is to set time standards for a job. Standards are important because of the reasons listed below:

1. **To schedule work and allocate capacity:** All scheduling approaches require some estimate of how much time it takes to do the work being scheduled.

2. **To provide an objective basis for motivating the workforce and measuring their performance:** Measured standards are particularly critical where output-based incentive plans are employed.

3. **To bid for new contracts and to evaluate performance on existing ones:** Questions such as "can we do it?" and "how are we doing?" presume the existence of standards.

4. **To provide benchmarks for improvement:** In addition to internal evaluation, benchmarking teams regularly compare work standards in their company with those of similar jobs in other organizations.

Work measurement and its resulting work standards have been controversial since Taylor's time. Much of the criticism has come from unions, which argues that management often sets standards that cannot be achieved on regular basis. Despite these criticisms, work measurement and standards have proven to be effective. Much depends on sociotechnical aspect of the work.

To produce effectively and efficiently, management must establish goals for evaluating employee performance. These goals are translated into standards. A production and operation standard is a quantified criterion for measuring output. The standard can be set for quantity, quality, cost or any other attribute of output and it is the basis for control.

## 9.8 LEARNING CURVE AND ITS APPLICATIONS:

As an organization gains experience in manufacturing a product, the resources inputs required per unit of output diminish over the life of the product. For example the hours of labour that go into manufacturing the first unit of a new automobile are typically higher than those need for the one-hundredth unit. As the cumulative output of the model grows, the labour inputs continue to decline. As the number of repetitions of doing a task increases, improvement results from the development of individual skills, plus other factors such as better organization of work improved methods, and enhanced work environment. This learning pattern applies to group and organizations as well as individuals. The general form of this pattern is termed as "Learning Curve". A learning curve is a line displaying the relationship between unit production time and the number of consecutive units produced.

**Learning Curve Applications:**

Learning or experience curve theory has a wide range of application in the business. In manufacturing, it can be used to estimate the time for product design and production, as well as costs. Learning curves are important and sometimes overlooked as one of the trade offs in Just-in time systems, where sequencing and short runs achieve lower inventories by forfeiting some advantages of experience benefits from long product runs.

Learning curves are also an integral part in planning corporate strategy, such as decisions concerning pricing, capital investment, and operating costs based on experience curves. Learning curves can be applied to individuals or organizations. Individual learning is improvement that results when people repeat a process and gain skill or efficiency from their own experience. Organizational learning results from practice as well but also comes from changes in administration, equipment, and product design. In organizational settings, both kinds of learning occurs simultaneously and often described the combined effect with a single learning curve.

## 9.9 NOTES

## 9.10. SUMMARY

In this unit we discussed about job design and work measurement. Outstanding organizations have designed jobs that use booth the mental and physical capabilities of their employees. Work methods can often be improved by conducting a scientific study of present methods using well developed questioning techniques and principles of motion economy.

Standards of performance should encourage the cooperation and participation of the workers to whom they will apply. Historical approaches, time studies, predetermined time methods, and work samplings are all useful ways of developing standards. Both time study and work sampling methods consists of sampling a worker's activities and subjectively rating the worker's performance level to determine a normal time (NT). Allowances are then taken into consideration and a standard time is determined.

Every operations manager has opportunities to foster a favorable work climate among the employees by providing safe working conditions, just wages, and environment that gives employees a stake in what the organization is doing.

## 9.11 SELF ASSESSMENT QUESTIONS

1. Define productivity. What are the ways to improve productivity?
2. Explain the Key methods of method study
3. Differentiate between observed time, normal time and standard time
4. Explain the use of learning curves in operations

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# UNIT-10 : JUST-IN – TIME AND KANBAN SYSTEM

**Structure:**

## 10.0 OBJECTIVES

**After studying this unit, You will be able to;**

- Define JIT
- Appreciate the Japaneese approach to quality improvement
- Apply JIT to service organization
- Explain Kanban System

## 10.1 INTRODUCTION

Several concepts have been lately developed in Japan and elsewhere, which are useful in improving the performance of the company in general and quality of goods in particular. The ultimate aim of JIT is to achieve "perfection" in process through continuous improvement and elimination of all types of waste.

Consider a situation where we produce the required goods only at the time when they are required and in the quantity that is needed, applicable for both for finished products and semi-finished goods. If such a situation materializes, the inventories of finished goods and work-in-progress would almost be nil. If the supplier also agrees to deliver their goods only at the time and in quantities we need them to, then we are almost eliminating raw material inventories as well. We shall then have virtually zero inventories (or near to zero). This technique of having the raw material supplied just before the production process and thereby reducing the inventory and the cost associated with inventory management is called "Just-in-Time" (JIT) production system founded by Taiichi Ohno at the Toyota Motor Corporation.

## 10.2 JUST- IN -TIME PHILOSOPHY

Just in time is a philosophy of continuous and forced problem solving. With JIT, supplies and components are "pulled" through a system to arrive where they are needed when they are needed. When good units do not arrive just as needed a problem has been identified. This makes JIT an excellent tool to help operations manager add value by driving out waste and unwanted variability. Because there is no excess inventory or excess time in a JIT system, costs associated with unneeded inventory are eliminated and throughput improved. Consequently, the benefits of JIT are particularly helpful in supporting strategies of rapid response and low cost. JIT can be viewed as 'big JIT' and 'little JIT'. Big JIT, also termed as lean production is the philosophy of operations management that seeks to eliminate wastes in all aspects of a firm's production activities: human relation, vendor relations, technology, and the management of materials and inventories. Little JIT focuses more narrowly on scheduling goods inventories and providing service resources where and when required.

## 10.3 JIT DEFINED

According to Monden "JIT is a production system for producing the kind of units needed, at the time needed and in quantities needed"

According to Hall, "JIT is not confined to a set of techniques for improving production defined in the narrowest way as material conversion".

"JIT is the successful completion of a product or service at each stage of production activity from vendor to customer just in time for its use and at a minimum cost"

"JIT is a manufacturing system whose goal is to optimize processes and procedures by continuously pursuing waste reduction".

## 10.4 JAPANESE APPROACH

The Japanese have had a national goal of full employment through industrialization since World War II. The strategy for obtaining market dominance has been targeted to specific product areas. Industries with competitive advantage were selected. To improve the country's competitive position, they imported technology. Instead of inventing new technology, they avoided major R&D expenditure and corresponding risks by buying licensing agreements from US companies. To make these products they concentrated their effort on the factory shop floor to achieve high productivity and lower unit cost. They directed their best engineering talent to the shop floor, not to product design activities. They also worked to improve product quality and reliability above what competitors could supply. Two philosophies, elimination of waste and respect for people supported their effort of achieving competitive advantage.

**JIT Movement in Japan:**

JIT movement in Japan received a tremendous boost with the formation of a new corporate grouping called "New Production System Research Association" (NPSRA). This association promises to usher in the second phase of JIT movement in Japan. NPSRA helped many member companies resulting in drastic improvements in their business in a short period of time. NPSRA continues to provide a tremendous trust to the future of growth of JIT in Japan, particularly amongst the smaller and medium sized organizations.

## 10.5 ELIMINATION OF WASTE

Waste in Japan, as defined by Toyota's Fujio Cho, is anything other than the minimum amount of equipment, material, parts and workers (working time) which are absolutely essential to production". The seven elements that address elimination of waste are:

- Focused Factory networks.
- Group Technology.
- Quality at source

- JIT production.
- Uniform plant loading
- Kanban production control system.
- Minimized setup time.

**Focused Factory Networks:**

Japanese build small-specialized plants rather than large vertically integrated manufacturing facilities. They find large operations and their hierarchies difficult to manage and not in line with their management styles. Plants designed for one purpose can be constructed and operated more economically.

**Group Technology:**

Group technology, while invented in US was most successfully employed in Japan. Instead of transferring jobs from one department to another specialized worker, Japanese consider all operations required to make a part and group those machines together. Group technology cells eliminate movement and queue (waiting) time between operations, reduce inventory, and reduce the number of workers required. Workers must be flexible to run several machines and processes.

**Quality at Source:**

Quality at the source means do it right the first time and when something goes wrong, stop the process or assembly line immediately. Workers become their own inspectors, personally responsible for the quality of their outputs. Workers concentrate on one part of the job at a time so quality problems are uncovered. If the pace is to fast, if the worker finds a quality problem, or if a safety issue is discovered, the worker is obligated to push a button to stop the line and turn on a visual signal. People from other areas respond to the alarm and the problem. Workers are empowered to do their maintenance and housekeeping until the problem is fixed.

**JIT Production:**

JIT means producing what is needed and when needed and no more. Anything over the minimum amount necessary is viewed as waste, since effort and material expended for something not needed now cannot be utilized now. JIT has been applied to repetitive manufacturing but does not require large volumes and is not limited to processes that produce the same part over and over.

Under JIT the ideal lot size is one. A worker completes the task and passes it on to the next worker for processing. While workstations may be geographically dispersed, the Japanese minimize the transit time and keep transfer quantities small-typically one-tenth of a day's production is a lot size. Vendors even ship several times a day to their customers to keep lot size small and inventory low. When all queues are driven to zero, inventory investment is minimized, lead-time are shortened, firms can react faster to demand changes and quality problems are uncovered.

**Uniform Plant Loading:**

Smoothing the production flow to dampen the reaction waves that normally occur in response to schedule variations is called 'Uniform plant loading'. When a change is made in the final assembly, the changes are magnified throughout the line and the supply chain. The only way to eliminate the problem is to make adjustments as small as possible by setting a firm monthly production plan for which the output rate is frozen.

The Japanese found they could do this by building the same mix of products every day in small quantities. Thus they always have a total mix available to respond to variations in demand.

**Kanban Production Control System:**

One way to achieve small lot sizes is to move inventory through the shop only as needed rather than pushing it on to the next workstation whether or not the personnel there are ready for it. When the inventory is moved only as needed, it is referred to as a pull system.

A Kanban control system uses a signaling device to regulate JIT flows. In Japanese Kanban means "Sign" or "Instruction card". In a paperless control system, containers can be used instead of cards. The cards or containers make up the "Kanban pull system", which signals the need for another container of material. The card is the authorization for the next container of material to be produced. Typically, a Kanban signal exists for each container of items to be obtained. An order for the container is then initiated by each kanban and "pulled" from the producing department or supplier. A sequence of kanbans "pulls" the material through the plant.

Other signals rather than cards are also used to initiate production and can include voice directions, flashing colored lights over a work center, electronic messages sent via computer terminal, or a signal marker hanging on a post by the workstation. In a system where operations are within sight of each other, no cards are needed at all- only a strict restriction on the inventory between operations. This can be done by marking a space or square between operations called Kanban square. If square are empty, workers fill them up and leave no extras. A Kanban system can set reorder quantities equal to the numbed of parts held by the inventory bin or equal to the amount with drawn from the bin.

**Minimized Setup Times:**

Because small lot sizes are the norms, machine setups must be quickly accomplished to produce the mixed models on line. For example in early 1970s Toyota team took just 10 minutes to change a 800 ton press as compared with the average of six hours for US workers and four hours for German workers. To achieve such setup time's reduction, setups are divided into internal and external activities. Internal setups must be done while q machine is stopped. External setups can be done while the machine is running. Other time- saving devices such as duplicate tool holders are also used to reduce setups.

## 10.6 JUST-IN-TIME IMPLEMENTATION REQUIREMENTS

Some of the requirements for Just-in-Time implementation are as listed below:

**JIT Layouts and Design Flow:**

JIT requires the plant layout to be designed to ensure a balanced workflow with a minimum of work-in-process inventory. Each workstation is a part of a production line, whether or not a physical line actually exists. Capacity balancing is done using the same logic for an assembly line and operations are linked through a pull system. In addition, care must be taken to understand all aspects of internal and external logistics system tie to the layout.

Preventive maintenance is emphasized to ensure that flows are not interrupted by downtime or malfunctioning equipments. Operators perform much of the maintenance because they are most familiar with their machine and because machines are easier to repair as JIT operations favor several simple machines rather than one large complex one.

The reductions in setup and changeover time are necessary to achieve a smooth flow. Under a traditional approach, setup cost is treated as a constant, under the kanban approach of JIT; setup cost is treated as a variable.

**JIT Application for Line Flow:**

In a pure JIT environment, no employee does any work until the product has been pulled from the end of the line by the market. The product could be a final product or a component used in later production. When a product is pulled, a replenishment unit is pulled from upstream operations. The rules of the flow layout requires employees to keep completed units at their workstation and if some one takes the completed work away, the employee must move upstream in the flow to get additional work to complete.

**JIT Application for Job Shops:**

JIT is traditionally applied to line flows, but job shop environment also offers JIT benefits. The focus of JIT is product flow. Though job shops are characterized by low volume and high variety, JIT can be used if demand can be stabilized to permit repetitive manufacture. Stabilizing demand is usually easier to accomplish when the demand is from a down stream production stage rather than an end user.

In a job shop setup operators could make periodic rounds throughout the facility to pick up empty containers and drop them off at the corresponding upstream work centers and pick up full containers. The handling procedure can be manual or automated, but either way, these periodic pickups and drop-offs allow the system to operate in a Just-in-Time mode.

**Total Quality Control (TQC):**

TQC is the practice of building quality into the process and not identifying quality by inspection. JIT works at its best since only good quality products are pulled through the system. When all products are good, no "Just- in-case" inventory is needed. Thus organizations can achieve high quality and high productivity.

A component of quality is improved product design. Standard product configurations, fewer parts, and standardized parts are important elements in JIT. These design modifications reduce variability in the end item or in the materials that go into the product. Product design activity can facilitate the process of engineering change.

**A Stable Schedule:**

JIT firms require a stable schedule over a lengthy time horizon. This is accomplished by level scheduling; freeze windows, and underutilization of capacity. A level schedule is the one that requires materials to be pulled into final assembly in a pattern uniform enough to allow various elements of production to respond to pull signal.

The term freeze window refers to that period of time during which the schedule is fixed and no further changes are possible. An added benefit of the stable schedule is seen in how parts and components are accounted for in a pull system. Here the concept of back-flush measurement is used to periodically explode an item's bill of materials to calculate how many of each part went into the final product. This eliminates much of the shop-floor data collection activity, which is required if each must be tracked and accounted for during production.

Underutilization of capacity is a controversial feature of JIT. Excess or underutilized capacity is realized as excess inventory buffers are removed from the system. The safety stocks and early deliveries were used as hedge against production problem like poor quality, machine failure, and unanticipated bottlenecks in traditional manufacturing. Under JIT, excess labour and machine provides the hedge. The excess capacity in labour and equipment that results is much cheaper than carrying excess inventory. During idle periods personnel can be put to work on other activities such as special projects, work group activities, and workstation housekeeping.

**Work with Vendors:**

Just as customers and employees are key components of the JIT system, vendors are also important to the process. If a firm shares its projected usage requirements with its vendors, they have a long run picture of the demand that will be placed on their production and distribution system. Some vendors are linked on-line with a customer to share production scheduling and input need data. This permits them to develop level production systems. Maintaining stock at a JIT level requires frequent deliveries during the day. Some suppliers even deliver to a location on the production line and not at the receiving docks. When vendors adopt quality practices, incoming receiving inspection of their products can be bypassed.

Thus to assess JIT progress, performance measures emphasize the number of processes and practices changed to improve materials flow and reduce labour content. If the process physically improves over time, lower costs follow. Other JIT benefits include lower carrying cost, scrap and quality improvements, worker involvement, higher motivation and morale and productivity increases.

## 10.7 JUST- IN -TIME IN SERVICES

All of the JIT techniques for dealing with suppliers, layout, inventory, and scheduling are used in services just as in case of manufacturing, the suitability of each technique and corresponding work steps depends on the characteristics of the firm's markets, production and equipment technology, skill sets, and corporate culture.

**Upgrade Housekeeping:**

Good housekeeping means that only the necessary items are kept in a work area, that there is a place for everything, and that everything is clean and in constant state of readiness.

Service organizations like McDonald's and Disneyland have recognized the critical nature of housekeeping. Their dedication to housekeeping has meant that services processes work better, the attitude of the continuous improvement is easier to develop, and customers perceive that they are receiving better services.

**Upgrade Quality:**

The only cost-effective way to improve quality is to develop reliable process capabilities. Process quality is quality at the source- it guarantees first time production of consistent and uniform products and services. For example Mc Donald is famous for building quality into its service delivery process. Quality doesn't mean producing the best; it means consistently producing products and services that give customers their moneys worth.

**Clarify Process Flows:**

Clarification of the flows, based on the JIT themes, can drastically improve the process performance for example Federal Express Corporation changed air flight patterns from origin-to-destination to origin-to-hub where the freight is transferred to an outbound plane heading for the destination. This revolutionized the air transport industry. Changes in process flow can literally revolutionize service industries.

**Revise Equipment and Process Technology:**

Revising technologies involves evaluation of the equipment and processes for their ability to meet the process requirements, to process consistently within tolerance, and to fit the scale and capacity of the work group. For example a hospital reduced operating room setup time so that it had flexibility to perform a wider range of operations without reducing the operation room availability.

**Level the Facility Load:**

Service firms synchronize production with demand. They have developed unique approaches to leveling demand so they can avoid making customers wait for service. For example Mc Donald's offers a special breakfast menu in the morning. The post office charges more for the next day delivery. These are examples of the service approach for creating uniform facility load.

**Eliminate Unnecessary Activities:**

A step that does not add value is a candidate for elimination. A step that does add value may be a candidate for reengineering to improve the process consistency or to reduce the time to perform the task. For example a hospital discovered that during an operation significant time was spent waiting for an instrument that was not available when the operation began. It developed a checklist of instruments required for each category of operations

**Reorganize Physical Configuration:**

Work area configuration frequently requires reorganization during a JIT implementation. Often manufacturers accomplish this by setting up manufacturing cells to produce items in small lots, synchronous to demand. These cells amount to 'micro factories' inside the plant. For example some hospitals instead of routing patients all over the building for tests, exams, x-rays and injections-are reorganizing their services into work groups based on the type of problems, resulting in "microclinics" within the hospital facility.

**Introduce Demand–Pull Scheduling:**

Due to the nature of service production and consumption, demand –pull scheduling is necessary for operating a service business.

**Develop Supplier Network:**

Supplier networks in the JIT context refers to the cooperative association of suppliers and customers working over long term for mutual benefits. Service firms have not emphasized supplier networks for material because the service costs are often predominantly labour.

## 10.8 TOYOTA PRODUCTION SYSTEM

The JIT system is developed and ideally practiced at Tayota. Taichi Ohno, Shigeo Shingo and Yasahiro Manden are called pioneers of JIT system.

**Key features of Tayota's Strategy**

Toyota is the richest automobile manufacturer in world having 11.8 % globar share and 40 per cent in Japan. The key strategy is to wait for the competitors to do much of the innovation and if they were successful contradicting with its own version.

It restructured its management, abolished some the management layers and shortened approval procedure. Further it created a network of suppliers. It took the shares in the supplier companies.

**The Philosophy of TPS**

Small lot production, frequent delivery of lots, leveling of production volume, reduction is set up time, use of multi skilled workers etc enabled the Tayota Company to overcome depression and record a high level profit while other companies were suffering from losses. With these techniques the inventory turnover ratio was reduced to 97.

The basic Idea of TPS is to maintain a continuous flow of products in factory in order to flexibly adopt to the demand changes

In order to give importance to cost reduction Toyota gave importance to

1. Quality control
2. Quality assurance
3. Respect for humanity

The Toyota Production system is conceived and conceptualized in Toyota Motars. The Toyota Company was founded by Ejji Tayoda. When his son Kichero Tayoda took up the responsibility of running the Toyota Motar Company, he visited US. He was impressed by the mass production system of Ford and just in time filling up system employed in supermarkets of US. He combined the requisite features of both of these to have his own production system.


**Fig 10.1 Basic Framework of TPS**

The continuous flow manufacturing is achieved through two concepts. Just in time and automation are keys to the success of TPS.

## 10.9 KANBAN SYSTEM

A production control system for Just in Time Production system and making full use of worker's capabilities is the Kanban System. Utilizing Kanban System, workshops of Toyota have lo longer relied upon a electronic computer. Kanban is a Japaneese world meaning Visual Card. These cards are shown to pull, withdraw material from one work station to another station. These cards is to signal the start and stop of production in a workstation. They can look like tickets. They can be sticked on a tray or a pallet or on a cart.

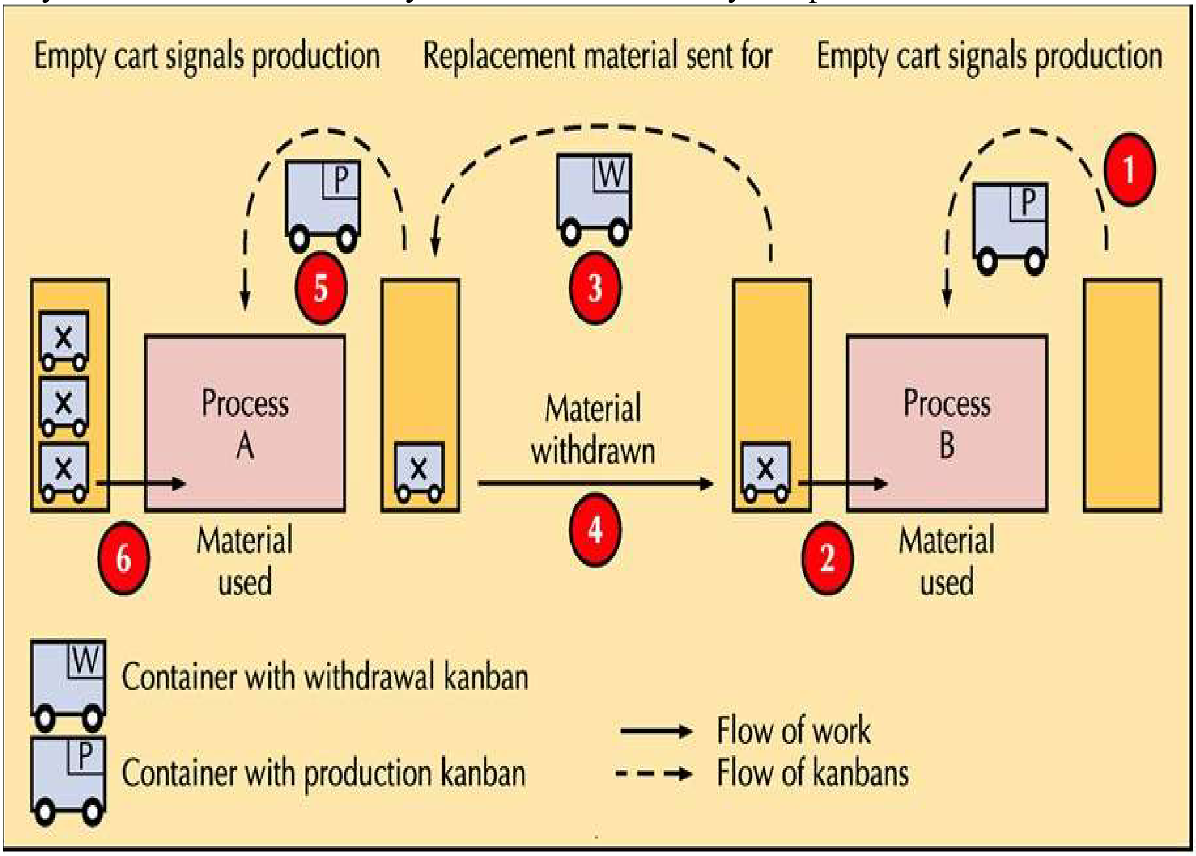


**Fig 10.2 KANBAN SYSTEM**

Assume two processes A and B. A is a preceding process and B is a subsequent process. The following steps are followed in Kanban system of production

1. Process B gets a signal to start production
2. Process B is started by taking material
3. Withdrawal Kanban is issued to process A to produce the part
4. The material at the cart is withdrawn by the Process B
5. The empty cart near Process A signal the work at Process A. It produces the part and places it in the bin
6. Process A withdraws the material near by it

There are two types of Kanban Systems

a. Production Kanban: The production Kanban is used to signal the start of production of a particular item

b. Withdrawal Kanban: The withdrawal Kanban signals the withdrawing of parts from the previous work station

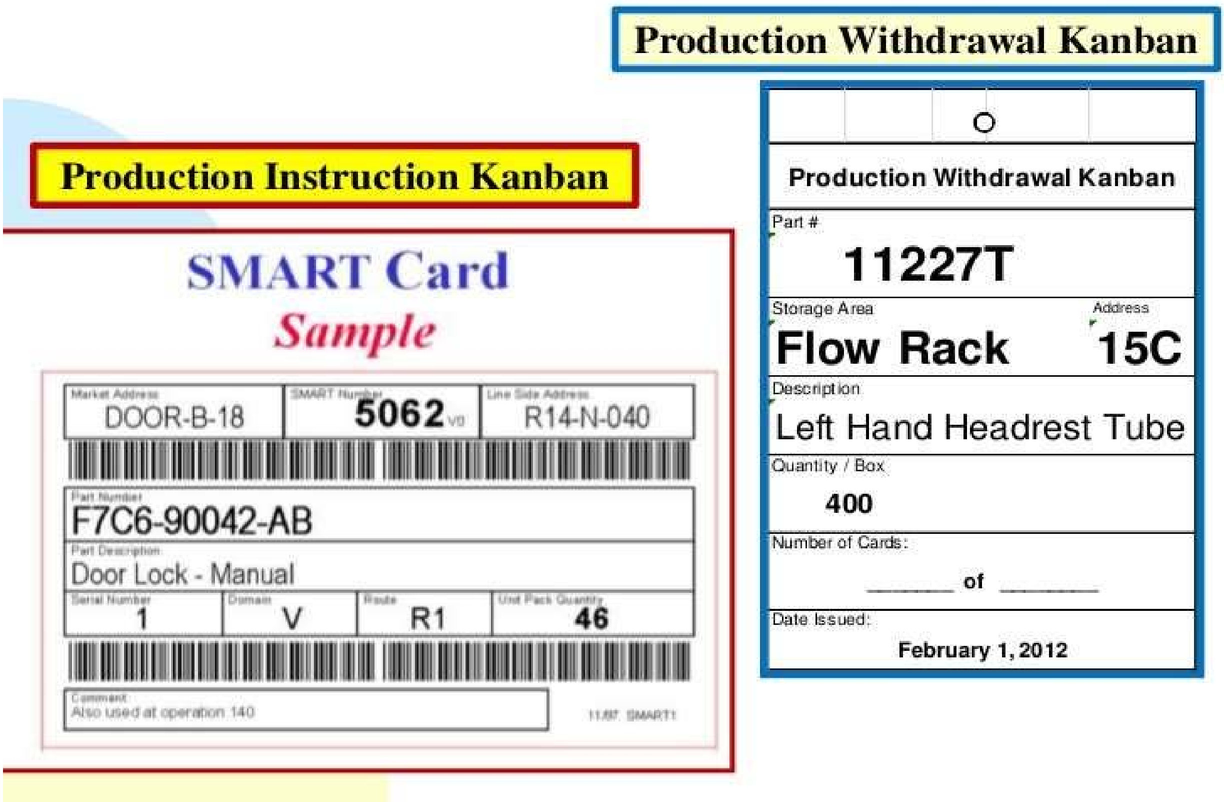


**FIG 10.3 KANBAN CARDS**

**Types of Kanban**

**1. Subcontract Kanban**

It is used to withdraw parts from subcontractor. As there is no separate store for each item Toyota Designate through which gate the product should be delivered.

**2. Emergency Kanban**

Thus is temporarily used for defective work, extra insertion etc. It is issued only for extraordinary purpose and collected after use

**3. Special Kanban**

It is prepared for Job Order. IT is issued and and collected for each job order. It is similar to the emergency Kanban

**4. Signal Kanban**

It used in lot production. It is tagged to a box or a drum containing the parts. If the withdrawal is made down the tagged position of this Kanban, production order must be set in motion.

## 5. Electric Kanban

This is used to withdraw parts between automatic process

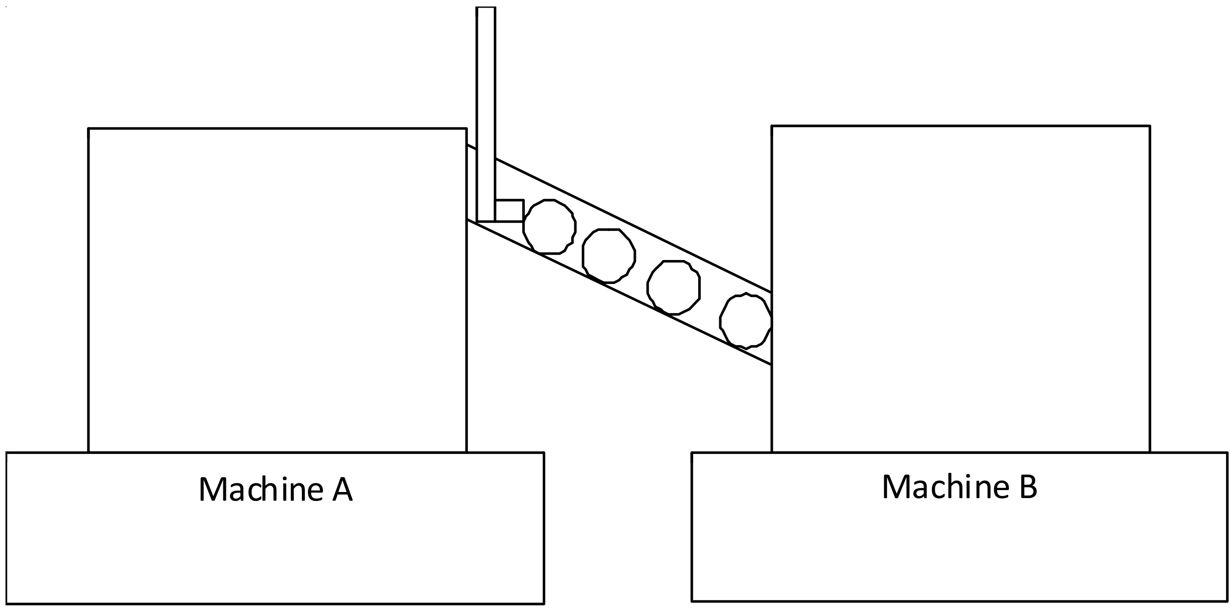


**FIG 10.4 ELECTRIC KANBAN**

When the inventory in the second machine falls below re order point, the first machines starts production. When the second machines gets the required inventor a limit switch automatically stops the operations of the first machine.

## 10.10 NOTES

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## 10.11 SUMMARY

JIT represents a powerful tool for reducing inventory and improving production and service operations. Its principles can result in many improvements. JIT is a philosophy of continuous improvements. It focuses on driving all waste out of the production process. Waste occurs when defects are produced within the production process or by outside suppliers. JIT attacks wasted space because of less-than-optimal layout; it attacks wasted time because of poor scheduling; it attacks waste in idle inventory; it attacks waste from poorly maintained machinery and equipment. JIT expects committed, empowered employees to work with committed management and suppliers to build systems that respond to customers with ever lower and ever higher quality.

## 10.12 SELF ASSESSMENT QUESTIONS

1. Define JIT
2. Explain the Key features of TPS
3. Discuss the applicability of JIT in services
4. Explain KANBAN system with examples

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# UNIT - 11 : MATERIALS AND MAINTENANCE MANAGEMENT

**Structure:**

## 11.0 OBJECTIVES

**After studying this unit, you should be able to;**

- Define material Management
- Explain the importance of purchasing activities
- Describe various material handling equipments
- Explain types of maintenance
- Perform resource requirement planning

## 11.1 INTRODUCTION

Materials constitute a major cost component for any Industry. The total cost of installed materials (may be 60% or more of the total cost, even though the factory cost may be a minor part of the total, probably less than 20-30%. This is because the manufactured item must be stored, transported, and restored before it is put in place or "consumed" at the site. The total cost of materials will include, in addition to the manufacturer selling cost, the cost of procurement (cost of placing processing and paying the material, physical distribution, the distributor's cost, and the transportation of materials), and the site-handling costs (cost of receiving, storage, issuing, and disposal). The efficient procurement and handling of material represent a key role in the successful completion of the work. Further the maintenance of the material, components, machineries and work space is also equally important.

## 11.2 MATERIALS MANAGEMENT

The Webster's dictionary defines materials as "the elements, constituents, or substances of which something is composed or can be made."

Ballot defines materials as the physical materials that are purchased and used to produce the final product and does not suggest that materials are the final product. In other words, materials are the parts used to produce the final product.

Bailey et al. define materials as the goods purchased from sources out of the organization that are used to produce finished products

Materials used in an organization can be classified into five categories. These categories are:.

- **Raw materials-** materials that the company converts into processed parts. This might include parts specifically produced for the company and parts bought directly off the shelf (i.e. bolts, nuts).

- **Purchased parts-** parts that the company buys from outside sources (i.e. rubber parts, plastic parts).
- **Manufactured parts-** parts built by the company (i.e. tower case for a computer).
- **Work in process-** these are semi-finished products found at various stages in the production process (i.e. assembled motherboard).
- **MRO supplies-** maintenance, repairing, and operating supplies used in the manufacturing process but are not part of the final products (i.e. soap, lubricating oil).

**Importance of Material Management:**

Material management is a service function. It is as important as manufacturing, engineering and finance. The supply of proper quality of materials is essential for manufacturing standard products. The avoidance of material wastage helps in controlling cost of production. Material management is essential for every type of concern.

**The importance of material management may be summarized as follows:**

1. The material cost content of total cost is kept at a reasonable level. Scientific purchasing helps in acquiring materials at reasonable prices. Proper storing of materials also helps in reducing their wastages. These factors help in controlling cost content of products.
2. The cost of indirect materials is kept under check. Sometimes cost of indirect materials also increases total cost of production because there is no proper control over such materials.
3. The equipment is properly utilized because there are no break downs due to late supply of materials.
4. The loss of direct labour is avoided.
5. The wastages of materials at the stage of storage as well as their movement is kept under control.
6. The supply of materials is prompt and late delivery instances are only few.
7. The investments on materials are kept under control as under and over stocking is avoided.
8. Congestion in the stores and at different stages of manufacturing is avoided.

**Functions of Material Management:**

Material management covers all aspects of material costs, supply and utilization. The functional areas involved in material management usually include purchasing, production control, shipping, receiving and stores.

**The following functions are assigned for material management:**

**1. Production and Material Control:**

Production manager prepares schedules of production to be carried in future. The requirements of parts and materials are determined as per production schedules. Production schedules are prepared on the basis of orders received or anticipated demand for goods. It is ensured that every type or part of material is made available so that production is carried on smoothly.

**2. Purchasing:**

Purchasing department is authorized to make buying arrangements on the basis of requisitions issued by other departments. This department keeps contracts with suppliers and collects quotations etc. at regular intervals. The effort by this department is to purchase proper quality goods at reasonable prices. Purchasing is a managerial activity that goes beyond the simple act of buying and includes the planning and policy activities covering a wide range of related and complementary activities.

**3. Non-Production Stores:**

Non-production materials like office supplies, perishable tools and maintenance, repair and operating supplies are maintained as per the needs of the business. These stores may not be required daily but their availability in stores is essential. The non-availability of such stores may lead to stoppage of work.

**4. Transportation:**

The transporting of materials from suppliers is an important function of materials management. The traffic department is responsible for arranging transportation service. The vehicles may be purchased for the business or these may be chartered from outside. It all depends upon the quantity and frequency of buying materials. The purpose is to arrange cheap and quick transport facilities for incoming materials.

**5. Materials Handling:**

It is concerned with the movement of materials within a manufacturing establishment and the cost of handling materials is kept under control. It is also seen that there are no wastages or losses of materials during their movement. Special equipment's may be acquired for material handling.

**6. Receiving:**

The receiving department is responsible for the unloading of materials, counting the units, determining their quality and sending them to stores etc. The purchasing department is also informed about the receipt of various materials.

## 11.3 MATERIAL HANDLING

Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption and disposal. As a process, material handling incorporates a wide range of manual, semi-automated and automated equipment and systems that support logistics and make the supply chain work. Their application helps with:

- Forecasting
- Resource allocation
- Production planning
- Flow and process management
- Inventory management and control
- Customer delivery
- After-sales support and service

A company's material handling system and processes are put in place to improve customer service, reduce inventory, shorten delivery time, and lower overall handling costs in manufacturing, distribution and transportation.

**Different Types of Material Handling Equipment**

Material handling equipment encompasses a diverse range of tools, vehicles, storage units, appliances and accessories involved in transporting, storing, controlling, enumerating and protecting products at any stage of manufacturing, distribution consumption or disposal.

**Categories of Material Handling Equipment**

The four main categories of material handling equipment include:

- Storage,
- Engineered systems,
- Industrial trucks and
- Bulk material handling

**Storage and Handling Equipment**

Storage equipment is usually limited to non-automated examples, which are grouped in with engineered systems. Storage equipment is used to hold or buffer materials during "downtimes," or times when they are not being transported. These periods could refer to temporary pauses during long-term transportation or long-term storage designed to allow the buildup of stock. The majority of storage equipment refers to pallets, shelves or racks onto which materials may be stacked in an orderly manner to await transportation or consumption. Many companies have investigated increased efficiency possibilities in storage equipment by designing proprietary packaging that allows materials or products of a certain type to conserve space while in inventory.

**Examples of storage and handling equipment include:**

Racks, such as pallet racks, drive-through or drive-in racks, push-back racks, and sliding racks

- Stacking frames
- Shelves, bins and drawers
- Mezzanines

**Fig 11.1 Storage and Manual Material Handling Devices**

**Engineered Systems**

Engineered systems cover a variety of units that work cohesively to enable storage and transportation. They are often automated. A good example of an engineered system is an Automated Storage and Retrieval System, often abbreviated AS/RS, which is a large automated organizational structure involving racks, aisles and shelves accessible by a "shuttle" system of retrieval. The shuttle system is a mechanized cherry picker that can be used by a worker or can perform fully automated functions to quickly locate a storage item's location and quickly retrieve it for other uses.

 

**Fig 11.2 Engineering Systems**

**Other types of engineered systems include:**

- Conveyor systems
- Robotic delivery systems
- Automatic guided vehicles (AGV)

**Industrial Trucks**

Industrial trucks refer to the different kinds of transportation items and vehicles used to move materials and products in materials handling. These transportation devices can include small hand-operated trucks, pallet-jacks, and various kinds of forklifts. These trucks have a variety of characteristics to make them suitable for different operations. Some trucks have forks, as in a forklift, or a flat surface with which to lift items, while some trucks require a separate piece of equipment for loading. Trucks can also be manual or powered lift and operation can be walk or ride, requiring a user to manually push them or to ride along on the truck. A stack truck can be used to stack items, while a non-stack truck is typically used for transportation and not for loading.

**There are many types of industrial trucks:**

Hand trucks

- Pallet jacks
- Pallet trucks
- Walkie stackers

- Platform trucks
- Order picker
- Sideloader
- Many types of AGV

**Fig 10.3 Pallet Truck**

**Bulk Material Handling Equipment**

Bulk material handling refers to the storing, transportation and control of materials in loose bulk form. These materials can include food, liquid, or minerals, among others. Generally, these pieces of equipment deal with the items in loose form, such as conveyor belts or elevators designed to move large quantities of material, or in packaged form, through the use of drums and hoppers.

- Conveyor belts
- Stackers
- Reclaimers
- Bucket elevators
- Grain elevators
- Hoppers
- Silos

## 11.4 INVENTORY MANAGEMENT

Inventory is a common phenomenon is business. The manufacturing industry has to have inventory to ensure smooth flow of production. An Inventory may be defined as a stock of idle tangible resources of any kind having an economic value. The inventories can be in the form of raw materials, semi-finished goods or finished product to be delivered to the customer. These could even be the human resources such as available unused labour or financial resources such as working capital and so on. For many organisations, inventories may be 30 to 70 per cent of the total assets. It varies from organisation to organisation. It is the level of inventory that matters for any organisation as capital investment is tied up in these resources.

Since it is blocking the working capital, which is so costly, it is not desirable to have -inventory. The inventory requires holding and maintenance or preservation cost. It carries the risk, spoilage, leakage or obsolescence. The cost of keeping inventory may be very high. Hence it is important to have a tight control over the level of inventory build up. It is a necessary evil, a must to keep uncertainty away in order to have business going, but should be kept only to the extent of minimum desired.

Controlling is a process by which the change in the system is modified to maintain the system an optimal performance level. The inventory control is highly desirable in any organization. Excess inventory on one hand results in blocking of working capital where the fewer inventories may affect the production on the other. Few of the examples of inventory in Product/Service industry are given be

Factory: Raw materials, parts and components, semi-finished inventory and finished goods.

Bank: Cash reserve tellers.

Hospitals: Number of beds, specialised personnel and stocks of drugs.

Airline*:* Aircraft seat miles per route, parts for repairs of aircrafts, stewards and other specialist persons for repair and maintenance.

**Terminologies used in Inventory Management**

***1) Demand****:* In order to decide on optimum level of inventory and its control policy, customers requirement in terms of its size (number of items required), the rate (how many items are required and the pattern (whether continuously increasing or decreasing and at what rate, or whether a seasonal demand) need to be collated. Hence demands can be deterministic or probabilistic. Deterministic demands are those types of demands, which can be predicted or known with certainty with a definite time frame whereas probabilistic demands are those, which cannot be known in either form i.e., neither its quantity, nor time schedule nor the pattern be predicted.

***2)*** ***Order Cycle****:* It is the time period between two successive orders placed to meet the demand; it needs to be established, if there is a set pattern in placing the orders. This is possible for such situations demands are known with a definite pattern and are constantly reviewed. But for situations like scale projects, environmental factor take toll of the pattern and order cycle may be difficult to adhere to. Then items are ordered as and w hen required.

***3)*** ***Time Horizon****:* It is the period over which the inventory level will be controlled. It can be finite or infinite depending on the nature of demand.

***4)*** ***Lead Time:*** It is the time elapsed between the time of ordering the item and its actual receipt /place of requirement. Lead time plays a very important role in the inventory control policy. The cost associated with inventory are largely dependent on the lead time, which can be constant, variable, deterministic or probabilistic. The best situation can be JIT (Just-in-time) i.e., the situation of zero lead If the material can be received when item is required, the order need not be placed in advance and may be no requirement for carrying cost. Another good situation exists when lead time is deterministic. All functions of inventory are then under control with definite system. But when lead time ain, then ordering and carrying costs can disturb the balance of inventory control.

***5)*** ***Safety Stock or Buffer Stock:*** It is the level of inventory kept procured when either the lead time is uncertain or the demand is critical and shortage cost may be high. This inventory is planned to meet the demand during uncertain supply period or else to cater for sudden spurt in demand for a short duration.

***6)*** ***Re-order Quantity:*** It is the quantity of items ordered to replenish the exhausted or utilised inventory with a comprehensive inventory policy. It should be the Economic Order Quantity (EOQ) which Should be procured when required.

***7)*** ***Re-order Level:*** It is the level of stock inventory at which it is decided to replenish the stock. It is connected with the lead time, such that the item should be received just at a time when the stock level is at the minimum desired level. In quite a few cases, when safety of buffer stock is planned, the ~e-order level) should cater for the level of consumption of inventory just sufficient to reach Safety stock level during the lead time.

**Reasons for Carrying Inventory**

Some of the important reasons for carrying inventory emerge out of the environmental conditions and can be summarised as follows:

1. Variation in production
2. Variable customer lead time
3. Uncertain vendor reliability in quality

4. Financial gains when prices are uncertain or fluctuate or else when quantity discounts are attractive.

## 11.5 PURCHASE

At first glance, it may seem to be to find and purchase a quantity of material for the best price. But price is not the only concern. Low-priced material may not be a bargain if it is of unacceptable quality or if delivery is not reliable.

Clearly, the purchasing function involves more than obtaining the best price. It also involves buying the best value, which means buying:

- ♦ The right quantity and quality
- ♦ At the best price
- ♦ From suppliers who are reliable and provide good service

One way to obtain the best value on a purchase is to set purchasing objectives and carefully follow the procurement cycle. This is explained later in this section.

**Purchasing Objectives**

It is often helpful to state the goals of purchasing for your business. In this way, you will never lose sight of the purpose of the purchasing function and will be able to make more intelligent purchasing decisions.

Here is a sample list of purchasing objectives:

- ♦ To provide an uninterrupted flaw of materials and services for company operations
- ♦ To find reliable alternative sources of supply
- ♦ To buy at the most economic order quantities
- ♦ To buy the best value: a combination of right quality at the best price with the best supplier service
- ♦ To maintain good relations with vendors

**The Procurement Cycle**

Effective procurement consists of a series of steps which form a cycle. The steps in the cycle can be described as follows:

**1. Determine needs.** Before you buy anything, it is necessary to know what you need to buy and how much. It is important to remember that determining what you need involves not only quantity, but quality decisions as well. Determining and specifying appropriate quality requirements, in some situations, is a more difficult task than deciding what quantity to buy.

**2. Select the supplier(s).** When there are many suppliers to choose from, it is not simple to choose those who will give the best value - not only in price but in service, and consistent quality as well. Selection of suppliers may also mean finding more than one acceptable vendor if the purchased product is so important that you would suffer substantial losses if it were not available. In such a situation, in case the primary supplier cannot meet your needs as a result of a heavy workload, strike, unavailability of raw materials, etc.

When deciding to use more than one supplier, you have to weigh these advantages against the possible disadvantages of higher price and poorer service when you buy smaller quantities from two vendors rather than larger quantities from a single, reliable one.

**3. Negotiate the purchase.** In addition to specifying quantities and obtaining agreement on price, this can involve guarantees, method of payment, containers and packaging, delivery dates and other details of the purchase. Proper documentation of the purchase agreement is part of negotiation and assures that any questions or disputes that may arise will be settled in line with your expectations.

**4. Follow-up.** Here you look at the quality of product and service as well as the accuracy of quantities to determine what improvements, if any, are needed for the future.

## 11.6 RESOURCE REQUIREMENT PLANNING

Resource requirement planning (RRP) is directed at determination of the amount of and timing of production resources such as personnel, materials, cash and production capacity needed to produce the finished products or end items as per master production schedule

Resource requirement planning is also known as rough cut capacity planning. It can be used to evaluate the feasibility of a trail master production schedule. It is aggregate planning tool tat is used to sum up and evaluate the work load that a production plan imposes either on all work centres or on only selected key work centres where resources are limited.

Steps involved in RRP are

a. Developing a trial production plan

b. Computing the work load this production plan will impose on each key work centre

c. The load profile i.e. the load on each work centre over time us evaluated for feasibility by comparing the work load with the available capacity.

d. The plan be revised based on resources at the key work centres

e. The capacity requirement of the revised plan can be evaluated

f. Steps 4 and 5 are repeated until a plan considered to be satisfactory is obtained

Components of Resource Requirement planning

There are mainly two components of RRP namely

a. Material Requirement Planning

b. Capacity requirement Planning

Material requirement planning provides detailed list of materials required such as raw materials, parts and sub assemblies nedded to produce the end items in each time period. A schedule of orders is developed for purchased materials and in house manufacturing items

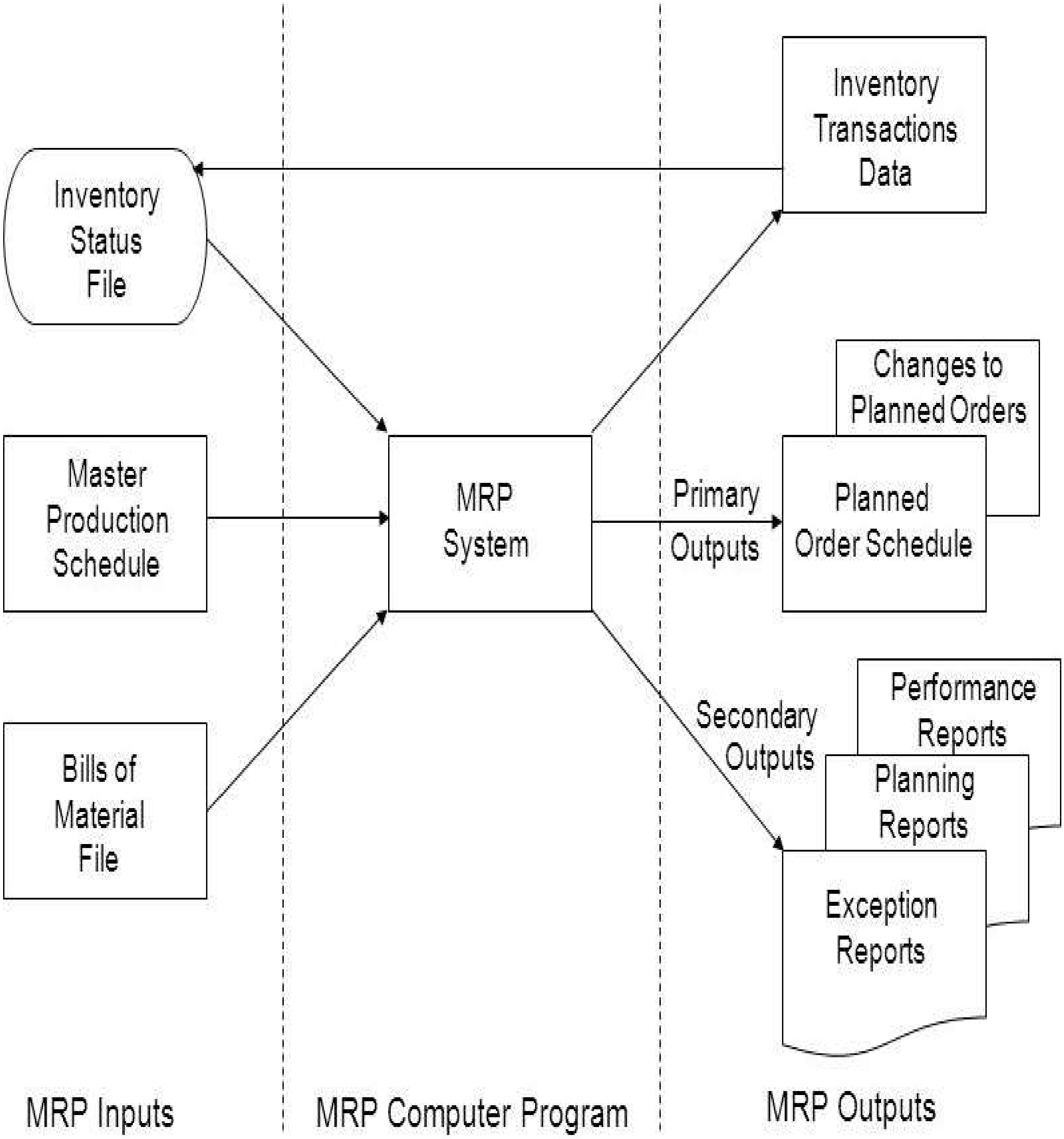


**Fig 11.4 Overview of MRP**

MRP II is extended version of MRP to integrate financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of the basic MRP system, resulting in a broad based coordination system.

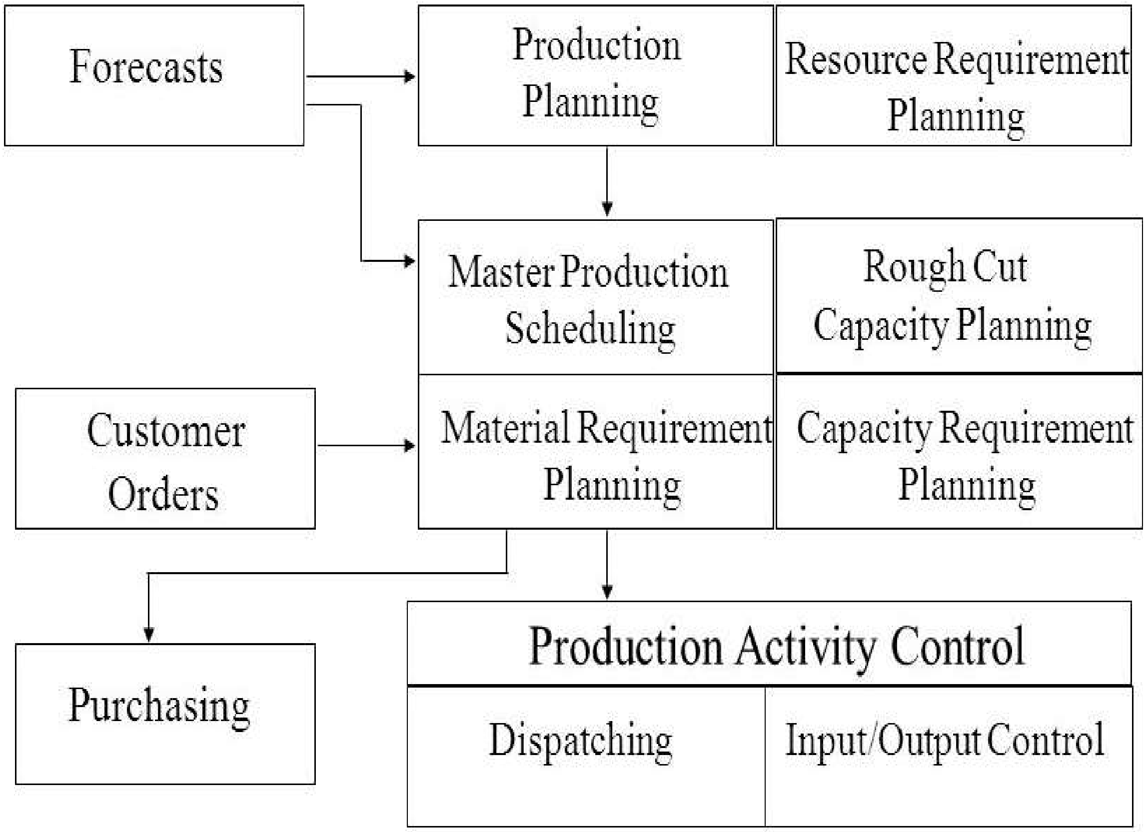


**Fig 11.5 MRP2**

## 11.7 MAINTENANCE MANAGEMENT

Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: “the work of keeping something in proper condition; upkeep.” This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order.

Unfortunately, data obtained in many studies over the past decade indicates that most private and government facilities do not expend the necessary resources to maintain equipment in proper working order. Rather, they wait for equipment failure to occur and then take whatever actions are necessary to repair or replace the equipment. Nothing lasts forever and all equipment has associated with it some predefined life expectancy or operational life. For example, equipment may be designed to operate at full design load for 5,000 hours and may be designed to go through 15,000 start and stop cycles.

The need for maintenance is predicated on actual or impending failure – ideally, maintenance is performed to keep equipment and systems running efficiently for at least design life of the component(s). As such, the practical operation of a component is time-based function. If one were to graph the failure rate a component population versus time, it is likely the graph would take the "bathtub" shape shown in below Figure. In the figure the Y axis represents the failure rate and the X axis is time. From its shape, the curve can be divided into three distinct: infant mortality, useful life, and wear-out periods.

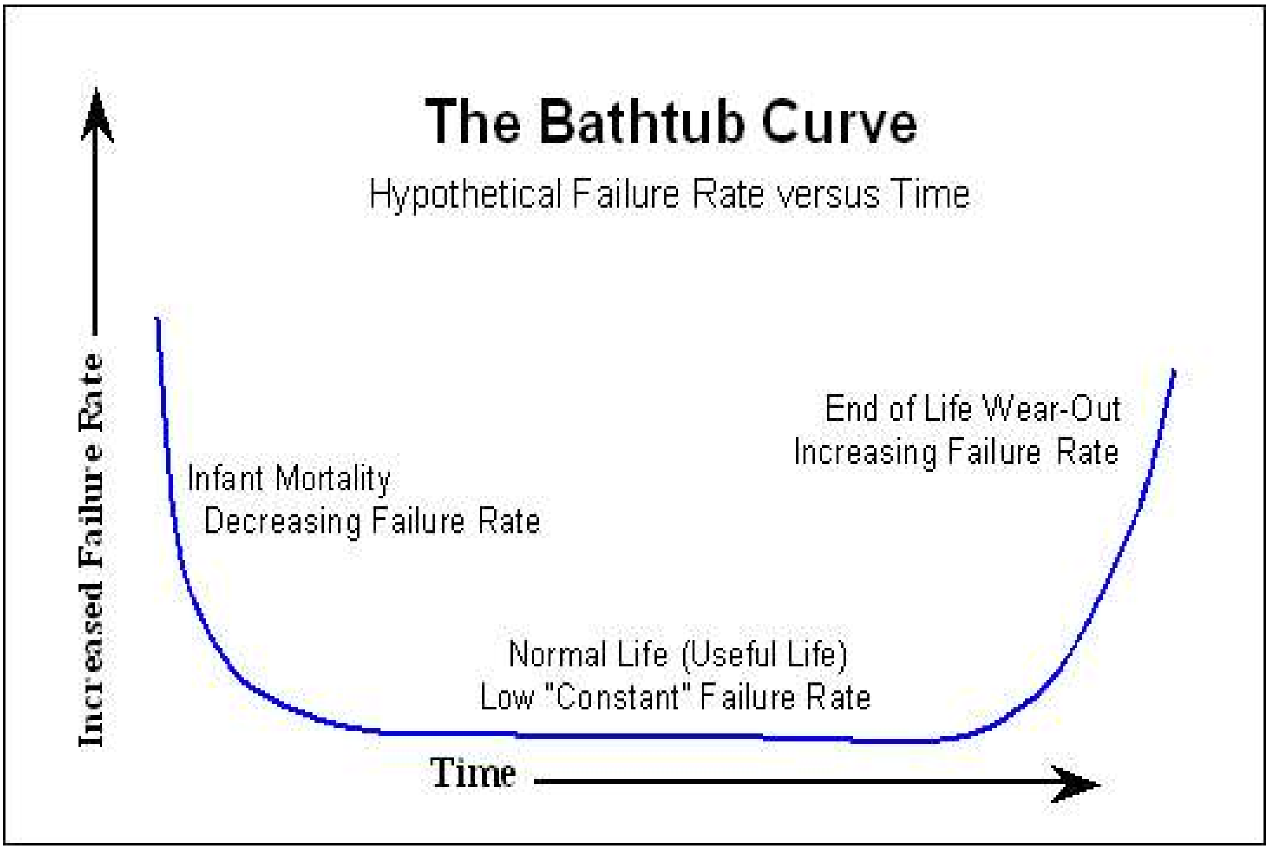


**Fig 11.6 Bath Tub Curve**

**Types of Maintenance**

Traditionally, 5 types of maintenance have been distinguished, which are differentiated by the nature of the tasks that they include:

♦ **Corrective maintenance:** The set of tasks is destined to correct the defects to be found in the different equipment and that are communicated to the maintenance department by users of the same equipment.

- **Preventive Maintenance:** Its mission is to maintain a level of certain service on equipment, programming the interventions of their vulnerabilities in the most opportune time. It is used to be a systematic character, that is, the equipment is inspected even if it has not given any symptoms of having a problem.
- **Predictive Maintenance:** It pursues constantly know and report the status and operational capacity of the installations by knowing the values of certain variables,which represent such state and operational ability. To apply this maintenance, it is necessary to identify physical variables (temperature, vibration, power consumption, etc.). Which variation is indicative of problems that may be appearing on the equipment. This maintenance it is the most technical, since it requires advanced technical resources, and at times of strong mathematical, physical and / or technical knowledge.
- **Zero Hours Maintenance (Overhaul):** The set of tasks whose goal is to review the equipment at scheduled intervals before appearing any failure, either when the reliability of the equipment has decreased considerably so it is risky to make forecasts of production capacity . This review is based on leaving the equipment to zero hours of operation, that is, as if the equipment were new. These reviews will replace or repair all items subject to wear. The aim is to ensure, with high probability, a good working time fixed in advance.
- **Periodic maintenance (Time Based Maintenance TBM):** the basic maintenance of equipment made by the users of it. It consists of a series of elementary tasks (data collections, visual inspections, cleaning, lubrication, retightening screws,…) for which no extensive training is necessary, but perhaps only a brief training. This type of maintenance is the based on TPM (Total Productive Maintenance).

## 11.8 NOTES

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## 11.9 SUMMARY

The manufacturing operations calls for several activities with in the factory premises. The production planning has to be done. Materials should be ordered and be procured. The purchased items have to stored properly. The materials are used in the shop floor by the labourers using suitable material handling devices. Finally proper maintenance has to be done to ensure smooth functioning of the production.

## 11.10 SELF ASSESSMENT QUESTIONS

1. Define material management. What is the significance of material management?
2. Explain various material handling devices
3. Write a note on Resource requirement planning
4. Describe various types of maintenance activities carried out in a industry

## 11.11 REFERENCES

1. JIT by MANGESH R Kargaovkar.
2. Production and Operations Management – K. Ashwathappa and K. Sridhara Bhat
3. Production and Operations Management- R. Paneer Selvam
4. Production Management – Manoj Kumar Sarkar

# UNIT - 12 : PRODUCTION PLANNING AND CONTROL

**Structure:**

## 12.0 OBJECTIVES

After studying this unit, you should be able to

- Define Production Planning
- Carry out loading and scheduling
- Balance the lines
- Exercise production and shop floor control

## 12.1 INTRODUCTION

For efficient, effective and economical operation in a manufacturing unit of an organization, it is essential to integrate the production planning and control system. Production planning and subsequent production control follow adaption of product design and finalization of a production process.

Production planning and control address a fundamental problem of low productivity, inventory management and resource utilization.

Production planning is required for scheduling, dispatch, inspection, quality management, inventory management, supply management and equipment management. Production control ensures that production team can achieve required production target, optimum utilization of resources, quality management and cost savings.

## 12.2 PRODUCTION PLANNING

Production planning is one part of production planning and control dealing with basic concepts of what to produce, when to produce, how much to produce, etc. It involves taking a long-term view at overall production planning. Therefore, objectives of production planning are as follows:

- To ensure right quantity and quality of raw material, equipment, etc. are available during times of production.
- To ensure capacity utilization is in tune with forecast demand at all the time.

A well thought production planning ensures that overall production process is streamlined providing following benefits:

- Organization can deliver a product in a timely and regular manner.
- Supplier are informed will in advance for the requirement of raw materials.
- It reduces investment in inventory.
- It reduces overall production cost by driving in efficiency.

Production planning takes care of two basic strategies' product planning and process planning. Production planning is done at three different time dependent levels i.e. long-range planning dealing with facility planning, capital investment, location planning, etc.; medium-range planning deals with demand forecast and capacity planning and lastly short term planning dealing with day to day operations.

**The benefits of production planning and control are as follows:**

- It ensures that optimum utilization of production capacity is achieved, by proper scheduling of the machine items which reduces the idle time as well as over use.
- It ensures that inventory level are maintained at optimum levels at all time, i.e. there is no over-stocking or under-stocking.
- It also ensures that production time is kept at optimum level and thereby increasing the turnover time.
- Since it overlooks all aspects of production, quality of final product is always maintained.

**Functions of PPC**

1 Materials : To ensure availability of raw material, spare parts, components and sub assemblies in correct quantities and specification at the right time.

2 Methods: Choosing the best method form savaral alternatives. IT involves deciding the best sequence of operations for manufacturing the parts, building up sub assemblies and major assemblies which in turn will make the finished product

3 Machines and equipments: Obtaining of required machines either hire or purchase basis. Maintaining the equipment to ensure problem less operations.

4 Make or Buy Decision: Deciding whether to manufacture a part in house or to buy it from outside based on several criteria such as economy, time constraints, availability of resources such as skilled workers, machines required and raw material.

5 Routing: Routing prescribes flow of work in the plant and is related to the consideration of layout, of temporary storage location for raw materials. Components and semi processed parts and of material handling system

6 Estimating: The processing times required for the parts to be manufactured in house are estimated and the standard times are established as performance standards

7 Loading and scheduling: Machines have ot be loaded according to their capacity and capability. Machine loading is carried out in conjunction with routing to ensure smooth workflow. Scheduling refers to the execution of planned functions at the allotted time.

8 Expediting: This means the follow up of the progress made in completing the production as per schedules.

9 Inspection: This function relates to the checking the quality in production and of evaluating the efficiency of the processes, methods and workers.

## 12.3 LINE BALANCING

Line balancing is arranging a production line so that there is an event flow of production from one work station to the next i.e. so that there are no delays at any work station that will leave the next work station with idle time.

Line balancing is also defined as the appointment of sequential work activities work activities into work stations in order to gain a high utilization of labour and equipment and therefore minimize idle time. Balancing may be achieved by rearrangement of work station or by adding machines and or workers at some of the stations so that all operations take about the same amount of time.

Steps in line balancing

1. Draw a precedence diagram. Identify which task should be completed first and which task follows next. You can refer to PERT and CPM in statistics for Managers in your first semester.

2. Determine the required cycle time. The required cycle time is calculated by dividing total time available by no. of piece need to produce. For this you need to calculate

   $CT$ = (operating time per day) / (desired output per day)

3. No. of Work stations: The no. of work stations are calculated using the following formula.

$N_{min}$ = (sum of all the task times) / (actual cycle time)

You have to round off the answer to the next whole number.

4. Assign the task to work stations. Nearby tasks and parallel tasks can be grouped together. The total time taken by any work station should be less that cycle time. Calculate idle time in each work station. You may have add more stations if needed.

   Idle Time= Cycle time- Work station time

5. Calculate the total idle time and percentage idle time.

Percentage Idle time= Total idle/[No of work stations X Cycle time]

6. Determine Line efficiency

Line efficiency= 1- Percentage idle time

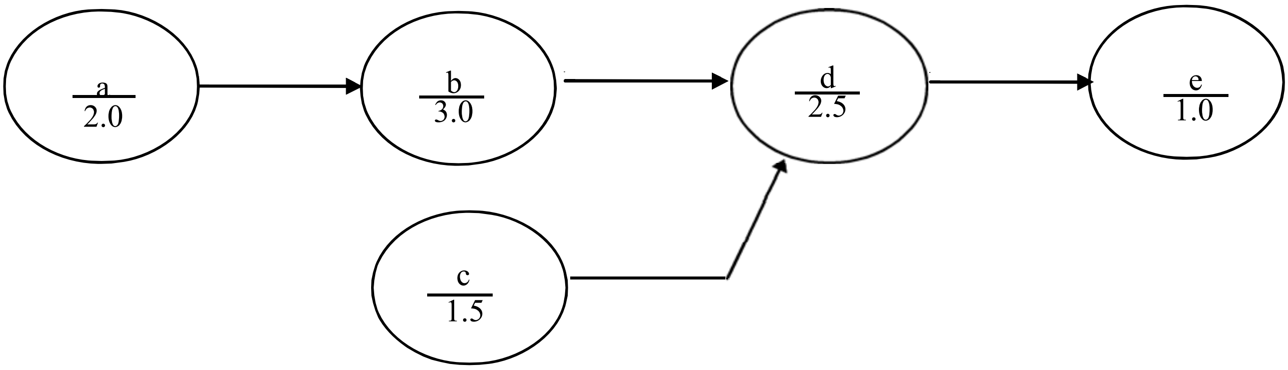
**Line balancing problem 1.**

A precedence table is given below for a process with 5 tasks, their immediate predecessors and their task times:

| **Task label** | **Immediate predecessor(s)** | **Task time (minutes)** |
|---|---|---|
| *a* | – | 2.0 |
| *b* | *a* | 3.0 |
| *c* | – | 1.5 |
| *d* | *b, c* | 2.5 |
| *e* | *d* | 1.0 |
| | | ∑ 10.0 |

Workers are known to work 8 hours in one shift, and there are 2 shifts per day dedicated to this job. The daily output need is 320 pieces.

a) Precedence diagram for the process:




b) $CT$ = (operating time per day) / (desired output per day) = (2 shifts × 8 hrs × 60 mins) / 320 pieces = 3 mins

c) $N_{min}$ = (sum of all the task times) / (actual cycle time) = 3.33 = 4 work station

d)

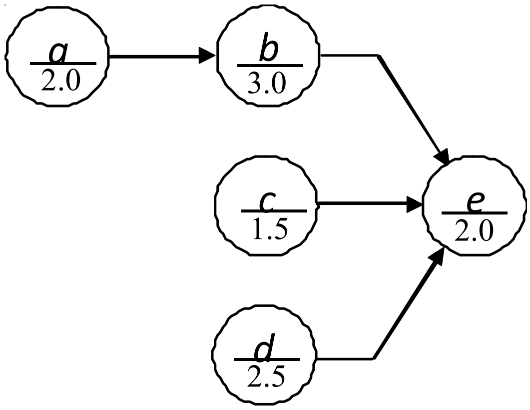
| **Work-station** | **Assign task** | **Idle time (minutes)** |
|---|---|---|
| 1 | *a* | 1.0 |
| 2 | *c* | 1.5 |
| 3 | *b* | 0.0 |
| 4 | *d* | 2.5 |
| 5 | *e* | 2.0 |
| | | ∑ 7.0 |

e) Percentage of idle time (balance delay) for the line: (idle time per cycle) / [$N_{actual}$ × (cycle time)] = 0.3333 = 33.33%

f) Efficiency of the line = 1 – (percentage of idle time) = 53.33%

***Exercise 2.***

A precedence diagram is given below for a manufacturing process with 5 tasks:




Daily working time is 12 hours. The daily output need is 200 pieces.

a) $CT_{max}$ = sum of all the task times = 11.0 minutes

$CT$ = (operating time per day) / (desired output per day) = (12 hrs × 60 mins) / 200 pieces = 3.6 mins

b) $N_{min}$ = (sum of all the task times) / (actual cycle time) = 11 / 3.6 = 3.06 = 4 work stations

c)

| Work-station | Assign task | Idle time (minutes) |
|---|---|---|
| 1 | *a, c* | ~~1.6~~ 0.1 |
| 2 | *d* | 1.1 |
| 3 | *b* | 0.6 |
| 4 | *e* | 1.6 |
| | | |
| | | ∑ 3.4 |

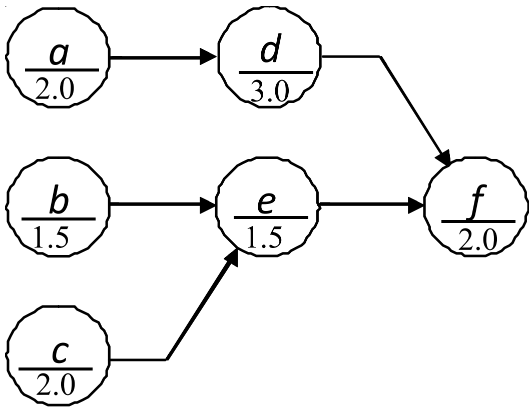
d) Percentage of idle time (balance delay) for the line:

(idle time per cycle) / [$N_{actual}$ × (cycle time)] = 3.4 / (4 × 3.6) = 23.61%

e) Efficiency of the line = 1 – (percentage of idle time) = 76.39%

***Exercise 3.***

A precedence diagram is given below for a manufacturing process with 5 tasks:




Daily working time is 14 hours. The daily output need is 210 pieces.

a) $CT_{max}$ = sum of all the task times = 12.0 minutes

$CT$ = (operating time per day) / (desired output per day) = (14 hrs × 60 mins) / 210 pieces = 4.0 mins

b) $N_{min}$ = (sum of all the task times) / (actual cycle time) = 12 / 4 = 3 workstations

c)

| **Work-station** | **Assign task** | **Idle time (minutes)** |
|---|---|---|
| 1 | *a, c* | ~~2.0~~ 0.0 |
| 2 | *b, e* | ~~2.5~~ 1.0 |
| 3 | *d* | 1.0 |
| 4 | *f* | 2.0 |
| | | |
| | | $\sum$ 4.0 |

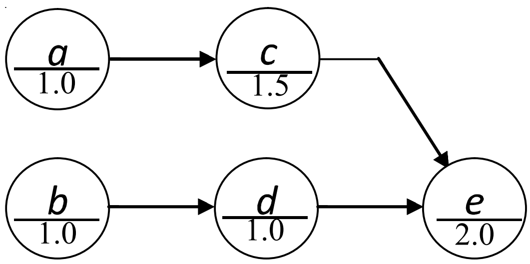
d) Percentage of idle time (balance delay) for the line:

(idle time per cycle) / [$N_{actual}$ × (cycle time)] = 4.0 / (4 × 4.0) = 25.00%

e) Efficiency of the line = 1 – (percentage of idle time) = 75.00%

***Exercise 4.***

A precedence diagram is given below for a manufacturing process with 5 tasks:



Daily working time is 16 hours. The daily output need is 300 pieces.

**Solution for problem 4.**

a) $CT_{max}$ = sum of all the task times = 6.5 minutes

$CT$ = (operating time per day) / (desired output per day) = (16 hrs × 60 mins) / 300 pieces = 3.2 mins

b) $N_{min}$ = (sum of all the task times) / (actual cycle time) = 6.5 / 3.2 = 2.03 = 3 workstations

c)

| Work-station | Assign task | Idle time (minutes) |
|---|---|---|
| 1 | *a, b, d* | ~~2.2~~ ~~1.2~~ 0.2 |
| 2 | *c* | 1.7 |
| 3 | *e* | 1.2 |
| | | |
| | | |
| | | $\sum$ 3.1 |

d) Percentage of idle time (balance delay) for the line:

(idle time per cycle) / [$N_{actual}$ × (cycle time)] = 3.1 / (3 × 3.2) = 32.29 %

e) Efficiency of the line = 1 – (percentage of idle time) = 67.71%

## 12.4 PRODUCTION CONTROL

Production control looks to utilize different type of control techniques to achieve optimum performance out of the production system as to achieve overall production planning targets. Therefore, objectives of production control are as follows:

- Regulate inventory management
- Organize the production schedules
- Optimum utilization of resources and production process

The advantages of robust production control are as follows:

- Ensure a smooth flow of all production processes
- Ensure production cost savings thereby improving the bottom line
- Control wastage of resources
- It maintains standard of quality through the production life cycle.

Production control cannot be same across all the organization. Production control is dependent upon the following factors:

- Nature of production ( job oriented, service oriented, etc.)
- Nature of operation
- Size of operation

Production planning and control are essential for customer delight and overall success of an organization.

The production control includes the following

- Material control
- Labour control
- Scheduling
- Shop floor control

Material control ensures usage of materials of right specification in right quantity. It ensures supply of material at right time. It balances two sided objectives. On one hand production should not stop for the want of material on the other hand material should not be wasted. Many organizations adopt JIT philosophy for material control which ensures supply of right material just in time the production. This avoids storage cost and expiry cost. Some organizations go for standardization of parts so that less number of items can be used.

For example, in manufacturing of a car 30,000 different parts, from a small screw to engine control units, are used. These items are assembled together through different processes. Screws of different sizes would be employed. But a manufacturer can try to reduce different sizes of screws and try to put same sized screws wherever possible.

Labour control can be exercised by adopting time study as discussed before. Incentives may be given to those workers who turn out more products than the standard set. Similarly disciplinary actions may be taken on those workers who produce less items than the standard set.

The master schedule (or master production schedule or MPS) sets the quantity of each item (finished product) to be completed in each time period (week or month) of the short range-planning horizon. Master production schedules are developed by reviewing market forecasts, customer orders, inventory levels, facility loading, and capacity information regularly. The MPS is a plan for future production of end items over a shortrange planning horizon that usually spans from a few weeks to several months. It is an important link between marketing and production. Objectives of Master Production Scheduling : • To schedule end item to be completed promptly and when promised to customers. • TO avoid overloading or under loading the production facility so that production capacity is efficiently utilized and low production costs results.

There are two ways of scheduling

- Forward Scheduling
- Backward Scheduling

Forward scheduling is taking a job with a number of tasks and allocates those tasks to resources as early as possible when resources the resources allow. The first available time that the resource is available to be used the task should make use of it. As with all scheduling methods there are pros and cons on how they work. Forward scheduling may result in jobs being completed earlier then the requested due date because forward scheduling schedules the tasks as early as possible. Forward scheduling tells you when a job could be completed vs completing the job when required.

Backwards scheduling is taking a job with a number of tasks and allocates those tasks to resources in reverse orders and schedules the task on the resource. Backwards scheduling requires a delivery date from the customer because the system schedules backwards from the delivery date to arrive at a start date. Backward scheduling tells the manufacturer if this date could be hit based on the allocation of resources. Unlike forward scheduling which schedules into the future, backward scheduling could potentially schedule into the past because the resources where not available to complete the job. Backwards scheduling then may turn around and actually forward schedule the job to tell the customer the earliest delivery time.

## 12.5 NOTES

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## 12.6 SUMMARY

Shop floor operations are the major activities in any manufacturing organization. All other functions like HR, Finance are the supporting functions. In this unit we have studies about production planning and control. We have learnt about scheduling and line balancing.

## 12.7 SELF ASSESSMENT QUESTIONS

1. Define Production planning and control. What is the significance of it?

2. Explain different types of scheduling

3. Consider the following production line in which the elements A to H must be performed in the alphabetic order.

| Work Centre | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Work Elements | A,B | C | D,E | F | G | H |
| Element Time | 2,1.5 | 4 | 2,2 | 3 | 2.5 | 3 |

Assuming a eight hours shift, what is the maximum daily output . Calculate the efficiency of the line

## 12.8 REFERENCES

1. JIT by MANGESH R Kargaovka - K Sridhara Bhat

2. Production and Operations Management – K. Ashwathappa

3. Production and Operations Management- R. Paneer Selvam

4. Production Management – Manoj Kumar Sarkar

# MODULE - IV
# TOTAL QUALITY MANAGEMENT

## UNIT - 13 : TOTAL QUALITY MANAGEMENT-INTRODUCTION

**Structure:**

## 13.0 OBJECTIVES

After studying this unit, you should be able to;

- ♦ Explain the meaning of quality
- ♦ Differentiate between quality and total quality
- ♦ Examine the concept of TQM and its advantage

## 13.1 INTRODUCTION

The TQM has been the buz word of todys's organization. Total Quality Management is the process of instilling quality throughout an organisation and its business processes. The system of Total Quality Management aims at achieving success and customer satisfaction through embedding an awareness of quality all the way through a business, through planning and feedback. It is a system of acticities directed at achieving delighted customers, empowered employees, higher revenues and lower costs. Companies are aiming at continuous improvement throughw which they can achieve totla quality management.

## 13.2 QUALITY

The word Quality is used in daily life. When the word quality is used it may mean several terms such as finish, cost, usability, adoptability, size, thickness, durability etc. In this context Quality can be defined as follows.

**a. Quality is fitness to use.**

A product/ service may be available at different prices. According to one's convenience and need one may choose a particular product or service which he accepts as of good quality.

**b. Quality is fitness to standard**

Customer will keep in mind a standard when a product/ service are purchased. A product is accepted or reject in meeting the quality be keeping into consideration a standard

**c. Quality is fitness to cost.**

Customers will have a budget when they want to purchase a product/ service. A product is accepted or rejected by comparing it with its price. Sometimes prices can compensate for quality. In some cases it can not. Also the degree to which it can compensate varies depending upon the product/service.

**d. Fitness to latent requirement**

Here the product is developed to satisfy latent needs. That means meeting the customer needs before customers are aware of those needs. If a company can find the latent requirement of the market, it may achieve a monopoly for a litter while.

According to BS 4778, quality can be defined as “the totality of features and characteristics of a product or service which has a bearing on its ability to satisfy a state or implied need “.

According Armand V. Feigenbaum quality is the total composite of product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product and service in use will meet the expectations of the customers.

According to ISO: 9000:2000 quality is the degree to which a set of inherent characteristics fulfills the requirements.”

Q= P/E

Where

Q= Quality

P=Performance

E=Expectations

If Q> 1 customer has good feeling about the product or service given to him.

**Terminologies**

**a. Quality of Design:** It consists of identification of fitness for uses and translating the features of product concepts in detailed set of specification**.**

**b. Quality of Conformance:** It consists the quality of manufacturing technology, process, supervision, manpower and management

**c. Quality Policy:** It is the overall quality intentions and direction of organization as regards quality.

**d. Quality Management:** It is that aspect of the overall management function that determines and implements the quality policy.

**e. Quality system:** It means the organized structure, responsible procedure, processes and resources for implementing quality management.

**f. Quality Control:** It means the operational techniques and activities that are used to fulfill the requirements for quality**.**

**g. Quality assurance:** It means all those planned and systematic action which enhances to build up more confidence on a product or service and will satisfy the given requirement of quality.

**Dimensions of Quality**

The quality of a product has different dimension which includes the following.

1. Performance: How a product perform affects quality
2. Features: The secondary characteristics, added features has an impact on quality For ex: Remote control of a TV
3. Conformance: Meeting specification or industry standards, workmanship
4. Reliability: Consistency if performance over time, average time for the unit to fail
5. Durability: Useful life, includes repair
6. Service: Resolution of problems and complaints, ease of repair
7. Response: Human to human interface, such as the courtesy of the dealer
8. Aesthetics: Sensory characteristics, such as exterior finish
9. Reputation Past performance and other intangibles, such as being ranked first.

The quality of a service has the following dimension.

1. Time: The time required or duration to provide a service
2. Timeliness: The promptness in providing service in stipulated time, Say, TV repair in two days.
3. Courtesy: & Responsiveness The Attitude and behavior of service providers
4. Speed: The speed at which the service is done
5. Consistency; the ability to provide same quality service every time For e.g.;

**Benefits of Quality**

1. Lower costs
2. Higher productivity
3. Increased customer satisfaction
4. Increased market share
5. Higher profits
6. Higher productivity
7. More efficient processes
8. High employees morale

**Problems of neglecting Quality**

1. Customer complaints

2. Wasted time

3. Frustration

4. Hassles

5. Confusions

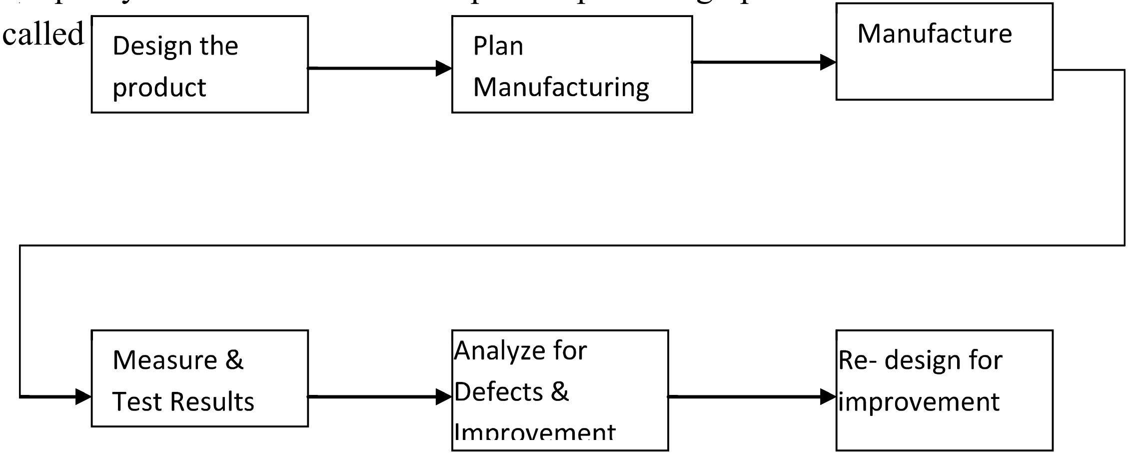
6. Overload

## 13.3 TOTALQUALITY

Quality, many a time, is confused with inspection which is done after production. But today the concept is changing drastically. Companies view inspection as a postmortem business. In true sense inspection will not increase quality. It is just a sorting process; Sorting of good and bad.

Need for organized approach to quality was seriously realized during World War II, because of inconsistent behavior and functioning of arms and other ordnance.

Quality has to be inserted in the product right from the inception stage. Quality is an essential part of design, quality is an integral part of manufacturing and quality is a part of delivery. Thus quality is the initial and the final point in producing a product or service and this concept is called




According to Atkinson total quality is a strategic approach to product the best product and service possible through constant renovation. Concentration should not be only on the production side but also on the service side.

Total Quality provides an umbrella under which everyone in the organization can strive and create customer satisfaction at continually lower real costs.

Juran focused on three major aspects of quality improvement.

1. **Quality planning:** A process for presetting the quality goals and preparation to meet the goals
2. **Quality control:** The process for ensuring that quality goals are being achieved during operations
3. **Quality improvement:** the process for breaking through to higher levels of quality for superior performance.

**Factors affecting Total Quality Control**

1. Marketing evaluates the level of quality which customers want and for which they are willing to pay.
2. Engineering specification
3. Purchasing of materials from vendors
4. Selection of jig, tools and processes for production
5. Sub contractors
6. Inspection of testing equipments
7. Installation and product service.

## 13.4 TOTAL QUALITY MANAGEMENT

The management of an enterprise to lead it towards total quality is called total quality management. It is a team work rather than individual effort. All the employees as well as employers complete involvement is required to implement total quality in an organization.

According to ISO "TQM is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society". One major aim is to reduce variation from every process so that greater consistency of effort is obtained. TQM is composed of three paradigms:

- **Total**: Involving the entire organization, supply chain, and/or product lifecyle
- **Quality**: With its usual Definitions, with all its complexities
- **Management**: The system of managing with steps like Plan, Organize, Control, Lead, Staff, provisioning and suchlike

There four pillars of total quality management. They are

1. Customer satisfaction
2. Employee participation

3. Continuous improvement

4. Top management orientation

Total quality control is defined as an effort of continuous quality improvement of all processes, products and services through universal participation that results in increasing customer satisfaction and loyalty and improved business results.

According to Confederation of Indian Industries TQM is defined meeting the requirements of the internal and external customers consistently by continuous improvement in the quality if work of all employees. TQM can be conceptualized into the following three processes.

1. Quality process for understanding who the customer is what are his /her needs and taking steps to completely satisfy the needs of this customer.
2. Management process for continuous improvement: The process comprises the PDCA cycle and its continuously evolving policies, objectives and methods to achieve goals, education and training, implementation, checking causes.
3. People process – It is initiating and maintaining the TQM.

**Basic Elements of TQM**

**1. Senior Management Commitment:** the implementation of TQM requires capital in terms of money and labor item. To provide this the top management commitment is very much necessary. Without the support of top management it is impossible to implement TQM in any organization. The Top management should provide training to employees so that they over come initial resistance.

**2. Improvement orientation:** The top management as well as employees of the organization should be trained towards improvement. Continuous improvement is the mantra of TQM without which the TQM can not be achieved.

**3. Customer Focus:** Customer is the prime focus of any organization. Customer satisfaction is the only avenue through which long term profit and good brand name can be achieved.

**4. Company wide improvement:** The improvement can be taken up should be company wide This company wide quality improvement (CWQC) concept quality was intiated during the 1980s. It mainly focussed on management and people came to the fore. It was realised that, if all departments approached quality with an open mind, success was possible if the management led the quality improvement process. The company-wide quality approach places an emphasis on three aspects :-

1. Elements such as controls, job management, adequate processes, performance and integrity criteria and identification of records

2. Competence such as knowledge, skills, experience, qualifications

3. Soft elements, such as personnel integrity, confidence, organisational culture, motivation, team spirit and quality relationships.

The quality of the outputs is at risk if any of these three aspects are deficient in any way.

The approach to quality management given here is therefore not limited to the manufacturing theatre only but can be applied to any business activity:

- Design work
- Administrative services
- Consulting
- Banking
- Insurance
- Computer software
- Retailing
- Transportation

It comprises a quality improvement process, which is generic in the sense it can be applied to any of these activities and it establishes a behaviour pattern, which supports the achievement of quality.

This in turn is supported by quality management practices which can include a number of business systems and which are usually specific to the activities of the business unit concerned.

In manufacturing and construction activities, these business practices can be equated to the models for quality assurance defined by the International Standards contained in the ISO 9000 series and the specified Specifications for quality systems.

Still, in the system of Company Quality, the work being carried out was shop floor inspection which did not control the major quality problems. This led to quality assurance or total quality control, which has come into being recently.

5. Commitment to training & education: Training and education is a mandatory process in implementation of TQM. Training makes the employees to understand the need and importance the TQM and how to go about it.

6. Ownership of the process and quality: The responsibility for quality should be clearly defined and some one must take the responsibility. In many organization the inspection work is coupled with the process and as such the person who performs the work is responsible for inspecting it also. One of the JIT concepts called kanban system emphasizes much on this. It says work should immediately go to next process. In other sense until the next process calls

for the work it should not done. As such the next worker would immediately give feedback on the work and the previous worker would be careful in performing the work.

7. Emphasis on measurement and review : In TQM periodical meetings are held to review the improvement works that has been taken up. Without review corrective and preventive action taken up can not be effective. Measurement is also an important aspect. Today organizations are emphasizing on measuring everything in terms of money. For internal rejection

8. Team work: Team work is yet an another focal point f TQM, TQM is more human based approach rather ISO which is a system based approach. TQM give much emphasis on team work. Several concepts like quality circle are evolved on the basis of team work.

9. Commitment to quality: The quality is the basic aspect of total quality management. Without concentrating on quality the organization can provide customer satisfaction. Quality first is the motto of TQM organizations.

10. Defect prevention: Prevention is better than cure is common [principle which applies better to TQM also. Defect preventive mechanism like Poka yoke are employed in TQM oriented organization.

11. Quality measurement : The quality measurement aspect of TQM asks the questions; Where are we and where we are going? Quality is measurable entity and we need to know what the current quality levels are and what quality level we aspire.

12. Universal responsibility for quality : Another basic TQQQQM percept is that the responsibility for quality is not restricted to only quality assurance department, but is guiding philosophy started by every one in the organization. The traditional thinking was that inspection (or detection rather than prevention) is necessary to ensure quality of products, thereby installing a deep belief in people who actually manufacture

13. Bench marking: Benchmarking is a continuous, systematic process of evaluating and comparing the capability of one organization with others normally recognized as industry leaders, for insights for optimizing the organizations processes." Performance analysis forms the basis for the current process improvement which enables the organization to make better products/services tomorrow. Performance benchmarking removes misconceptions; A **Benchmark** is often used for improving communication, professionalizing the organization / processes or for budgetary reasons. Traditionally, performance measures have been compared with previous measures from the same organization at different times. Although this can be a good indication of the rate of improvement within the organization, it could be that although the organization is improving, the competition is improving faster.

There are **four types of benchmarking methods**:

**1. Internal** (benchmark within a corporation, for example between business units)

**2. Competitive** (benchmark performance or processes with competitors)

**3. Functional** (benchmark similar processes within an industry)

**4. Generic** (comparing operations between unrelated industries)

Typically, benchmarking models involves the following steps:

- ♦ Scope definition
- ♦ Choose benchmark partner(s)
- ♦ Determine measurement methods, units, indicators and data collection method
- ♦ Data collection
- ♦ Analysis of the discrepancies
- ♦ Present the results and discuss implications / improvement areas and goals
- ♦ Make improvement plans or new procedures
- ♦ Monitor progress and plan ongoing benchmark.

14. Value improvement : The essence of value improvement is the ability to meet or exceed customer expectations while removing unnecessary costs. TQM removes unnecessary costs while simultaneously customer expectation and requirements are satisfied. However simple cutting cost without satisfying the customers will not result in value improvement.

15. Supplier teaming : TQM aims at developing long term relationships with a few high quality suppliers rather simple selecting those suppliers who supply at lowest cost.

16. Statistical approach : Statistical methods or techniques are useful for reducing processes or product design variations for improving quality. Statistical process control using charts for control of ongoing processes and taguchi concepts for variability reduction are used for achieving continuous improvement

**Principles of TQM**

1. Putting the customer first : The fundamental aspect of total quality management is customer emphasis. For an organization to be profitable, it should put the customer on first preference. The profit will follow automatically. Giving importance to customer will lead to improved quality and reduce customer complaints.

1. Management by Fact : The second principle which TQM companies world wide are adopting these days is management by fact. This principle is difficult to institutionalize, because every employee in an organization has opinions views and notions about how things should be done. They may tell what the root cause if a problem is but may nit give you the facts fir solving the problem. This way people may become the part of the problem itself

rather than solvers, Facts are far better than opinions although opinions, views and ideas cannot be ignored.

2. Principle of PDCA Cycle: PDCA stands for Plan-Do- Check – Act. According this principle, one should plan his work, Do according to the plan; Check whether it confirms to standards and finally act on the difference. This PDCA cycles leads to continuous improvement. This PDCA cycle was first proposed by Deming. Hence it is also called as Deming's cycle.

3. Focus on prevention. Taking corrective action is a common step in any organization. But trying to prevent any causes is far better than correction. A s such the TQM concentrates on prevention rather than correction. Whenever a problem is a raised the importance should be given to correction as well as to find out the root cause of the problem and solve such causes so that such problems do not occur in future.

4. Principles of employee involvement : this principle emphasizes on how people should wok together. For becoming TQM company, employees should be respected, their suggestions should be taken.

5. Cross functional Management: Cross functional Management stands for training the workers in all the fields. Workers must be cross functional in the sense they should be able to do any work that is assigned to them. It allows flexibility in allotting the works to the workers.

**Basic Concepts of TQM**

1. A committed and involved management to provide log term top to bottom organization support, Here management must participation the quality program; a quality council must be established to develop a clear vision, long term goals and direct programs.
2. Industry has to concentrate on customer satisfaction through design, quality defective prevention.
3. An unwavering focus on the customer, both internally and externally.
4. Effective & voluntary in jobs and also optimum utilization of the entire workforce.
5. Continuous improvement of the business and production process
6. Treating supplier as partners
7. Establish performance measures for the process

**Quality and Business Results**

Companies that invest n quality management efforts experience outstanding returns and improvements in performance. Winners of Malcom Baldrige National Quality Award, which represent companies having the highest level of commitment to quality management have achieved outstanding operational and financial results. These companies achieved better employee relations, higher productivity, greater customer satisfaction, increased market share and improved profitability.

**Why TQM can fail?**

- Uncorrected Vision

Vision statement is like a tome. Visions must be short and to the point.

- Poor Objectives

Encourages functional groups to battle for resources.

- Loose Cannons

Beware of people who use quality to establish fiefdoms and people who remain in powerful positions but don't get with the program and finally, managers who drag their feet.

- Wandering Teams and Lost Supervisors

Avoid creating cross functional teams with no clear charter.

- Statistical & Non-statistical Thinking

Use the "five-why's". Use statistics wisely and where appropriate. If there is a major consumer problem statistics alone might not alert you to the problem until it is too late.

- New Program Syndrome

Many motivation scams. New initiatives are eyed with suspicion. Need to quit calling it a program - make it an integral part of employees activities.

- Change Management

Don't expect behaviors to change over-night. Provide the organizational support and encouragement to develop positive behaviors.

## 13.5 NOTES

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## 13.6 SUMMARY

Quality is not just the conformance to the specification; quality is best fit for use. Quality originates from the minds of individual. Total quality management is a concept rather than a process by itself. The TQM can not be implemented overnight. The pillars of TQM have to be achieved the implement TQM. These pillars are noting but customer satisfaction, employee involvement, Top management support and continuous improvement.

## 13.7 KEY WORDS

- Quality
- Total Quality
- Total Quality Management

## 13.8 SELF ASSESSMENT QUESTIONS

1. Define quality. Explain its importance
2. Differentiate between quality and total quality
3. Define TQM. What are the basic elements of TQM?
4. What are the principles of TQM?
5. Why does TQM fails sometimes?

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# UNIT 14 - :QUALITY COSTS

**Structure:**

## 14.0 OBJECTIVES

After studying this unit, you should be able to;

- Explain the meaning of quality costs
- Examine Implication of quality costs in quality management
- Describe the meaning of quality assurance
- Analyze the importance of quality management

## 14.1 INTRODUCTION

The costs of quality are the cost associated with the prevention, discovery, and resolving of defects in parts i.e. it, refers to the costs associated with providing poor quality product or service.

These costs can arise whether the product in the design stages, manufacturing plant, or in the customer's hand. According to Philip Crosby it is the price of nonconformance and according to Juran it is the cost of poor quality. It is important to identify the cost of quality so that we can determine the expenses associated with producing a quality product.

**Quality assurance**, or **QA** for short, is the activity of providing evidence needed to establish quality in work, and that activities that require good quality are being performed effectively. All those planned or systematic actions necessary to provide enough confidence that a product or service will satisfy the given requirements for quality.

For products, quality assurance is a part and consistent pair of quality management offering supposedly fact-based external confidence to customers and other stakeholders that a product meets needs, expectations, and other requirements. QA claims to assure the existence and effectiveness of procedures that attempt to make sure - in advance - that the expected levels of quality will be reached.

## 14.2 QUALITY COSTS

The Cost of Quality ("COQ") measurement can track changes over time for one particular process, or be used as a benchmark for comparison of two or more different processes (e.g. two machines, different production lines, sister plants, two competitor companies, etc.).

Usually, Cost of Quality ("COQ") is measured in currency , requiring all losses and wastes to be converted to their liquidated cost equivalent (i.e. man-hrs lost or spent are converted to rupees by multiplying by the hourly rate, Rs/hr).

Joseph Juran divided the costs of quality into 4 categories. Using this system, we can better understand where the money is being spent. The 4 categories are:

**Internal Failure Costs** - These include the cost of evaluating, disposing of, or other action on a part that has failed inspection. Some examples are; rework, scrap, retesting, and troubleshooting. External Failure Cost

It is the cost associated with defects found after the customer receives the product or service ex: processing customer complaints, customer returns, warranty claims, product recalls. For example, if your company sells thousands of copies of the same program, you will probably print several thousand copies of a multi-color box that contains and describes the program. You (your company) will often be able to get a *much* better deal by booking press time with the printer in advance. However, if you don't get the artwork to the printer on time, you might have to pay for some or all of that wasted press time anyway, and then you may have to pay additional printing fees and rush charges to get the printing done on the new schedule. This can be an added expense of many thousands of dollars.

Some programming groups treat user interface errors as low priority, leaving them until the end to fix. This can be a mistake. Marketing staff need pictures of the product's screen long before the program is finished, in order to get the artwork for the box into the printer on time. User interface bugs the ones that will be fixed later can make it hard for these staff members to take (or mock up) accurate screen shots. Delays caused by these minor design flaws, or by bugs that block a packaging staff member from creating or printing special reports, can cause the company to miss its printer deadline.

Including costs like lost opportunity and cost of delays in numerical estimates of the total cost of quality can be controversial. Campanella (1990) [5] doesn't include these in a detailed listing of examples. Gryna (1988)[6] recommends against including costs like these in the published totals because fallout from the controversy over them can kill the entire quality cost accounting effort. I include them here because I sometimes find them very useful, even if it might not make sense to include them in a balance sheet.

**External Failure Costs** - These are all costs associated with failure of parts after they are shipped to the customer. They are usually a result of not meeting the needs or specifications of the user. Some examples are; recalls, complaints, returns, and replacements. It is the cost associated with defects found before the customer receives the product or service ex: scrap, rework, re-inspection, re-testing, material review, material downgrades.

**Appraisal Costs** - These are the cost of evaluating a product or a service throughout the process of design until the product is shipped. The evaluation is to test conformance to set standards. Some examples are part inspection, testing, and audits. Inspection (appraisal) Cost

It is cost incurred to determine the degree of conformance to quality requirements (measuring, evaluating or auditing) ex: inspection, testing, process or service audits, calibration of measuring and test equipment.

**<u>Prevention Costs</u>** - Prevention cost are those associated with preventing defect in products or processes. Some examples are training and quality planning. Prevention Cost

Prevention costs are incurred to prevent (keep failure and appraisal cost to a minimum) poor quality ex: new product review, quality planning, supplier surveys, process reviews, quality improvement teams, education and training

Many companies spend about 25% of their total sales on costs of quality. Often, management perceives it to be much less than this. It is recommended that the costs of quality be more like 2 or 3 % of sales.

As much of 90% of the cost of quality in a company can come from failure costs. It is much more expensive to fix a part once it has left the plant and is received by the company. It costs even less if the problem can be corrected in the design stages or by refining the manufacturing process.

If more focus is put in prevention, there will be less need to spend money on scrap or rework. The earlier the problem can be identified and corrected, the less it will cost the company.

| ***Prevention*** | ***Appraisal*** |
|---|---|
| • Staff training<br>• Requirements analysis<br>• Early prototyping<br>• Fault-tolerant design<br>• Defensive programming<br>• Usability analysis<br>• Clear specification<br>• Accurate internal documentation<br>• Evaluation of the reliability of development tools (before buying them) or of other potential components of the product | • Design review<br>• Code inspection<br>• Glass box testing<br>• Black box testing<br>• Training testers<br>• Beta testing<br>• Test automation<br>• Usability testing<br>• Pre-release out-of-box testing by customer service staff |

***Table 14.1-Examples of Quality Costs Associated with Products/Service.***

| *Internal Failure* | *External Failure* |
|---|---|
| 1. Bug fixes<br>2. Regression testing<br>3. Wasted in-house user time<br>4. Wasted tester time<br>5. Wasted writer time<br>6. Wasted marketer time<br>7. Wasted advertisements [7]<br>8. Direct cost of late shipment [8]<br>9. Opportunity cost of late shipment | • Technical support calls[9]<br>• Preparation of support answer books<br>• Investigation of customer complaints<br>• Refunds and recalls<br>• Coding / testing of interim bug fix releases<br>• Shipping of updated product<br>• Added expense of supporting multiple versions of the product in the field<br>• PR work to soften drafts of harsh reviews<br>• Lost sales<br>• Lost customer goodwill<br>• Discounts to resellers to encourage them to keep selling the product<br>• Warranty costs<br>• Liability costs<br>• Government investigations[10]<br>• Penalties[11]<br>• All other costs imposed by law |

| ***Seller: external failure costs*** | ***Customer: failure costs*** |
|---|---|
| These are the types of costs absorbed by the seller that releases a defective product. | These are the types of costs absorbed by the customer who buys a defective product. |
| • Technical support calls<br>• Preparation of support answer books<br>• Investigation of customer complaints<br>• Refunds and recalls<br>• Coding / testing of interim bug fix releases<br>• Shipping of updated product<br>• Added expense of supporting multiple versions of the product in the field<br>• PR work to soften drafts of harsh reviews<br>• Lost sales<br>• Lost customer goodwill<br>• Discounts to resellers to encourage them to keep selling the product<br>• Warranty costs<br>• Liability costs<br>• Government investigations<br>• Penalties<br>• All other costs imposed by law | • Wasted time<br>• Lost data<br>• Lost business<br>• Embarrassment<br>• Frustrated employees quit<br>• Demos or presentations to potential customers fail because of the software<br>• Failure when attempting other tasks that can only be done once<br>• Cost of replacing product<br>• Cost of reconfiguring the system<br>• Cost of recovery software<br>• Cost of tech support<br>• Injury / death |

**Table 14.2-Comparison of External Failure Costs Borne by the Buyer and the Seller**

The point of quality-related litigation is to transfer some of the costs borne by a cheated or injured customer back to the maker or seller of the defective product. The well-publicized cases are for disastrous personal injuries, but there are plenty of cases against computer companies and software companies for breach of contract, breach of warranty, fraud, etc.

The problem of cost-of-quality analysis is that it sets us up to underestimate our litigation and customer dissatisfaction risks. We think, when we have estimated the total cost of quality associated with a project, that we have done a fairly complete analysis. But if we don't take customers' external failure costs into account at some point, we can be surprised by huge increased costs (lawsuits) over decisions that we thought, in our incomplete analyses, were safe and reasonable.

***Importance of Cost of Quality***

Cost of Quality ("COQ") can be used to identify the global optimum for a process, and monitor that process' progress towards its global optimum. Global optimum is defined as the best possible outcome from all physically possible operating modes, combinations, and permutations of the current process.

**Uses of Cost of Quality**

Cost of Quality ("COQ") is used to collect cost data on a sampling basis (e.g. all data occurring during a 24 hr period, calculated once each quarter), or on a continuous basis (e.g. Cost of Quality ("COQ") is calculated with all data occurring in the month, and reported monthly) .

After confirming that the data is accurate and comprehensive, and consistent with previous definitions and implementations, it is analyzed for opportunities and trends. Based upon statistical analysis (e.g. regression analysis, indexes, correlations, Pareto analysis, factor analysis, etc.), conclusions and recommendations are presented to managers of the process being analyzed.

In some cases (supported by process modeling, heuristics, prior experience, or intuition) the optimum Cost of Quality ("COQ") can be predicted, and the process design necessary for achieving this global optimum Cost of Quality ("COQ") can be defined. A plan can then be defined to modify the current process, phase by phase, so as to move towards this global optimum process.

Management responsible for the process can decide on if, how, and when they will run the current process, or modify the process for even better results. All projects are analyzed for their impact on Cost of Quality ("COQ"), and projects that show high ROQ are implemented on a priority basis

(ROQ%= $Cost of Quality ("COQ") savings/$Implementation cost*100%).

When all costs are included, Cost of Quality ("COQ") as a % of gross sales $ will probably be around 30% to 35% for a profit orientated organization, 40% to 60% for a not-for-profit organization (i.e. hospitals, charities, government, etc.). Many organizations take only a sub-set of the costs, including only those that tend to fluctuate, or that often need management intervention. The others are assumed to be constant.

When manufacturing companies often earn only 5% NPBT (Net Profit Before Tax), a 35% Cost of Quality ("COQ") indicates that 40% of gross revenue is generated by the company as profit, but only 5% of that gets trapped as NPBT. Therefore, the profit yield is only 12.5% (87.5% of the available profit is lost before it gets to the bank).

For improvements in Cost of Quality ("COQ"), some manufacturers have been able to reduce manufacturing costs by as much as 7.65% per year, every year, for more than 10 years. For Six Sigma processes, Cost of Quality ("COQ") is usually reduced to less than 1% of gross sales $. This indicates that, as large and unbelievable as Cost of Quality ("COQ") $ seems to most managers, it is a real number that can be eliminated through hard work and dedication.

Obviously, as more and more improvements are made, it becomes more difficult to find the next saving. This is when an excellent Cost of Quality ("COQ") system can help point out the remaining opportunities.

***Typical Symptoms***

For organizations that:

♦ Currently have **no Cost of Quality ("COQ")** system, but could benefit from a well-designed & implemented Cost of Quality ("COQ") system

Have a Cost of Quality ("COQ") system, but that Cost of Quality ("COQ") system is **poorly designed, or poorly implemented.**

The following symptoms are typically felt:

♦ Slow rate of improvement

♦ Low or no profitability

♦ Bureaucracy or complexity of business processes continue to get worse and worse

♦ Changes in one area tend to have disastrous effects in other areas

♦ Management get personally involved in quality problems only during a major crisis

♦ Management is running out of ideas on where to cut costs any further

♦ All employees are not actively and personally involved in driving the Organization's

Mission forward

- Many individuals and departments disagree on what are the top priorities for the Organization
- Sub-processes and Departments are operated in a manner that is detrimental to the Organization's overall best interest.

## 14.3 QUALITY ASSURANCE

Quality Assurance covers all activities from design, development, production, installation, servicing to documentation. It introduced the sayings "fit for purpose" and "do it right the first time". It includes the regulation of the quality of raw materials, assemblies, products and components; services related to production; and management, production, and inspection processes.

The term Quality Assurance, as used in the United States Nuclear Regulatory Commission regulation 10 CFR Part 50, Appendix B, comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

One of the most widely used paradigms for QA management is the PDCA (Plan-Do-Check-Act) approach, also known as the **Shewhart cycle.**

In developing products and services, quality assurance is any systematic process of checking to see whether a product or service being developed is meeting specified requirements. Many companies have a separate department devoted to quality assurance. A quality assurance system is said to increase customer confidence and a company's credibility, to improve work processes and efficiency, and to enable a company to better compete with others. Quality assurance was initially introduced in World War II when munitions were inspected and tested for defects after they were made. Today's quality assurance systems emphasize catching defects before they get into the final product.

**Objective of Quality Assurance**

1. To have in a place a fomal system that continualy surveys the effectivenss of the quality philosophiy of the company.

2. To ensure product quality and service quality by all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.

3. To provide continuous evaluation of the factors that affect adequacy of design or specification ofr intended application as well as verification and audits of prodcution , installation and inspection activities.

4. It serves as management tool.

5. It also serves to provide confidence in supllier/ manufacturer.

A proper quality assurance system has to be developed and maintained in every organization. The first step towards this is to have a quality policy.

A quality policy is a written document stating the objectives of the company with reference to quality. This quality policy should made known and understandable to every employees of the organization and the employees should strive towards achieving these policies.

The next step is to preapre quality amanual which includes indetaisl the organziation structure, departmentization, nature of work, flow of work stagesof inspection and the quality aspects that are taken care in the organziation. This quality manual is a document which the suppliers, customers can refer.

## 14.4 CASE STUDY

ABC company recently discovered that the costs due to shipment of defective item had risen to an alarming level. TO correct the situation, they decided to implement a quality assurance programme./ Previously, all inspection was done by workers on their own work. Because of lack of formal education in quality assurance for the present employees and managers ut was decided to form a team of recent college graduates fro quality assurance programs

The team which was formed was given the responsibility of reducing the percentage defective items being produced to half of the present level in one month.

Problems, however began to crop up immediately, conflicts arose between the inspectors of the QAP and the workers. Some of the older employees felt they were being insulted whenever a quality problem was traced to their work. This resentment often in their work deteriorating further instead of improving.. Other workers believed they were being wringluy accused of shoddy workmanship. Some even accused the inspectors of actually making defects in their work so that they could claim they had found a problem spot (defect) and hence, look good in the eyes of the QAP manager.

Monitoring reports after the first month showed that the quality level had actually worsened. Management felt that perhaps they had introduced the quality assurance programme improperly.

Discussion question

1. What errors do you feel the ABC company made in the implementation of QAP.

2. What remedial action would you take to improve the present situation?

## 14.5 NOTES

## 14.6 SUMMARY

Cost of Quality ("COQ") is a measurement used for assessing the waste or losses from some defined process (e.g. machine, production line, plant, department, company, etc.).

Quality assurance is the process of verifying or determining whether products or services meet or exceed customer expectations. Quality assurance is a process-driven approach with specific steps to help define and attain goals. This process considers design, development, production, and service.

The most popular tool used to determine quality assurance is the Shewhart Cycle, developed by Dr. W. Edwards Deming. This cycle for quality assurance consists of four steps: *Plan*, *Do*, *Check*, and *Act*. These steps are commonly abbreviated as PDCA.

The four quality assurance steps within the PDCA model stand for:

**Plan:** Establish objectives and processes required to deliver the desired results.

**Do:** Implement the process developed.

**Check:** Monitor and evaluate the implemented process by testing the results against the predetermined objectives

**Act:** Apply actions necessary for improvement if the results require changes.

Quality assurance demands a degree of detail in order to be fully implemented at every step. *Planning*, for example, could include investigation into the quality of the raw materials used in manufacturing, the actual assembly, or the inspection processes used. The *Checking* step could include customer feedback, surveys, or other marketing vehicles to determine if customer needs are being exceeded and why they are or are not. *Acting* could mean a total revision in the manufacturing process in order to correct a technical or cosmetic flaw.

Competition to provide specialized products and services results in breakthroughs as well as long-term growth and change. Quality assurance verifies that any customer offering, regardless if it is new or evolved is produced and offered with the best possible materials, in the most comprehensive way, with the highest standards. The goal to exceed customer expectations in a measurable and accountable process is provided by quality assurance.

## 14.7 KEY WORDS

Cost of Quality

Prevention cost

Appraisal Cost

Failure Cost

Quality Assurance

## 14.8 SELFASSESSEMENT QUESTIONS

1. Define Cost of quality. What are different categories of Cost of Quality.

2. Differentiate between internal and external Failure Costs.

3. Define quality assurance. What are the objectives of quality assurance?

## 14.9 REFERENCE

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# UNIT - 15 -BENCH MARKING AND BPRE

**Structure:**

## 15.0 OBJECTIVES

After studying this unit, you should be able to;

- Examine the underlying principles of benchmarking
- Interpret the implication of Business process reenginerring in TQM
- Identify the recent trends in Quality Management

## 15.1 INTRODUCTION

Benchmarking is the process of determining who is the very best, who sets the standard, and what that standard is. For example, who is the best sales organization? Which is the most responsive customer service department? What is the leanest manufacturing operation? And how do we quantify that standard? Benchmark identifies the best in the industry, whether it is manufacturing or service. Toyota is the benchmark for automobile industry; similarly Sony is one in electronics.

BPRE or Business process re-engineering is a process of radical rethinking and radical changes in the operations of any industry. It speaks about the complete change in the operations, which aims to provide the best service or product to customer. Swtching over the operations of telecommunications from analog to digital is one classic example of BPRE.

## 15.2 BENCH MARKING

**Robert Camp** first coined the term Benchmarking in 1980, while engaged in stuyding the improvement programme at Xerox Coprporation. According to Camp the meaning of Benchmarking is finding and implementing best practices in business.

Bench marking is a process of comparing and measuring one's own business process with those business leaders anywhere in the world with a view to gaining information and understanding their methods and process, and then adopting it in the own orgnization for improving performance to higher level. Juran described this as practice for managerial breakthrough. The essence of benchmrakring is the endeavour to anlyse and understand the processes, products or service of a world class company in order to learn how they achieved that superior performaence,and then setting up one's own internal meadures to meet or surpass them, the purposeof benchmarking is to enaable the organization to take a quantam jump in improvement resulting in increassed business performance.

Bench marking is the formal process, which makes the organization lokk outside toa recognized business leader for knowing and understandin g the way to their success. The key to the success of benchmarking process is in understanding of what, why, how and when of the success story.

Good benchmarking excercises produces two type so f uinformation. Quantitiative date athat are used to measure current performaence ans set future target, and qualittative information on the design and adoption of jey success factors that expalins how the benchmarkeked company become the leader in that function.

Outline of benchmarking process

a. Plan: Critical success factors, select processes for benchmarking, form teams, document processes, develop performance measures.

b. Search: Find benchmarking partners

c. Observe: Understand and document the partners' proces, performance and practice.

d. Analyse: Identify gaps in performance and find the root causes for the gaps

e. Adopt : Choose best practise adapt to compnay's conditions and implement changes

Pitfalls of Benchmarking:

1. Benchmarking can not work unless there is an environemnt of creativity. Commitment d involvement of people.
2. Failure of management to maintain the mmetum if gains and furhetring it by inspring great vision.
3. Failure to empower people to introud ce improvement by h=judicious exercise of their creativity and skills,

**Methodology**

Benchmarking involves the following steps:

- Select a product, service or process to benchmark;
- Identify the key performance metrics;
- Choose companies or internal areas to benchmark;
- Collect data on performance and practices;
- Analyze the data and identify opportunities for improvement;
- Adapt and implement the best practices, setting reasonable goals and ensuring company-wide acceptance.

**Common uses**

Companies use Benchmarking to:

- Improve performance. Benchmarking identifies methods of improving operational efficiency and product design;

- Understand relative cost position. Benchmarking reveals a company's relative cost position and identifies opportunities for improvement;
- Gain strategic advantage. Benchmarking helps companies focus on capabilities critical to building strategic advantage;
- Increase the rate of organizational learning. Benchmarking brings new ideas into the company and facilitates experience sharing.

## 15.3 BUSINESS PROCESS RE ENGINEERING (BPRE)

According to Michel Hammer of US who coined the term re-engineering the definition of reengineering is as follows. RE-engineering has been defined as the fundamental rethinking and radical design of business processes to achieve dramatic improvement in critical contemporary measures of performance such as cost, quality, service and speed. The term is also known as Process re –engineering or business process re-engineering.

The BPRE is focused on break through improvement to dramatically improve the quality and speed of work and to reduce its cost by fundamentally changing the process by which work gets done

**Process of reengineering**

Continuous improvements

Measurements and controls

Stream lining

Understanding the process

The reengineering process

- State a case for action
- Identify the process for reengineering
- Evaluate enablers for reengineering
- Understand the current process
- Create anew process design
- Implement the reengineering process

**Principles of reengineering**

- Organize around outcomes, not tasks
- Have those who use the output of the processes perform the process
- Merge information processing work into the real work that produces the information
- Treat geographically dispersed resources as though they work centralized

- Link parallel activities instead of integrating their results
- Have those who use the output of the process to reform the process
- Put the decision point where the work is performed and build control over the process
- Capture information once at source

**Application of re-engineering**

1. Develop business vision and process objectives
2. Identify process to be redesigned
3. Understand and measure existing processes
4. Identify information technology levels
5. Design and build prototype of the process

**Requirement of Re engineering process**

1. Critical process
2. Strong leadership
3. Cross functional teams
4. Information technology
5. Clean state philosophy
6. Process analysis

## 15.4 TOP MANAGEMENT ROLE IN IMPLEMENTING TQM

Without top management commitment, TQM implementation is an impossible task. Commitment begins by placing quality at the top of every agenda. The ideal implementation model is top-down implementation, i.e. top, middle, lower management and finally employees. 'How Good?' must precede 'How Much?' and 'How Many?'

The areas that require management commitment are: Customer satisfaction. This includes internal customers within the organisation.

Acquisition of new skills and perspectives. This propounds that statistical analysis must become the basis in place of opinions and feelings. Recognising success. Thanking people for their contributions.

The commitment of the chief executive of the organisation is vital. He or she sets the tone for the whole effort by becoming visible in their support for TQM. This commitment can be expressed by providing each employee with a personal copy of the Quality Policy. The policy statement will be most meaningful if it is signed by the top managers. The statement should be clear, concise and cover all aspects of quality.

Management must establish TQM as an objective and accept responsibility

- Top management must be able to overcome the obstacles, most of which would emanate from the management itself.

The top management has major role to perform in implementing TQm. It includes

- ♦ Management Commitment
- ♦ Plan (drive, direct)
- ♦ Do (deploy, support, participate)
- ♦ Check (review)
- ♦ Act (recognize, communicate, revise)

## 15.5 NOTES

## 15.6 SUMMARY

The implementation of TQM is not an ordinary job. IT involves of lots of task. IT includes convincing and the employees and winning their support. In the initial phases the employees resist the implementation of TQM due to lack of knowledge and the natural tendency to resist change. The second phase of implementation includes developing the mission statement which aims at continuous improvement. Last but not the least the top management commitment is required to implement TQM.

## 15.7 KEY WORDS

- Bench marking
- BPRE

## 15.8 SELFASSESMENT QUESTIONS

1. Explain the different resistance that the employees offer and how to tackle these resistances.
2. What is a mission statement? Explain with example
3. Explain why top management commitment is necessary for implementing TQM.

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# UNIT - 16 : QUALITY GURUS OF TQM

**Structure:**

## 16.0 OBJECTIVES

After studying this unit, you should be able to;

- Explain the Contributions of the Dr. Kaoru Ishikawa
- Highlight the Contributions Edward Deming's
- Evaluate the Contributions of Phillips Crosby
- Examine the Contributions of the Dr. Joseph M Juran

## 16.1 INTRODUCTION

Quality Guru is an expert thinker who communicates his thoughts through verbal & written expressions and thus contributes to the field of TQM. The name Total Quality Management was first suggested by Nancy Warren. Most of the quality gurus are originated from Japan. Some of the major contributors towards the thought of TQM are

- W. Edward Deming
- Joseph M Juran
- Phillips B Crosby
- Armand V Feigenbaum
- Kaoru Ishikawa
- Genuchi Taguchi
- Shigeo Shingo

## 16 .2 CONTRIBUTIONS OF DR KAORU ISHIKAWA

Dr Kaoru Ishikawa (1915-1989) is considered as Japan's leading figure in the area of Total Quality Management. He was a Japanese University professor and influential quality management innovator best known in North America for the Ishikawa or cause and effect diagram (also known as Fishbone Diagram) that are used in the analysis of industrial process to evaluate the root cause for nay defect.

Born in Tokyo, the oldest of the eight sons of Ichiro Ishikawa. In 1939 he graduated from University of Tokyo with an Engineering degree in applied chemistry. His first job was as a naval technical officer (1939-1941) then moved on to work at the Nissan Liquid Fuel Company until 1947. Ishikawa would now start his career as an associate professor at the University of Tokyo. He then undertook the Presidency of the Musashi Institute of Technology in 1978

## 16.3 ISHIKAWA'S MAJOR CONTRIBUTIONS

1. Quality Control Circles : He was first to introduce this concept and to put it into practice successfully. Qulaity circles are nothing but a smaal group of workers and managers who take up a small objective to be achieved in a short period of time and discuss problems pertaining to quality and try to avoid such problems in future.

2. He is the originator of fishbone diagram or Ishikawa diagrams which are now used world wide for problem solving and continuous improvement through cause effect analysis. A finbone diagram usually look like a fish bone. It is also called as cause effect diagram or Ishikawa diagram. A horizontal line would show the effect or a problem to be rectified and a number of inclined lines would hsow the possible causes for such a problem.

3. Ishikawa had commented that Feigenbaum's approach to Total Quality Control includes many non specialists and therefore the input on quality problem solving may be limited. He argues that Company Wide Quality Control has to rely on wide use of statistical techniques.

4. He was instrumental in developing audit process for determining whether a company could be selected for Deming Prize.

Some of the key elements of his philosophy

1. Quality begins with education and ends with education
2. The first step in quality is to know the requirements of customers
3. The ideal state of quality control occurs when inspection is no longer necessary.
4. Remove the root cause, not the symptoms
5. Quality control is the responsibility of all workers.
6. Do not confuse means with objectives.
7. Put quality first and your sights on long term profits.
8. Market is the entrance & exit of quality.
9. Top managements must not show anger when facts are presented by sub ordinates.
10. Ninety five percent of problems in a company can be solved with simple tools for analysis and problem solving.
11. Data without dispersion information (variability) are false data.

Ishikawa also showed the importance of the seven quality tools: control chart, run chart, histogram, scatter diagram, Pareto chart, and flowchart. Additionally, Ishikawa explored the concept of quality circles— a Japanese philosophy which he drew from obscurity into world wide acceptance. .Ishikawa believed in the importance of support and leadership from top level management. He continually urged top level executives to take quality control courses, knowing that without the support of the management, these programs would ultimately fail. He stressed that it would take firm commitment from the entire hierarchy of employees to reach the company's potential for success. Another area of quality improvement that Ishikawa emphasized is quality throughout a product's life cycle — not just during production. Although he believed strongly in creating standards, he felt that standards were like continuous quality improvement programs — they too should be constantly evaluated and changed. Standards are not the ultimate source of decision making; customer satisfaction is. He wanted managers to consistently meet consumer needs; from these needs, all other decisions should stem. Besides his own developments, Ishikawa drew and expounded on principles from other quality gurus, including those of one man in particular: W. Edwards Deming, creator of the Plan-Do-Check-Act model.

Ishikawa expanded Deming's four steps into the following six:

- Determine goals and targets.
- Determine methods of reaching goals.
- Engage in education and training.
- Implement work.
- Check the effects of implementation.
- Take appropriate action.

## 16.4 CONTRIBUTIONS OF W. EDWARD DEMING

Dr. W. Edward Deming was born in 14th October 1900 and is regarded as Quality Guru who has never gave up. Deming Overall approach focused on improvement of the systems and processes for efficient quality management. He believed it is the systems not the workers (i.e. people of the organization) which is responsible for the variations. He has preached 14 steps for quality improvement.

## 16.5 DEMING'S 14 POINTS OF QUALITY IMPROVEMENT

1. Create consistency of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.
5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
6. Institute training on the job.
7. Institute leadership (see Point 12). The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul as well as supervision of production workers.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.
10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11 a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

   b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

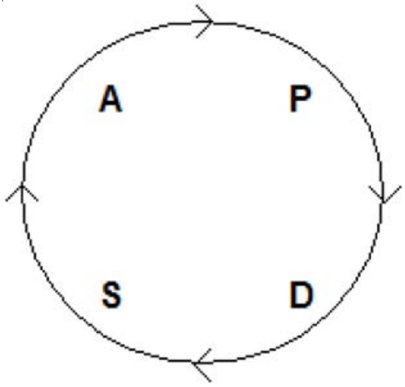
12 a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

   b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means abolishment of the annual merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

## 16.6 DEMING'S PDSA CYCLE

Deming describes a simple four step process for continuous improvement of quality that he learned from Dr. Walter A. Shewhart during the 1930's when he worked with and mentored under Shewhart at the Hawthorne Works Western Electric plant in Chicago. Deming refers to it as the PDSA Cycle (Plan Do Study Act) or the Shewhart Cycle. The Japanese call it the Deming Cycle. Others call it the PDCA Cycle (Plan Do Check Act) or the Deming Wheel. The PDSA Cycle contains five steps:




Plan Develop a plan for improving quality at a process

Do Execute the plan, first on a small scale

Study Evaluate feedback to confirm or to adjust the plan

Act Make the plan permanent or study the adjustments

The fifth step of the PDSA Cycle is the cyclical aspect of the technique. After all "action" is completed, this continuous cycle continues with another "plan."

Deming's PDSA Cycle bears very strong resemblance to the basic scientific method as represented by Dewey:

**Plan** corresponds to the developing of theories and propositions,

**Do** corresponds to observing and experimenting,

**Study** corresponds to the analyzing of data and the developing of conclusions, and

**Act** corresponds to the adoption of results into the body of knowledge.

## 16.7 CONTRIBUTIONS OF PHILIP CROSBY

Phillip B Crosby was a former corporate Vice president for quality at ITT. He is the founder of the Cross By Quality college where over 15000 senior managers have attended courses and seminars on quality . Crosby is perhaps best known for his more vocational style and popular programme such as zero defect conformance for requirements, and quality is free. He is also the author of many books amongst which quality is free- The art of making quality certain is universality adopted book. His one other book is quality without tears.

The essence of crossby's quality free is prevention. He agues that quality is free. The costs are only related to the various obstacles which prevent workers from producing right the first time.

The major objective of organizations implementing total quality should be Zero defect (ZD) according to Phillips Crosby. Acceptable quality levels (AQL) should be forbidden because they compromise the commitment towards the achievement of zero defects.

Poor quality is caused by

1. Poor awareness and knowledge
2. Carelessness and lack of attention of workers.

It is easy to avoid first type of mistake by providing proper training.

Crosby's four absolutes of quality

1. Quality means conformance to requirements.
2. Quality comes form prevention
3. Quality performance standard is zero defects
4. Quality measurement is the price of non conformance

Crosby's 6 C's

1. Comprehension : Understanding what is necessary
2. Commitment : Dedication
3. Competence Implementation of the improvement processes
4. Correction : Elimination of possibility of error
5. Communication: Complete understanding and support of all people
6. Continuance

## 16.8 CONTRIBUTIONS OF JOSEPH M JURAN

Dr. Joseph M. Juran was born in December 24th of 1904 at Braila, Rumania, he graduated as an Electric Engineer bachelor in science in 1924 and now a day he is considered the leader of the quality management of the last 70 years. The influence of the scripts he has written is considered the core of quality management, i.e. Juran's Quality Handbook 5th edition.

Dr. Juran worked together with tools like Pareto Principle and Total Quality Management and others that are part of the program that Dr. Juran used to increase the culture of quality in companies. His contribution includes

- Juran Trilogy

- Juran's ten steps to Quality improvement

## 16.9 JURAN'S TRIOLOGY

Dr. Juran's trilogy defined the three management processes required by every organization to improve: Quality control, quality improvement and quality planning.

This Trilogy shows how an organization can improve every aspect by better understanding of the relationship between processes that plan, control and improve quality as well as business results. It was created in the 1950's and defines managing for quality as three basic quality-oriented, interrelated processes:

Quality Planning — To determine customer needs and develop processes and products required to meet and exceed those of the customer needs. The processes are called Design for Six Sigma or Concurrent Engineering. This can be particularly challenging for a planning team, because customers are not always consistent with what they say they want. The challenge for quality planning is to identify the most important needs from all the needs expressed by the customer.

- Identify who are the customers.
- Determine the needs of those customers.
- Translate those needs into our language.
- Develop a product that can respond to those needs.
- Optimize the product features so as to meet our needs and customer needs.

A new term called quality function deployment (QFD) is also used in this regard.

Quality Control — The purposes of quality control is to ensure the process is running in optimal effectiveness, or to ensure that any level of chronic waste inherent in the process does not get worst. Chronic waste, which is a cost of poor quality that can exist in any process, may exist due to various factors including deficiencies in the original planning. It could cost a lot of money to the company, from rework time to scrap product to overdue receivables. If the waste does get worst (sporadic spike), a corrective action team is brought in to determine the cause or causes of this abnormal variation. Once the cause or causes had been determined and corrected, the process again falls into the zone defined by the "quality control" limits.

- Prove that the process can produce the product under operating conditions with minimal inspection.
- Transfer the process to Operations.

Quality Improvement — Eliminate waste, defects and rework that improves processes and reduces the cost of poor quality. The processes have to be constantly challenged and continuously improved. Such an improvement does not happen of its own accord. It results from purposeful Quality Improvement or "Breakthrough."

- Develop a process which is able to produce the product.
- Optimize the process.

## 16.10 JURAN'S TEN STEPS TO QUALITY IMPROVEMENT

- Build awareness of the need and opportunity for improvement
- Set goals for improvement
- Organize to reach the goals
- Provide training
- Carry out projects to solve problems
- Report progress
- Give recognition
- Communicate results
- Keep score
- Maintain momentum by making annual improvement part of the regular systems and processes of the company

## 16.11 PARETO'S PRINCIPLE

The Pareto principle suggests that most effects come from relatively few causes. In quantitative terms: 80% of the problems come from 20% of the causes (machines, raw materials, operators etc.); 80% of the wealth is owned by 20% of the people etc. Therefore effort aimed at the right 20% can solve 80% of the problems. Double (back to back) Pareto charts can be used to compare 'before and after' situations. In other words, it can be understand as when to decide where to apply initial effort for maximum effect.

The value of the Pareto Principle for a manager is that it reminds you to focus on the 20 percent that matters. An example can be of the things you do during your day, only 20 percent really matter. Those 20 percent produce 80 percent of your results. Identify and focus on those things.

## 16.12 TRAINING FOR QUALITY

The major problem in training for quality is that there needs to be an organized and integrated approach to management. In order to succeed the following steps can be followed:

1. A delineation of responsibilities for who contributes and in what ways

Executive leadership

The executive team takes the responsibility for creating a quality culture in the organization. A quality culture is a product of behaviors, skills, tools, and methods as they are applied to the work. These changes don't come about without showing people how to implement and sustain this culture.

Human resources

The human resources function bears the responsibility for implementing the quality training strategy. The implementation activities include the selection of subject matter, training design and delivery, and establishing an evaluation process.

The quality professionals

The quality professionals bear the responsibility to collaborate with the Human Resources professionals to share their technical expertise on quality, much the same as key sales professional would share their expertise in developing the curriculum for sales training.

2. A strong and unswerving focus on the customer—internal and external

It's necessary to know who the customers are, what their needs are, and what the features should be of a training strategy.

An integrated training system for quality requires an organization to design the system using a process that incorporates all of the basics of quality planning.

3. A plan established with clear strategies and tactics for quality training

Developing the strategic training plan for quality is critical to the success of any TQM implementation. A strategic training plan addresses these key areas: quality awareness, executive education, management training, technical training, resources, budgeting, and staffing. Strategic training plan uses different types of training like: Modular training: just-in-time training, mentoring, lectures by peers, self-study and conferences.

4. Resources

Every quality training program needs resources. There must be a purposeful effort to identify the staffing and materials funding necessary to achieve quality training goals.

5. A budget to fund the plan

They need to be committed specifically to the strategy and tactics that support training for quality.

6. Staffing.

It's the personnel requirements necessary to support training for quality. There are many basic types of staffing options that organizations utilize. There is, however, one constant trend: quality departments and the training function for quality are leaner and multifunctional. Various staffing structures are described below.

Centralized: There is a dedicated group of individuals that research, develop, instruct, and evaluate the quality-training curriculum. This structure tends to segregate the quality-training strategy from the general education strategies, creating a learning barrier. Participants view the quality training as something distinctly different from other professional development activities.

Hub and spoke: It consists of a training coordinator or manager at the headquarters unit with a "dotted line" relationship to training professionals in other divisions or business units. These individuals are usually part of the quality department infrastructure that is deployed throughout the organization.

Decentralized: In this model, each department, division, or business unit has its own approach to training for quality. However each unit is charged with developing its own tactics and deploying them within their areas of responsibilities. This is not an effective approach to quality training and takes a much higher level of coordination.

Shared: This is similar to the hub-and-spoke model, with slight enhancements. The trainers draft volunteers from the organization to support the training plan. These volunteers are selected from those who have received quality training in the past and may be supporting the quality system implementation as facilitator, team leader, or team member.

External quality consultants: External quality consultants provide an immediate, qualified resource that can support the organization's planning, development, delivery, and evaluation of training for quality.

7. Evaluation

Evaluation is critical to effective training for quality. Evaluation is not just an afterthought but a necessary and systematic part of an effective training process for quality.

To maintain the quality program based on the Juran's Trilogy Methodology is necessary follow the ten steps of Juran. Quality is a continuous improvement issue, so following the ten steps is possible maintain the methodology before and after the implementation.

## 16.13 NOTES

## 16.14 SUMMARY

The dictionary meaning of Guru is an authority, a respected teacher. The contributions of three widely known quality gurus are discussed here. Some people summarize these three gurus philosophy on quality improvement as three paths and one journey. All of them have contributed significantly towards quality improvement world wide and they have their wide acceptability.

## 16.15 KEY WORDS

- Quality trilogy
- Quality Improvement
- Edward Deming
- Fish Bone Diagram
- 80:20 Rule

## 16.16 SELF ASSESSMENT QUESTIONS

1. Briefly explain the philosophies of Juran
2. Briefly explain the philosophies of CrossBy
3. Discuss the principle of Deming and its applicability

## 16.17 REFERENCES

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# MODULE -V
# QUALITY TOOLS, TECHNIQUES AND SYSTEMS

## UNIT 17: JAPANEESE TECHNIQUES OF QUALITY IMPROVEMENT

**Structure:**

## 17.0 OBJECTIVES

After studying this unit you should be able to

- Appreciate Japanese contribution to quality Management
- Explain 5S technique
- Discuss about 7 wastes
- Apply 6 Sigma in an organization
- Identify various defect reduction techniques

## 17.1 INTRODUCTION

Japan, having been burned to the ground during the war, encouraged a climate of change from the start. Japanese managers took seriously the warnings about forthcoming changes in the customer's perception of quality and about the future demands for faster development of customer-oriented products and services. So they successfully combined the strategy of innovation with that of continuous quality improvement. This brought a reduction in costs, faster development times, prompt deliveries, customer satisfaction and enormous competitive advantage internationally. The Western approach was always based on the belief that innovation alone was enough for survival and growth. This has already been proved wrong on many occasions. The timing of Juran and Deming in Japan was impeccable. But, it was not only a question of arriving at a time when the Japanese were striving to rebuild their economy. Their ideas struck a chord in the East. Their emphasis on groups rather than individuals was attractive to the Japanese, while it simply failed to ignite a spark in the United States. Western preoccupation with individual achievement meant that sublimating individual aspirations to group consciousness was a quantum leap rather than a logical progression. Japanese industry was particularly receptive to the quality message for a number of reasons. Some of them are as follows:

i) The long-established Japanese tradition of fine craftsmanship and attention to detail through miniaturization struck a chord with these concepts.

ii) The strongly statistical flavour of the early work with its emphasis on quantifying variation in quality fitted well with the Japanese penchant for numbers.

Quality was seen as a national "survival" strategy. It was felt that the only way Japan would be able to afford the food and materials that it needed, being poor in natural resources, was to export goods of high quality at low prices. Quality was thus a key objective.

## 17.2 JAPANEESE TECHNIQUES FOR QUALITY IMPROVEMENT

As discussed above, Japaneese had to pioneer the production technology for which they developed various tools and techniques in the field of quality. They include

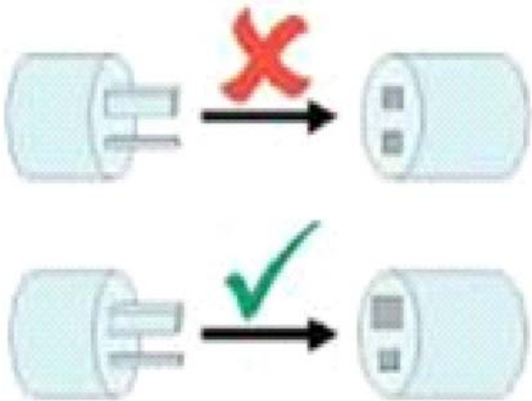
- Poka Yoke
- 5 S
- 7 Wastes
- Quality Function Deployment
- FMEA
- Six Sigma
- Quality Circles
- Miscellaneous Techniques

## 17.3 POKAYOKE

In terms of quality, Shingo's paramount contribution was his development in the 1960s of pokayoke and source inspection systems. These developed gradually as he realized that statistical quality control methods would not, in themselves, reduce defects to zero. The basic idea is to stop the process whenever a defect occurs, define the cause and prevent the recurring source of the defect. No statistical sampling is, therefore, necessary.

A key part of this procedure is that source inspection is employed as an active part of production to identify errors before they become defects. Error detection either stops production until the error is corrected, or it carries adjustment to prevent the error from becoming a defect. This occurs at every stage of the process by monitoring potential error sources. Thus, defects are detected and corrected at source, rather than at a later stage. Typically, this process is made possible by instrumenting machines with immediate feedback and reliance on the fallible judgment of personnel is minimized. They are essential, however, to establish the potential error sources.

Examples for Poka Yoke



## 17.4 5 S

5S represents five disciplines for maintaining a visual workplace. These are foundational to Kaizen and a manufacturing strategy based "Lean Manufacturing" concepts. 5S is the starting point for improvement activities that ensure our company's survival. The five disciplines are:

1. **Sort:** Remove all items from the workplace that are not needed for current operations. Leave only the bare essentials.

   - Target excess inventory, obsolete items, quality defects, unneeded tools/ equipment
   - Will use red tags, local and central red tag holding areas
   - Account for discarded items
   - Take before and after pictures

2. **Set:** Set in Order. Arrange needed items so that they are easy to find, use and put away.

   - Consider motion economy
   - Use painting, outlining and signboard strategies, Visual 5S

3. **Shine Sweeping**, wiping-off equipment, painting and assuring everything stays clean.

   - Create 5S schedules for painting
   - Should create cleaning inspection checklists
   - Create current and future shine targets

4. **Standardize:** Standardize method to maintain the first three disciplines (sort, set-in-order, shine)

   - Prevention steps for clutter-suspension, incorporation, elimination
   - Integrate 3S duties into regular work with 5S job cycle charts, five minute 5S, visual 5S activities

5. **Sustain** A top-down support of the ongoing 5S process should:

   - Create the conditions to support 5S
   - Allocate time
   - Create awareness
   - Provide a structure
   - Show support

- Offer rewards and recognition
- Encourage training/participation

## 17.5 7 WASTES

These wastes are as follows:

### 1. Defects

Quality defects originate rework, scrap and lost raw materials. If these defects go all the way to the customer, the loss will be even greater. To avoid this, one has to move from the traditional and obsolete "Quality Control" still in use in some facilities, to the innovative "Quality at the Source" (Jidoka) concept. Here, each member of the organization is empowered and will make sure that no faulty products leave or arrive at their workstations. This is supported with ingenious "mistake proofing" (Poka-Yoke) devices.

### 2. Waiting

Waiting is caused mainly by low reliability or availability of equipment, lack of stock or poor scheduling. Analyzing the process, one will be able to propose cost-effective improvements, from simple relocations or re-mapping to TPM and other implementations.

### 3. Processing

Over-processing takes place everywhere. Think of those steps that do not add any real value and processes that can be inaccurate or incorrect. An individual can team up the manufacturing force and find the appropriate actions that will start saving time, material, space and money.

### 4. Production

Over-production is just as bad as under-production. Production may also be too early or too late. Make sure production is performed at the right time in the right quantity. Lean Manufacturing establishes a one-piece flow environment where production obeys the market. One has to drastically reduce this disagreement between supply and demand.

### 5. Motion

There are many cases of people required to perform unnecessary motion, or awkward movements, or where motion is not efficient (not adding value to the product). A company saw in just a few hours, the reduction from 42 miles of motion of 24 people in three shifts to less than two miles of motion with 16 people in two shifts. The mission should be to use the same resources to produce more.

### 6. Inventory

Having too much raw material, WIP (Work in Process), finished goods because of large lots is sometimes overlooked and is a financial loss. SMED (Quick-Setup Strategy) implementations assist manufacturers to reduce lot sizes. Cellular organization or re-organization cuts WIP drastically. JIT deliveries provide instant solutions to the "conventional warehouse" problems.

**7. Transportation**

A defective or poor layout of the plant, an ineffective material handling system, an inconvenient location, all cause too much transportation which adds cost and risk to the operation. A value stream mapping will give you a cutting edge to reduce some of that overlooked unnecessary transportation. We are prepared to introduce these improvements and help many companies achieve their goals.

## 17.6 QUALITY FUNCTION DEPLOYMENT

Dr. Mizuno, professor emeritus of the Tokyo Institute of Technology, is credited with initiating the Quality Function Deployment (QFD) system. The first application of QFD was at Mitsubishi Heavy Industries Ltd. in the Kobe Shipyard, Japan, in 1972. After four years of case study development, refinement and training, QFD was successfully implemented in the production of mini vans by Toyota. Using 1977 as a base, a 20% reduction in startup costs was reported in the launch of a new van in October 1979, a 38% reduction by November 1982 and a cumulative 61% reduction by April 1984.

Quality function deployment was first introduced in the United States in 1984 by Dr. Clausing of Xerox. QFD can be applied to practically any manufacturing or service industry. It has become a standard practice by most of the leading organizations who also require it for their suppliers. Quality function deployment is a planning tool used to fulfill customer expectations. It is a disciplined approach to product design, engineering and production and provides in-depth evaluation of a product.

An organization that correctly implements QFD can improve engineering knowledge, productivity and quality, and reduce costs, product development time and engineering changes. QFD focuses on customer expectations or requirements, often referred to as the voice of the customer. It is employed to translate customer expectations, in terms of specific requirements, into directions and actions, in terms of engineering or technical characteristics, that can be deployed through the following:

- Product planning
- Part development
- Process planning
- Production planning
- Service industries

Quality function development is a team-based management tool in which customer expectations are used to drive the product development process. Conflicting characteristics or requirements are identified early in the QFD process and can be resolved before production. Organizations today use market research to decide what to produce to satisfy customer requirements. Some customer requirements adversely affect others and customers often cannot explain their expectations. Confusion and misinterpretation are also a problem while a product moves from marketing to design to engineering to manufacturing.

By implementing QFD, an organization is guaranteed to implement the voice of the customer in the final product or service. QFD helps in identifying new quality technology and job functions to carry out operations. This tool provides a historic reference to enhance future technology and prevent design errors. QFD is primarily a set of graphically oriented planning matrices that are used as the basis for decisions affecting any phase of the product development cycle. Results of QFD are measured based on the number of design and engineering changes, time to market, cost and quality. It is considered by many experts to be a perfect blueprint for quality by design.

Quality function deployment enables the design phase to concentrate on the customer requirements, thereby spending less time on redesign and modifications. The saved time has been estimated at one-third to one-half of the time taken for redesign and modification using traditional means. This saving means reduced development cost and also additional income because the product enters the market sooner.

**Benefits of QFD**

**Quality function deployment was originally implemented to reduce start-up costs.**

Organizations using QFD have reported a reduced product development time. For example, US car manufacturers of the late 1980s and early 1990s needed an average of five years to put a product in the market, from drawing board to showroom. Whereas Honda used to put a new product in the market in two and a half years and Toyota did it in three years. Both organizations credit this reduced time to the use of QFD. Product quality and, consequently, customer satisfaction improve with QFD due to numerous factors.

**Improves Customer Satisfaction**

Quality function deployment looks past the usual customer response and attempts to define the requirements in a set of basic needs that are compared to all competitive information. All competitors are evaluated equally from customer and technical perspectives. This information can then be prioritized using a Pareto diagram.

**Management can place resources where they will be the most beneficial in improving quality.**

Also, QFD takes the experience and information which are available within an organization and puts them together as a structured format that is easy to assimilate. This is important when an organization's employee leaves a particular project and a new employee is hired.

**Reduces Implementation Time**

Fewer engineering changes are needed when using QFD. When used properly, all conflicting design requirements can be identified and addressed prior to production. This education in used in operator training and changes in traditional quality control measures. By using QFD, critical items can be identified and monitored from product inception to production. Toyota reports that the quality of their product has improved by one-third since the implementation of QFD.

**Promotes Teamwork**

Quality function deployment forces a horizontal deployment of communication channels. Inputs are required from all facets of an organization— from marketing to production to sales. Thus, it ensures that the voice of the customer is being heard and that each department knows what the other is doing. This activity avoids misinterpretation, opinions and miscues. In other words, the left hand always knows what the right hand is doing. Efficiency and productivity always increase with enhanced teamwork.

**Provides Documentation**

A database for future design or process improvements is created. Data that are historically scattered within operations, frequently lost and often referenced out of context are now saved in an orderly manner to serve future needs. This database also serves as a training tool for new engineers. Quality function deployment is also very flexible when new information is introduced or things have to be changed on the QFD matrix.

## 17.7 FMEA

**Definition/Purpose:**

FMEA (Failure Modes and Effects Analysis) is a systematic, proactive method for evaluating a process to identify where and how it may fail and to assess the relative impact of different failures, in order to identify parts that are most in need of change. Typically, the purpose of FMEA is to identify specific ways a product, process or service might fail. It is designed to prevent tragedy by identifying potential failures. FMEA is useful in the Improve phase. FMEA includes review of the following:

- Steps in the process
- Failure Modes (What could go wrong?)

- Failure Causes (Why would the failure happen?)
- Failure effects (What would be the consequences of each failure?)

**Definitions:**

- Potential Failure Mode – What could go wrong? The four main types of process failure modes are *too much, too little, missing, or wrong.*
- Effects – What could be the *consequences* of each failure?
- Severity – How *serious* would the impact be if the potential failure were to occur?
- Potential Causes – What are the *drivers* of this failure?
- Occurrence – How *likely* is the cause and failure mode to occur?
- Current Controls – What *safeguards* are currently in place?
- Detection – How *difficult* is the cause and failure mode *to detect* prior to occurrence?
- Risk Priority Number (RPN) – Use to *prioritize* potential failure modes.
- RPN = (Occurrence) x (Severity) x (Detection)

Process of FMEA

1. Select a process.
2. Assemble a multi-disciplinary team who knows the process.
3. The team lists all steps in the process.
4. Identify high risk process steps.
5. List the failure modes and effects.
6. Define occurrence, severity and detection and calculate the RPN score.
7. Evaluate the results.

| FMEA Analysis | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project: | | | Team: | | | | | | | | Original Date: | | | | |
| | | | | | | | | | | | Revised Date: | | | | |
| Item or Process Step | Potential Failure Mode | Potential Effect(s) of Failure | S* | Potential Causes | O* | Current Controls | D* | R* | Recomm Action | Responsand Target Date | After" Action Taken | S* | O* | D* | R* |
| Risk Priority Number = | | | | | | | | "After" Risk Priority Number = | | | | | | | |

**Table 17.1 Capturing FMEA Information**

- S = Severity, O = Occurrence, D = Detection, R = RPN

## 17.8 SIX SIGMA

Before moving forward in order to understand the concept of six sigma, let us first understand the term sigma and statistics. Sigma, the term sigma means standard deviation. Standard deviation measures how much variation exists in a distribution of data. It is a key factor in determining the acceptable number of defective units found in a population. Six sigma projects strive for no more than 3.4 defects per million opportunities, yet this number is confusing to many statisticians.

### Standard Deviation

Small standard deviation means that data cluster closely around the middle of a distribution and there is little variability among the data. Normal distribution is the bell-shaped curve that is symmetrical about the mean or average value of a population.

### Definition

Six sigma at many organizations simply means a measure of quality that strives for near perfection. Six sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process from manufacturing to transactional and from product to service. Six sigma means a failure rate of 3.4 parts per million or 99.9997% perfect. However, the term in practice is used to denote more than simply counting defects.

Six sigma can now imply a whole culture of strategies, tools and statistical methodologies to improve the bottom line of companies. In all, six sigma is a rigorous analytical process for anticipating and solving problems. The objective of six sigma is to improve profits through defect reduction, yield improvement, improved consumer satisfaction and best-in-class product/process performance. Unlike the statistical term, "sigma" is a measure of conformance to specification.

As non-conforming rate decreases, "sigma" rating increases. The sigma rating is based on the distribution of a process output as related to a customer requirement. The short-term variability of the process output is such that the Upper Specification Limit (USL) and the Lower Specification Limit (LSL) are both six standard deviations (called ó or sigma in statistical parlance) away from the center. Recognizing that most of the processes shift somewhat over a long period of time, an arbitrary change of plus or minus 1.5ó is expected to happen, leaving 4.5ó between the shifted average and the specification limit. This means that a process running at a six sigma level in the short term can tolerate a relatively large amount of drift and still make only 3.4 PPM nonconforming over the long term with the dashed blue line.

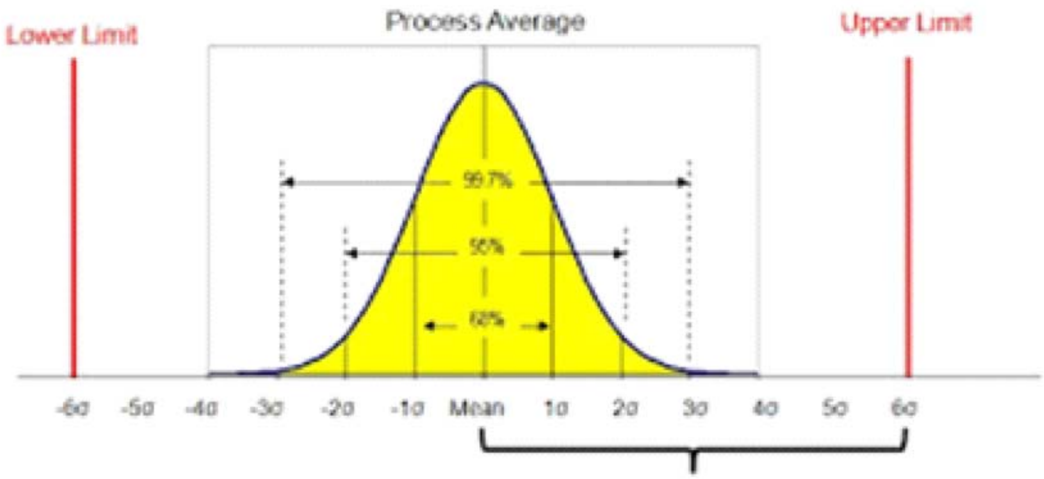



**FIG 17.1 NORMAL DISTRIBUTION**

**Phases of Six Sigma**

There are six generic implementation phases for six sigma. These are as follows:

- Establish management commitment
- Business diagnostics
- Develop the management infrastructure
- Business process identification and metrics
- Project selection
- Deployment
- Training
- Project execution

- Review

**Importance of Six Sigma**

World-class companies typically operate at about four sigma or 99% perfection. To get to the six-sigma level means cutting down on huge costs and thereby wasted dollars. For example, if you were at four-sigma level, you would be producing products at the rate of 6,200 defectives for every million you produce vs. 3.4 defectives if you are at the six-sigma level. Moreover, six sigma improvement projects typically return in excess of $150k to $250k per project with a black belt returning as much as $1 million to the bottom line each year.

The popularity of six sigma is growing. Some of the companies that have successfully implemented six sigma are as follows:

- Motorola (1987)
- Texas Instruments (1988)
- IBM (1990)
- Asea Brown Boveri (1993)
- Allied Signal/Kodak (1994)
- GE (1995)
- Whirlpool
- PACCAR
- Invensys and Polaroid (1996/98)

Recently, Ford, DuPont, Dow Chemical, Microsoft and American Express have started working on instituting six sigma processes.

**Methodology**

Six sigma focuses on process quality. As such, it falls into the category of a process capability (Cp) technique. Traditionally, a process is considered capable if the natural spread, plus and minus three sigma (a yield of 99.73%), was less than the engineering tolerance. A later refinement considered the process location as well as its spread (Cpk) and tightened the minimum acceptable so that the process was at least four sigma from the nearest engineering requirement. Six sigma requires that processes operate such that the nearest engineering requirement is at least plus or minus six sigma from the process mean. This requires considerable scientific and testing actions. Often, thousands of tests are run on multiple variables to get an understanding of what is going on. Once you determine the process variables, using the other process analysis techniques, you need to consider the ones causing the major losses and work on making them more capable.

- ♦ Understand who your consumers are and what your product/service is
- ♦ Review consumer surveys, concession reports and other data
- ♦ Screen and prioritize issues by severity, frequency/likelihood of occurrence etc
- ♦ Determine the internal processes causing most of the pain
- ♦ Find out why and where the defects are occurring
- ♦ Devise ways to address these defects effectively
- ♦ Setup a good metrics (six sigma places a lot of emphasis on measurement) There are a variety of nicknames for the principle players in the initiative.
- ♦ Have additional training beyond black belt training

♦ Can train and coach black belts o Provide consulting to management and champions

Six sigma champions are high-level individuals who understand six sigma and are committed to its success. In larger organizations, six sigma will be led by a full time, high-level champion, such as an executive vice-president. In all organizations, champions also include informal leaders who use six sigma in their day-to-day work and communicate the six sigma message at every opportunity. Sponsors are owners of processes and systems who help initiate and coordinate six sigma improvement activities in their areas of responsibilities.

**Black belt**

A person who is part of the leadership structure for process improvement teams are called "black belts" (just as total quality utilized "quality improvement team leaders" to provide structure). Black belts are highly-regarded, technically-oriented product or line personnel who have the ability to lead teams as well as to advise management. Black Belts Candidates for black belt status are technically oriented individuals held in high regard by their peers. They should be actively involved in the process of organizational change and development. Candidates may come from a wide range of disciplines and need not be formally trained statisticians or engineers. However, because they are expected to master a wide variety of technical tools in a relatively short period of time, black belt candidates will probably possess a background including college-level mathematics and the basic tools of quantitative analysis.

**Green Belt**

A green belt is a person trained in the six sigma methodology who is a team member of six sigma process improvement action teams. Green Belts Green belts are six sigma project leaders capable of forming and facilitating six sigma teams and managing six sigma projects from concept to completion. Green belt training consists of five days of classroom training and is conducted in conjunction with six sigma projects. Training covers project management, quality management tools, quality control tools, problem solving and descriptive data analysis.

Six sigma champions should attend green belt training. Usually, six sigma black belts help green belts define their projects prior to the training, attend training with their green belts and assist them with their projects after the training. The structure of a six sigma organization within a business would look something like the following:

## 17.9 QUALITY CIRCLES

Quality circle is the main ingredient of Ishikawa's company-wide quality control consisting typically of 5-10 personnel who meet at regular intervals. Led by a supervisor or team leader, they aim to contribute to and improve processes and activities, build up job satisfaction and company loyalty, and utilize existing and hidden resource potential. As part of membership, each member should be fully conversant with statistical quality control techniques and related methodologies in order to achieve quality improvement.

Wherever possible, the quality circles should be encouraged to implement improvements and solutions themselves. Or they can present to the higher management suggestions that identifies an additional training requirement of data presentation and reporting. This naturally produces an environment where operators are continually looking for solutions to problems, gaining a greater commercial awareness with an ability to "stand back" from the process, greater involvement and at the same time develop by using quality tools.

## 17.10 MISCELLANEOUS TECHNIQUES

### A. JIT

You must be already aware of JIT. The Just in Time (JIT) manufacturing concept was founded in part due to the contribution of Dr. Shingo Shigeo and Mr. Taichii Ohno of Toyota Motor Co. from 1949 to 1975. During this period, Dr. Shigeo took charge of industrial engineering and factory improvement training at Toyota Motor Corporation. This is commonly referred to as JIT or the Toyota Production System.

The essential element in developing JIT was the use of the Ford System along with the realization that factory workers had more to contribute than just muscle power. According to the American Production and Inventory Control Society (APICS),

- JIT can be defined as: A philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery and including all stages of conversion from raw material onward. The primary elements include
- Having only the required inventory when needed;

- To improve quality to zero defects;
- To reduce lead time by reducing setup times,
- Queue lengths and lot sizes;
- To incrementally revise the operations themselves; and
- To accomplish these things at minimum cost.

The basic essence of JIT has been implemented to the new "continuous improvement" or "lean manufacturing" wave in the industry today. The primary objective in implementing JIT to a production facility is to obtain a competitive advantage and increased productivity by eliminating the following seven types of wastes:

- Waste from overproduction
- Excess transportation
- Excess inventory
- Waiting time
- Processing waste
- Wasted motion
- Waste from production defects

In applying these simple concepts, a company can realize monetary savings. The use of statistical process control helps assure that the outcome of production is consistently met with desired results. In JIT, as soon as the notion of using small production lot sizes was developed, it became obvious that setup times would have to be reduced.

**B. SMED**

The SMED or Single Minute Exchange of Die system was born out of necessity, in order to achieve Just-In-Time production, one of Toyota's manufacturing corner stones.

Despite its name, SMED is applicable to almost any type of machine setup or changeover. Shingo's most striking successes with the method involved reducing the setup time for a boltmaking machine at Toyota from 8 hours to one minute and reducing the setup time for a boring machine at Mitsubishi Heavy Industries from 24 hours to less than three minutes. SMED uses the following four-step procedure:

1. Observe and Analyze how the Setup is currently performed Setups should be observed carefully and activity charts and worker-machine charts should be constructed. Whenever possible, one should videotape the setups. This is not only helpful in constructing the necessary data and charts; it is invaluable in showing workers what they are currently doing and how the setup can be improved. For example, when 3M Corporation videotaped its

changeover process, it was noticed that workers often did not have the correct tools when needed. Putting toolboxes near the changeover sites eliminated wasted time getting tools and reduced the changeover time.

2. Separate Internal from External Setup Activities One of the most effective ways to reduce setup times is to separate internal from external activities and then to make a written setup plan that ensures that external setup activities are performed while the process is operating. Some of the most common external setup activities are preparing and testing parts and tools, transporting these to the machine, bringing materials to be processed to the machine and transporting materials away from the machine such as finished products to storage or waste to disposal bins.

3. Convert Internal to External Setup Activities As Shingo found with setting up the engine-bed side planer, activities that appear to be internal setup activities can sometimes be converted to external activities. Changing work methods, adding work aids, or buying duplicate sets of tools or equipment can assist in this conversion.

4. Simplify and Streamline Activities Once as many activities as possible have been assigned to external setup, setup time can be reduced further by simplifying and streamlining work and by concentrating work more effectively. Although reducing the time needed to perform any activity is likely to have some benefit yet the primary focus should be on reducing the time for internal setup activities because this will reduce production system idleness. The best way to reduce setup activity times is by task simplification

5. The use of SMED procedures has become widespread in manufacturing, with hundreds of success stories reported. For example, Ford Motor Company reduced the time for a die change on one of its presses from 5 hours to 5 minutes and Packaging Corporation of America cut its changeover time for its carton-making machines from 21 hours to fewer than 8 hours.

**FIVE WHYS**

Five Whys helps identify the root cause of a problem. It determines the relationship between different root causes of a problem. It is the one of the simplest tools and is easy to complete without statistical analysis. It is used when problems involve human factors or interactions

**Methodology**

Write down the specific problem. Writing the issue helps you formalize the problem and describe it completely. It also helps a team focus on the same problem. 2. Ask why the problem happens and write the answer down below the problem. 3. If the answer you just provided does not identify the root cause of the problem that you wrote down in step 1, ask why again and write that answer down. 4. Loop back to step 3 until the team is in agreement that the problem's root cause is identified. Again, this may take fewer or more times than 5 Whys.

Examples of 5 whys Problem statement—

Statement: Customers are unhappy because they are being shipped products that do not meet their specifications.

Question 1 WHY: Why are customers being shipped bad products?

Statement: Because manufacturing built the products to a specification which is different from what the customer and the sales person agreed to.

Question 2 WHY. Why did manufacturing build the products to a different specification than that of sales?

Statement: Because the sales person expedites work on the shop floor by calling the head of manufacturing directly to begin work. An error happened when the specifications were being communicated or written down.

Question 3 WHY: Why does the sales person call the head of manufacturing directly to start work instead of following the procedure established in the company?

Statement: Because the "start work" form requires the sales director's approval before work can begin and slows the manufacturing process (or stops it when the director is out of the office).

Question WHY 4. Why does the form contain an approval for the sales director?

Statement: Because the sales director needs to be continually updated on sales for discussions with the CEO.

In this case, only four whys were required to find out that a non-value added signature authority is helping to cause a process breakdown.

Let us take a look at a slightly more humorous example modified from Marc R's posting of 5 Whys

Problem statement— You are on your way home from work and your car stops in the middle of the road.

1. Why did your car stop? Because it ran out of gas.

2. Why did it run out of gas? Because I did not buy any gas on my way to work.

3. Why did not you buy any gas this morning? Because I did not have any money.

4. Why did not you have any money? Because I lost it all last night in a poker game.

5. Why did you lose your money in last night's poker game? Because I am not very good at "bluffing" when I do not have a good hand.

In both the examples, the final "why" leads the team to a statement (root cause) that the team can take action upon. It is much quicker to come up with a system that keeps the sales director updated on recent sales or teach a person to "bluff" a hand than it is to try to directly solve the stated problems above without further investigation.

## 17.11 NOTES

## 17.12 SUMMARY

In this unit we have discussed about various techniques employed by Japanese in the field of quality. . We have studied about SMED, JIT, Pokayoke, Quality Cicle, Six Sigma. We have discussed about 5S and 7 waste

## 17.13 KEY WORDS

- Six Sigma
- 5S
- 7 Wastes
- JIT

## 17.14 SELF ASSESSMENT QUESTIONS

1. Explain Poka Yoke?
2. What is JIT?
3. Explain SMED system.
4. Explain six sigma
5. Discuss the application of quality circles

## 17.15 REFERENCES

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3. Production and Operations Management- R. Paneer Selvam
4. Production Management – Manoj Kumar Sarkar
5. Total Quality Management : D D Sharma

# UNIT - 18 : QUALITY CONTROL AND IMPROVEMENT

**Structure:**

## 18.0 OBJECTIVES

After studying this unit you should be able to

- Appreciate the application of Statistical Process Control
- Identify quality control tools
- Explain statistical Process Control
- Describe total preventive maintenance

## 18.1 INTRODUCTION

According to Deming the statistical quality control helps in finding the problems, stating in meaningful terms and solving them. The statistical quality control provides a plan or a road map that leads to a better competitive position. The heart of process control is PDCA cycle or Deming wheel adopted by Deming from Shewart cycle.

Organizations pursuing quality improvements must distinguish between common and special causes of problems. The advantages of statistical tools are that they allow people to differentiate between common causes and special causes of problems. Common causes constitute 85 per cent of the problems encountered in most work situations. They are the faults of the system.

Attempts to improve individual performance are useless when the problems lie in the system. The use of statistical techniques by the all the employees provides a common method of identifying and understanding critical problems and managing their solutions by facts.

## 18.2 TOOLS OF QUALITY

Basic problem-solving methods play a key role in modern statistical quality improvement applications. Since the 1960s, workers and engineers in Japanese industry have used simple graphical displays, referred to as the "basic seven QC tools" or the "magnificent seven QC tools," to analyze data and present the results of their problem-solving activities. These displays are now universally taught as tools for organization-wide quality improvement activities and they are often incorporated in large-scale systems for statistical process control. The "basic seven QC tools" are

1. Check sheets
2. Pareto charts
3. Ishikawa diagrams
4. Stratification
5. Histograms

6. Scatter plots

7. Control charts

**1. Check Sheet**

The **check sheet** is a form (document) used to collect data in real time at the location where the data is generated. The data it captures can be quantitative or qualitative. When the information is quantitative, the check sheet is sometimes called a **tally sheet**.

The defining characteristic of a check sheet is that data are recorded by making marks ("checks") on it. A typical check sheet is divided into regions, and marks made in different regions have different significance. Data are read by observing the location and number of marks on the sheet.

Check sheets typically employ a heading that answers the Five Ws:

- Who filled out the check sheet
- What was collected (what each check represents, an identifying batch or lot number)
- Where the collection took place (facility, room, apparatus)
- When the collection took place (hour, shift, day of the week)
- Why the data were collected.

**Uses**

Kaoru Ishikawa identified five uses for check sheets in quality control:

- To check the shape of the probability distribution of a process
- To quantify defects by type
- To quantify defects by location
- To quantify defects by cause (machine, worker)
- To keep track of the completion of steps in a multistep procedure (in other words, as a checklist)
- To assess the shape of a process's probability distribution

## Motor Assembly Check Sheet

Name of Data Recorder: Lester B. Rapp

Location: Rochester, New York

Data Collection Dates: 1/17 - 1/23

<table>
<tr><th rowspan="2">Defect Types/<br>Event Occurrence</th><th colspan="7">Dates</th><th rowspan="2">TOTAL</th></tr>
<tr><th>Sunday</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th></tr>
<tr><td>Supplied parts rusted</td><td></td><td>|||||||||</td><td>|||||</td><td>||||</td><td>||</td><td></td><td></td><td>20</td></tr>
<tr><td>Misaligned weld</td><td></td><td></td><td>|||</td><td></td><td></td><td>||</td><td></td><td>5</td></tr>
<tr><td>Improper test procedure</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td></tr>
<tr><td>Wrong part issued</td><td></td><td>|</td><td></td><td>||</td><td></td><td></td><td></td><td>3</td></tr>
<tr><td>Film on parts</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td></tr>
<tr><td>Voids in casting</td><td></td><td></td><td></td><td>||||</td><td>||</td><td></td><td></td><td>6</td></tr>
<tr><td>Incorrect dimensions</td><td></td><td></td><td></td><td></td><td></td><td>||</td><td></td><td>2</td></tr>
<tr><td>Adhesive failure</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td></tr>
<tr><td>Masking insufficient</td><td></td><td></td><td></td><td></td><td>|</td><td></td><td></td><td>1</td></tr>
<tr><td>Spray failure</td><td></td><td></td><td>|||||</td><td></td><td></td><td></td><td></td><td>5</td></tr>
<tr><td>TOTAL</td><td></td><td>10</td><td>13</td><td>10</td><td>5</td><td>4</td><td></td><td></td></tr>
</table>

**Fig 18.1 Check Sheet**

### 2. Pareto Chart

The Pareto chart is used to determine priorities for quality improvement activities. It is a bar chart that displays the relative frequency of problems in a process or operation. Each bar represents the relative frequency of a problem and the bars are arranged in decreasing order from left to right. Sometimes a curve is superimposed to indicate the cumulative percent of problem frequencies. The chart is named after Vilfredo Pareto (1848-1923), an Italian economist.

Pareto charts provide a tool for visualizing the Pareto principle which states that a small subset of problems (the "vital few") affecting a common outcome tends to occur much more frequently than the remainder (the "useful many"). The Pareto chart can be used to decide which subset of problems should be solved first, or which problems deserve the most attention. Pareto charts are often constructed to provide a before-and-after comparison of the effect of control or quality improvement measures.


**Fig 18.2 Pareto Chart**

### 3. Ishikawa Diagrams (Cause-and-Effect or Ishikawa or Fishbone)

The Ishikawa diagram, also referred to as a cause-and-effect diagram, tree diagram, or fishbone diagram, displays the factors that affect a particular quality characteristic, outcome, or problem. The diagram is named after its developer, Kaoru Ishikawa a leader in Japanese quality control.

An Ishikawa diagram is typically the result of a brainstorming session in which members of a group offer ideas on how to improve a product, process, or service. The trunk of the diagram represents the main goal and primary factors are represented as branches. Secondary factors are then added as stems and so on. Creating the diagram stimulates discussion and often leads to increased understanding of a complex problem.

Japanese QC circle members often post Ishikawa diagrams in a display area where they are accessible to managers and other groups. In the United States, Ishikawa diagrams are included in presentations by plant personnel to management or customers.

**a) Cause-effect diagram for car not starting in the morning**

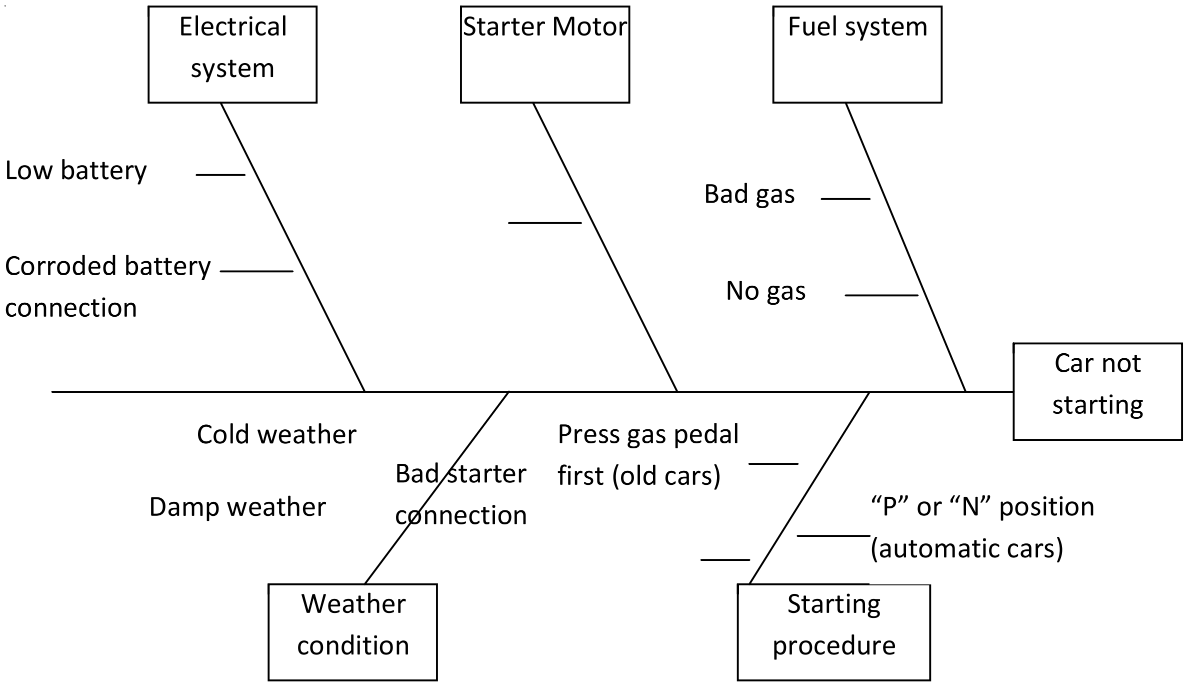



**Fig 18.3 Cause and Effect Diagram**

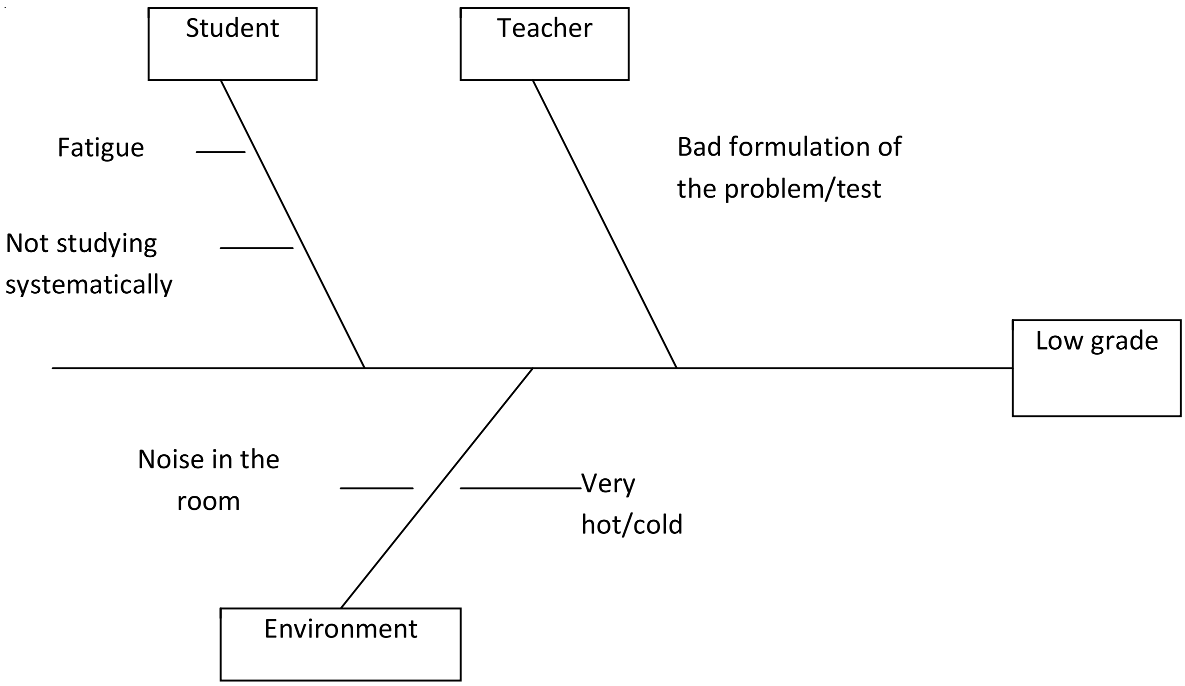



**Fig 18.4 Cause and Effect Diagram**

c) Cause-effect diagram for failing to graduate from college.

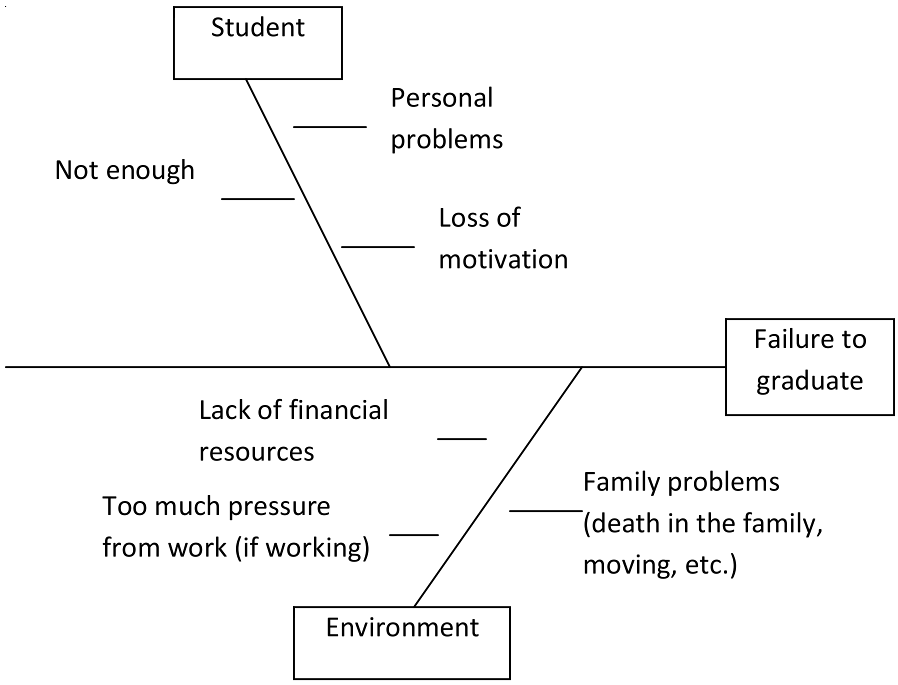



**Fig 18.5 Cause and Effect Diagram**

## 4. Stratification

Stratification is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be impossible to see. This technique separates the data so that patterns can be seen.

### When to Use Stratification

- Before collecting data.
- When data come from several sources or conditions, such as shifts, days of the week, suppliers or population groups.
- When data analysis may require separating different sources or conditions.

### Stratification Procedure

1. Before collecting data, consider which information about the sources of the data might have an effect on the results. Set up the data collection so that you collect that information as well.

2. When plotting or graphing the collected data on a scatter diagram, control chart, histogram or other analysis tool, use different marks or colors to distinguish data from various sources. Data that are distinguished in this way are said to be "stratified."

3. Analyze the subsets of stratified data separately. For example, on a scatter diagram where data are stratified into data from source 1 and data from source 2, draw quadrants,

count points and determine the critical value only for the data from source 1, then only for the data from source 2.

**Stratification Example**

The ZZ-400 manufacturing team drew a scatter diagram to test whether product purity and iron contamination were related, but the plot did not demonstrate a relationship. Then a team member realized that the data came from three different reactors. The team member redrew the diagram, using a different symbol for each reactor's data:

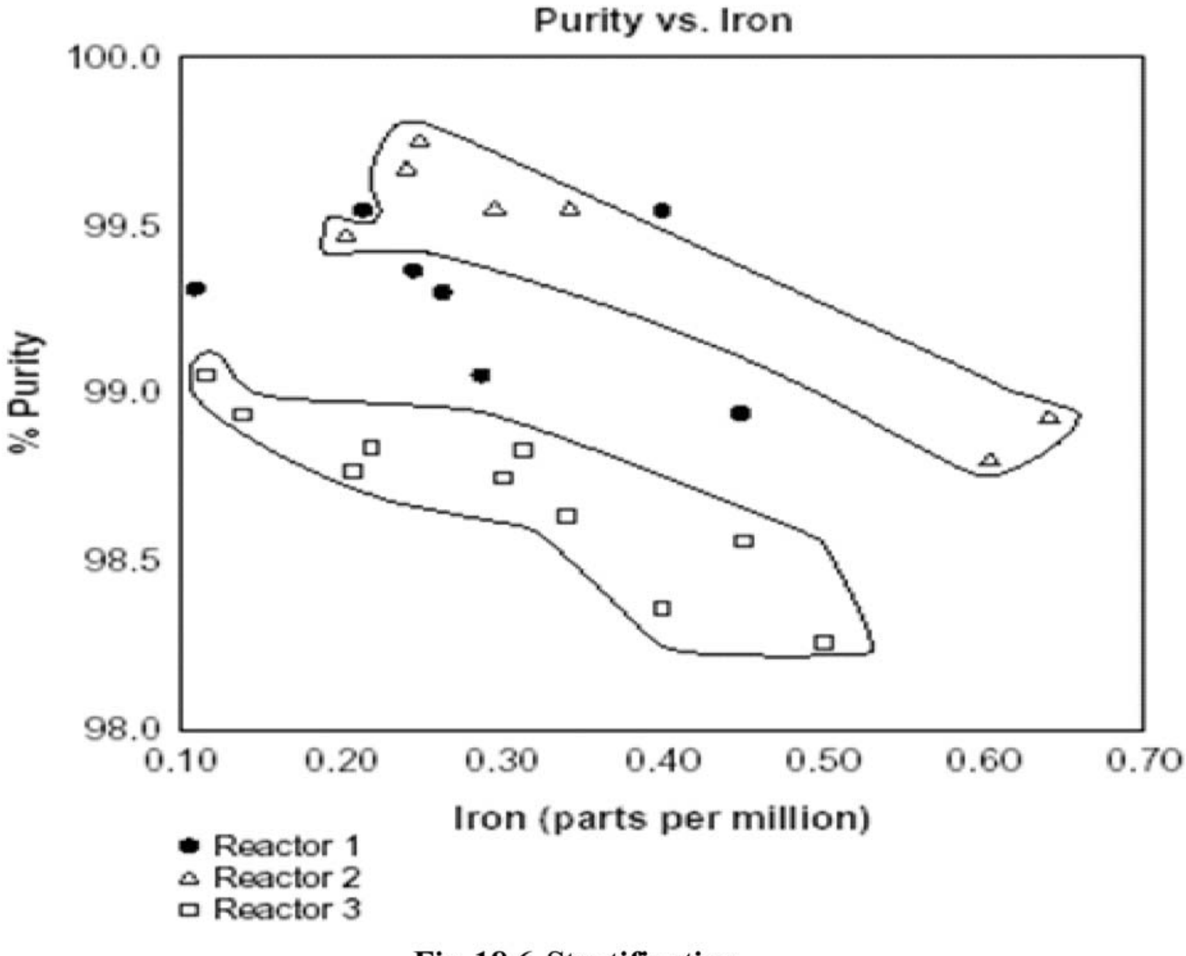



**Fig 18.6 Stratification**

Now patterns can be seen. The data from reactor 2 and reactor 3 are circled. Even without doing any calculations, it is clear that for those two reactors, purity decreases as iron increases. However, the data from reactor 1, the solid dots that are not circled, do not show that relationship. Something is different about reactor 1.

**Stratification Considerations**

Here are examples of different sources that might require data to be stratified:

- ♦ Equipment
- ♦ Shifts

- Departments
- Materials
- Suppliers
- Day of the week
- Time of day
- Products

Survey data usually benefit from stratification.

- Always consider before collecting data whether stratification might be needed during analysis. Plan to collect stratification information. After the data are collected it might be too late.
- On your graph or chart, include a legend that identifies the marks or colors used.

**5. Histogram**

A frequency distribution shows how often each different value in a set of data occurs. A histogram is the most commonly used graph to show frequency distributions. It looks very much like a bar chart, but there are important differences between them.

The histograms are used

- When the data are numerical.
- When you want to see the shape of the data's distribution, especially when determining whether the output of a process is distributed approximately normally.
- When analyzing whether a process can meet the customer's requirements.
- When analyzing what the output from a supplier's process looks like.
- When seeing whether a process change has occurred from one time period to another.
- When determining whether the outputs of two or more processes are different.
- When you wish to communicate the distribution of data quickly and easily to others.

**Procedure to construct Histogram**

- Collect at least 50 consecutive data points from a process.
- Use the histogram worksheet to set up the histogram. It will help you determine the number of bars, the range of numbers that go into each bar and the labels for the bar edges. After calculating $W$ in step 2 of the worksheet, use your judgment to adjust it to a convenient number. For example, you might decide to round 0.9 to an even 1.0.

The value for $W$ must not have more decimal places than the numbers you will be graphing.

- Draw x- and y-axes on graph paper. Mark and label the y-axis for counting data values. Mark and label the x-axis with the $L$ values from the worksheet. The spaces between these numbers will be the bars of the histogram. Do not allow for spaces between bars.
- For each data point, mark off one count above the appropriate bar with an X or by shading that portion of the bar.

**Histogram Analysis**

- Before drawing any conclusions from your histogram, satisfy yourself that the process was operating normally during the time period being studied. If any unusual events affected the process during the time period of the histogram, your analysis of the histogram shape probably cannot be generalized to all time periods.
- Analyze the meaning of your histogram's shape

**Example for Histogram**

| Hour of day | # of cans | Hour of day | # of cans |
|---|---|---|---|
| 1) 12:00mid - 1:00am | 24 | 13) 12:00noon1:00pm | 11 |
| 2) 1:00am - 2:00am | 17 | 14) 1:00pm - 2:00pm | 14 |
| 3) 2:00am - 3:00am | 29 | 15) 2:00pm - 3:00pm | 11 |
| 4) 3:00am - 4:00am | 19 | 16) 3:00pm - 4:00pm | 25 |
| 5) 4:00am - 5:00am | 13 | 17) 4:00pm - 5:00pm | 34 |
| 6) 5:00am - 6:00am | 22 | 18) 5:00pm - 6:00pm | 45 |
| 7) 6:00am - 7:00am | 14 | 19) 6:00pm - 7:00pm | 54 |
| 8) 7:00am - 8:00am | 17 | 20) 7:00pm - 8:00pm | 65 |
| 9) 8:00am - 9:00am | 17 | 21) 8:00pm - 9:00pm | 72 |
| 10) 9:00am - 10:00am | 24 | 22) 9:00pm - 10:00pm | 78 |
| 11) 10:00am - 11:00am | 16 | 23) 10:00pm - 11:00pm | 84 |
| 12) 11:00am - 12:00noon | 23 | 24) 11:00pm - 12:00mid | 13 |

**Table 18.1 Histogaram**

In a factory manufacturing soft drinks on 24 X7 basis, cans were overfilled just some of the time. When is that? Are they overfilled, perhaps, just at certain times of the day? Over the next two weeks, the members collect some data, some evidence: The overfilling frequency (ie, the number of cans overfilled) compared to the time of day:

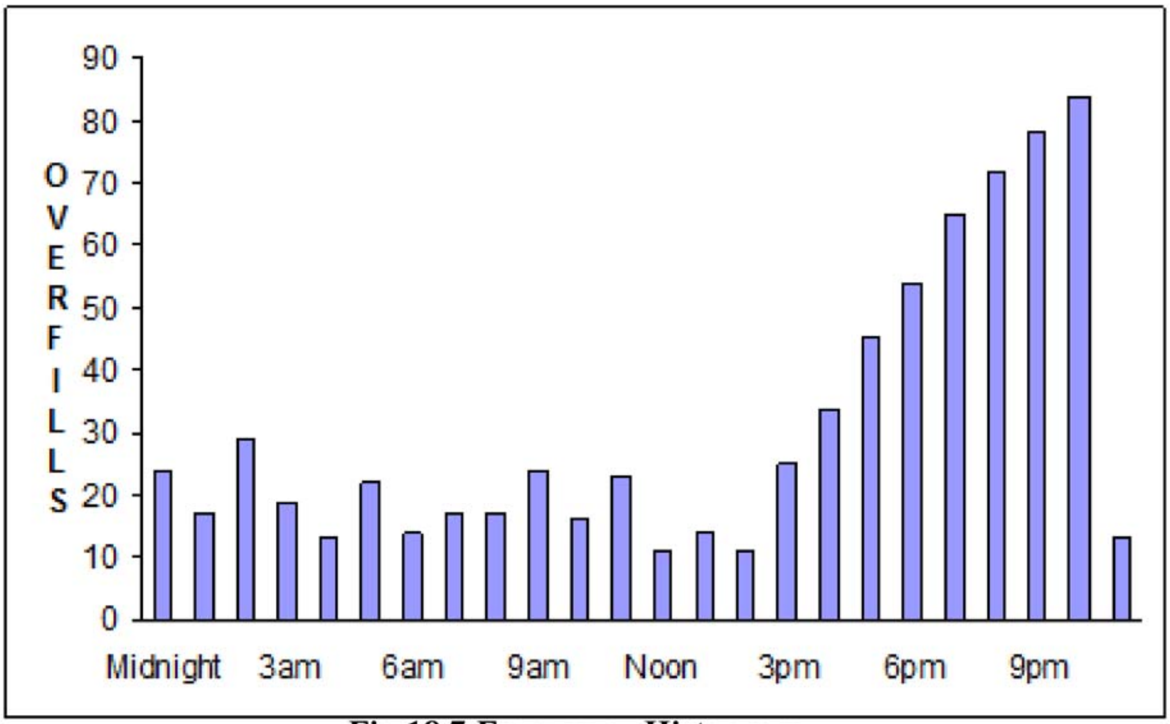



**Fig 18.7 Frequency Histogram**

The circle then charts the data as a **frequency histogram**. The height of a bar in a frequency histogram represents the "number of times" something is observed. The X axis in a frequency histogram represents each of the different categories.

The difference between a frequency histogram and the Pareto Chart is that, in a frequency histogram the categories on the X-axis are not arranged in order of descending frequency, but in their own 'natural' order, one after the other. From the histogram, the quality circle can easily see that the overfilling probem is worse between hours 16 (3:00 pm) and 23 (11:00 pm)—the plant's 'second shift'—and that it gets worse as the shift progresses. The quality team may further investigate the overfilling problem on second shift to look for the cause.

## 6. Scatter Plot

A scatter plot or a scatter diagram is a tool for analyzing relationships between two variables. One variable is plotted on the horizontal axis and the other is plotted on the vertical axis. The pattern of their intersecting points can graphically show relationship patterns. Most often a scatter diagram is used to prove or disprove cause-and-effect relationships. While the diagram shows relationships, it does not by itself prove that one variable *causes* the other. In addition to showing possible cause and effect relationships, a scatter diagram can show that two variables are from a common cause that is unknown or that one variable can be used as a surrogate for the other.

A scatter diagram is used in the following situations

1. To examine theories about cause-and-effect relationships and to search for root causes of an identified problem.
2. To design a control system to ensure that gains from quality improvement efforts are maintained.
3. To determine if two variables are related as after brainstorming causes and effects using a Fishbone Diagram, to decide whether a particular cause and effect are related.
4. To determine two effects that appear to be related occur due to the same cause.
5. To test for autocorrelation before constructing a control chart.

**Step by step guide to creating a scatter diagram:**

**1) Collect data** - Gather 50 to 100 paired samples of data that show a possible relationship.

**2) Draw the diagram** - Draw a graph with the independent variable on the horizontal axis and the dependent variable on the vertical axis. For each pair of data, put a dot or a symbol where the X-axis value intersects the Y-axis value. (If two dots fall together, put them side by side, touching each other, so that we can see both.)

**3) Analysis** – Look at the pattern of points if the relationship is apparent. If the pattern formed in the graph clearly from a line or curve, the variables are related. You can either use regression or correlation analysis.

**4)** Divide points on the graph into four quadrants. If there are N number of points on the graph, count N/2 points from top to bottom and draw a horizontal line similarly count N/2 points from left to right and draw a vertical line. If the number of points is odd, draw the lines through the middle point.

**5)** Count the points in each quadrant; don't count the points on the line.

**6)** Add the number of points in diagonally opposite quadrants. Find the smaller sum and the total number of points in each quadrant.

A= Points in Upper Left + points in Lower Right.

B= Points in Upper Right + points in Lower Left.

Q= The smaller of A and B.

N= A + B.

**7)** Look for the limit for N on the Trend Test Table below.

If Q is less than the limit, the two variables are related.

If Q is greater than or equal to the limit, the pattern could've occurred due to random chance.

| *N* | Limit | *N* | Limit |
|---|---|---|---|
| 1–8 | 0 | 51–53 | 18 |
| 9–11 | 1 | 54–55 | 19 |
| 12–14 | 2 | 56–57 | 20 |
| 15–16 | 3 | 58–60 | 21 |
| 17–19 | 4 | 61–62 | 22 |
| 20–22 | 5 | 63–64 | 23 |
| 23–24 | 6 | 65–66 | 24 |
| 25–27 | 7 | 67–69 | 25 |
| 28–29 | 8 | 70–71 | 26 |
| 30–32 | 9 | 72–73 | 27 |
| 33–34 | 10 | 74–76 | 28 |
| 35–36 | 11 | 77–78 | 29 |
| 37–39 | 12 | 79–80 | 30 |
| 40–41 | 13 | 81–82 | 31 |
| 42–43 | 14 | 83–85 | 32 |
| 44–46 | 15 | 86–87 | 33 |
| 47–48 | 16 | 88–89 | 34 |
| 49–50 | 17 | 90 | 35 |

**Types of correlation:**

**Interpret the data**. Scatter diagrams will generally show one of six possible correlations between the variables:

***Strong Positive Correlation:*** The value of Y clearly increases as the value of X increases (Fig.1)

***Strong Negative Correlation:*** The value of Y clearly decreases as the value of X increases. (Fig. 2)

***Weak Positive Correlation:*** The value of Y increases slightly as the value of X increases. (Fig. 3)

***Weak Negative Correlation:*** The value of Y decreases slightly as the value of X increases. (Fig. 4)

***Complex Correlation:*** The value of Y seems to be related to the value of X, but the relationship is not easily determined. (Fig. 4)

***No Correlation:*** There is no demonstrated connection between the two variables. (Fig. 6)

**Scatter Diagram - graphical representation**

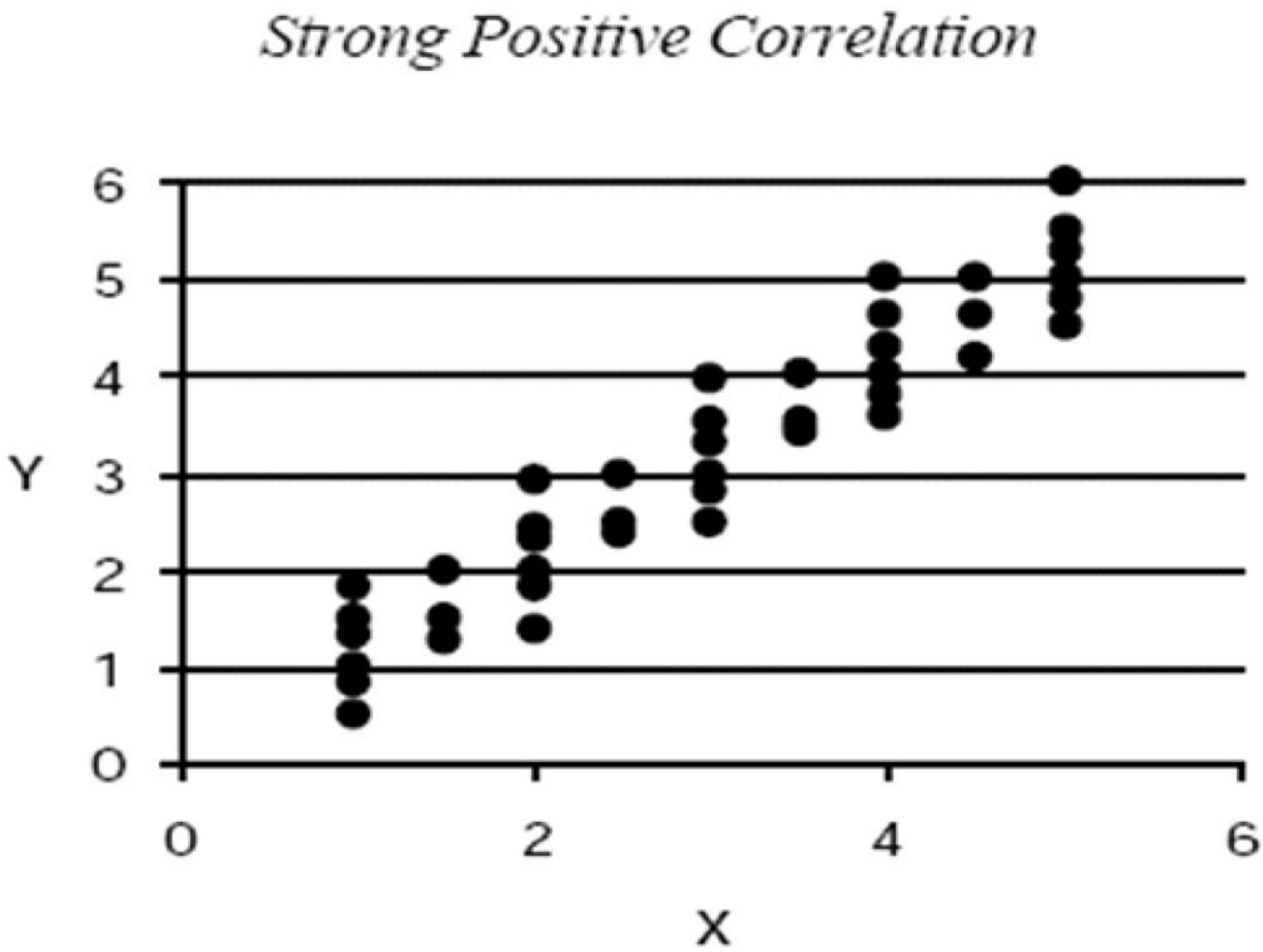



Fig. 1

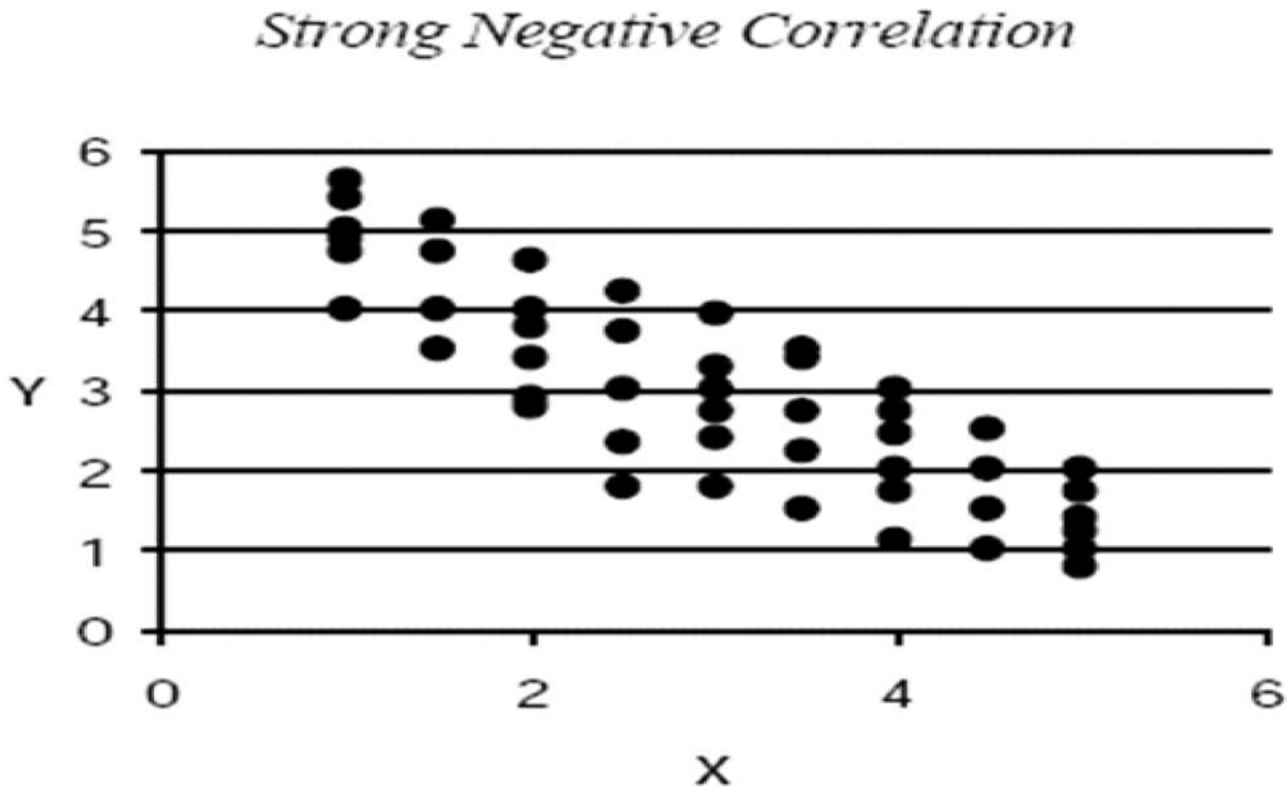

Strong Negative Correlation
6
5
4
Y 3
2
1
0
0
2
4
6
X

Fig. 2

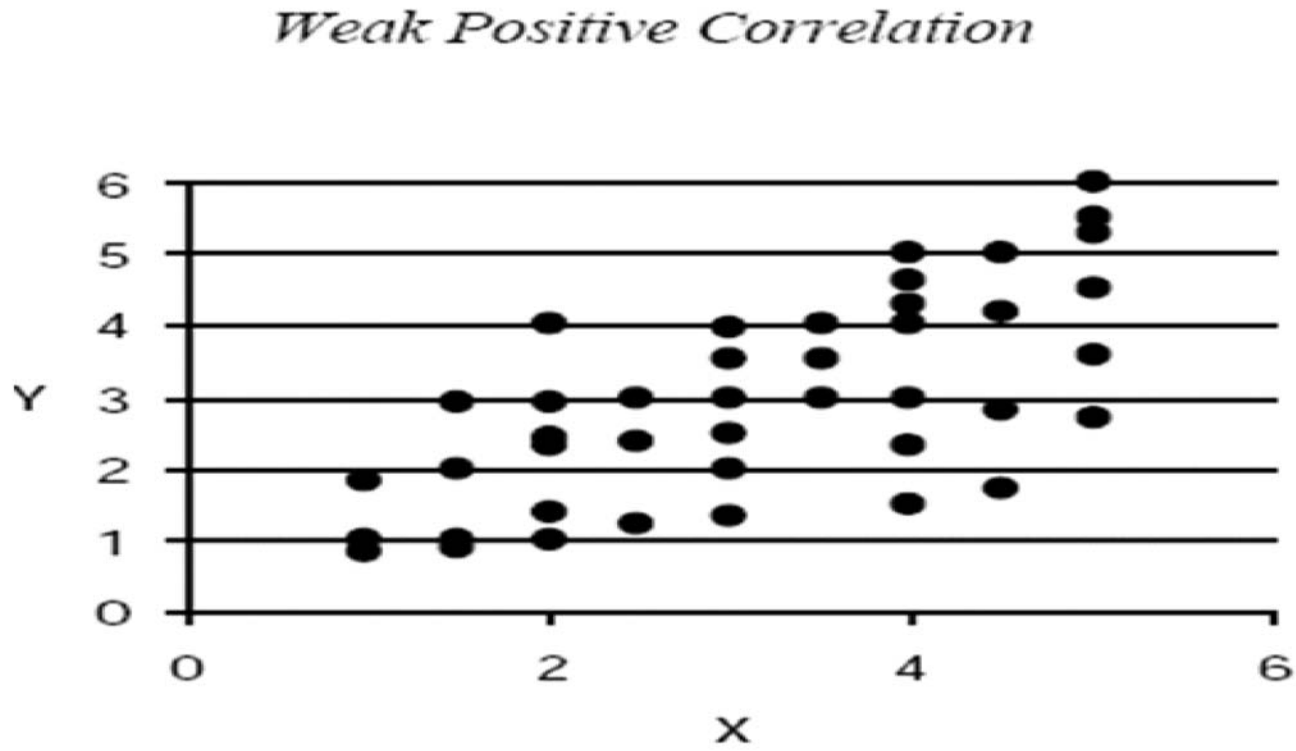

Weak Positive Correlation
6
5
4
Y 3
2
1
0
0
2
4
6
X

Fig. 3

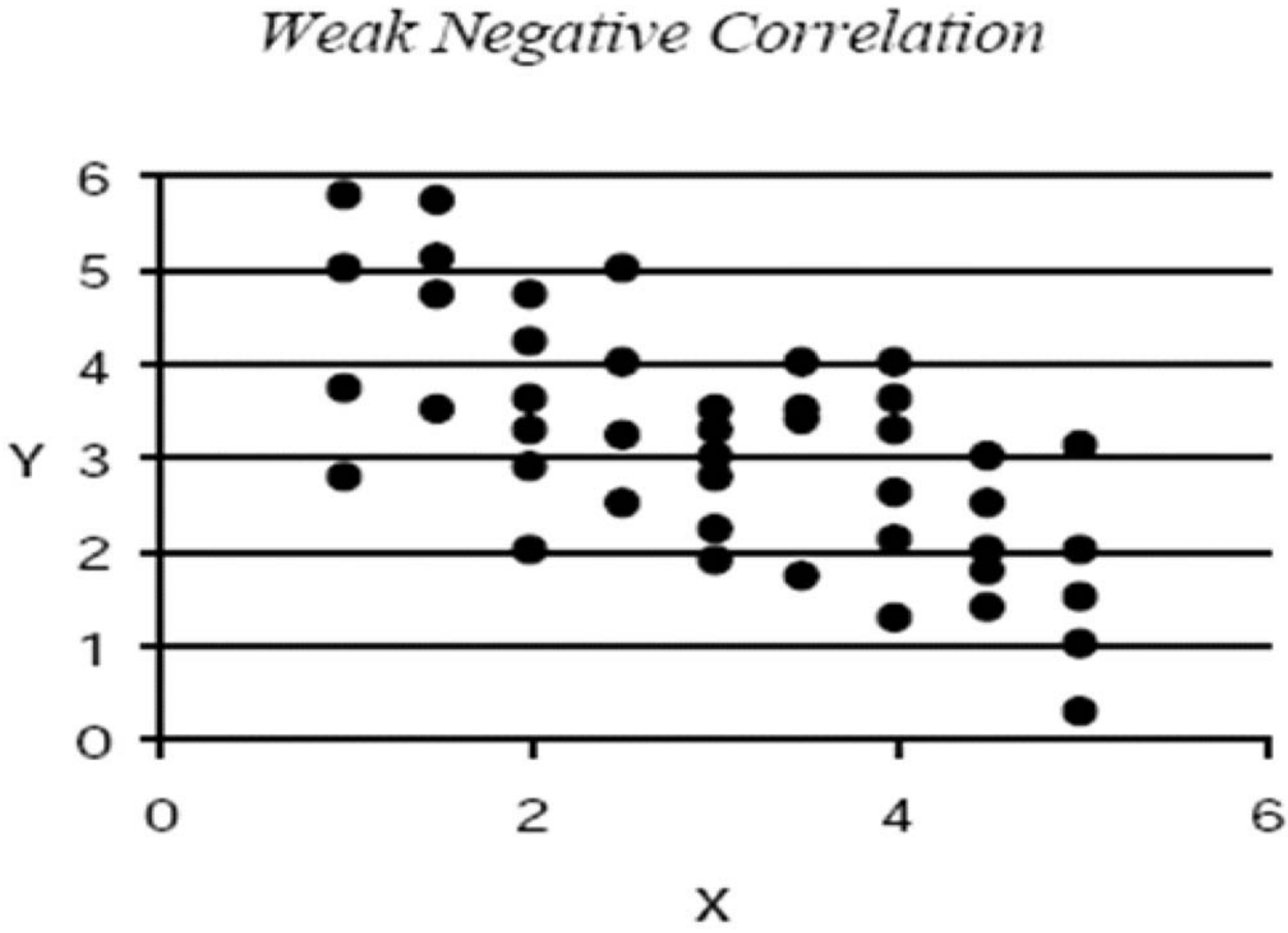

Weak Negative Correlation
6
5
4
Y 3
2
1
0
0
2
4
6
X

Fig. 4

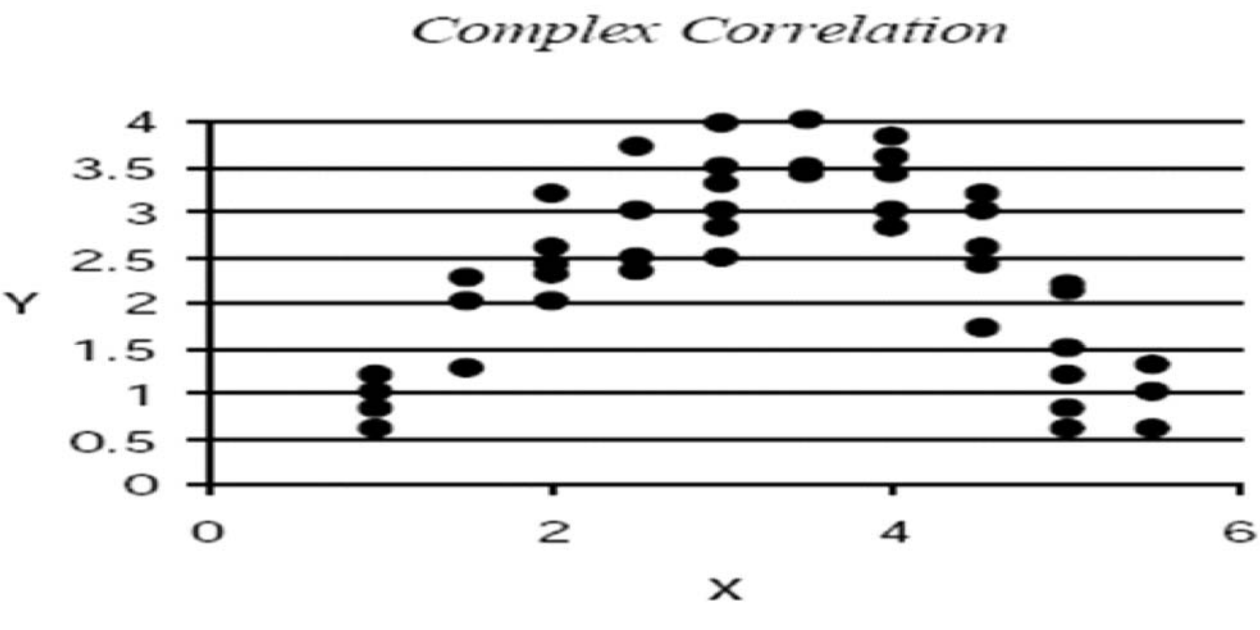

Complex Correlation
4
3.5
3
2.5
Y 2
1.5
1
0.5
0
0
2
4
6
X

Fig. 5

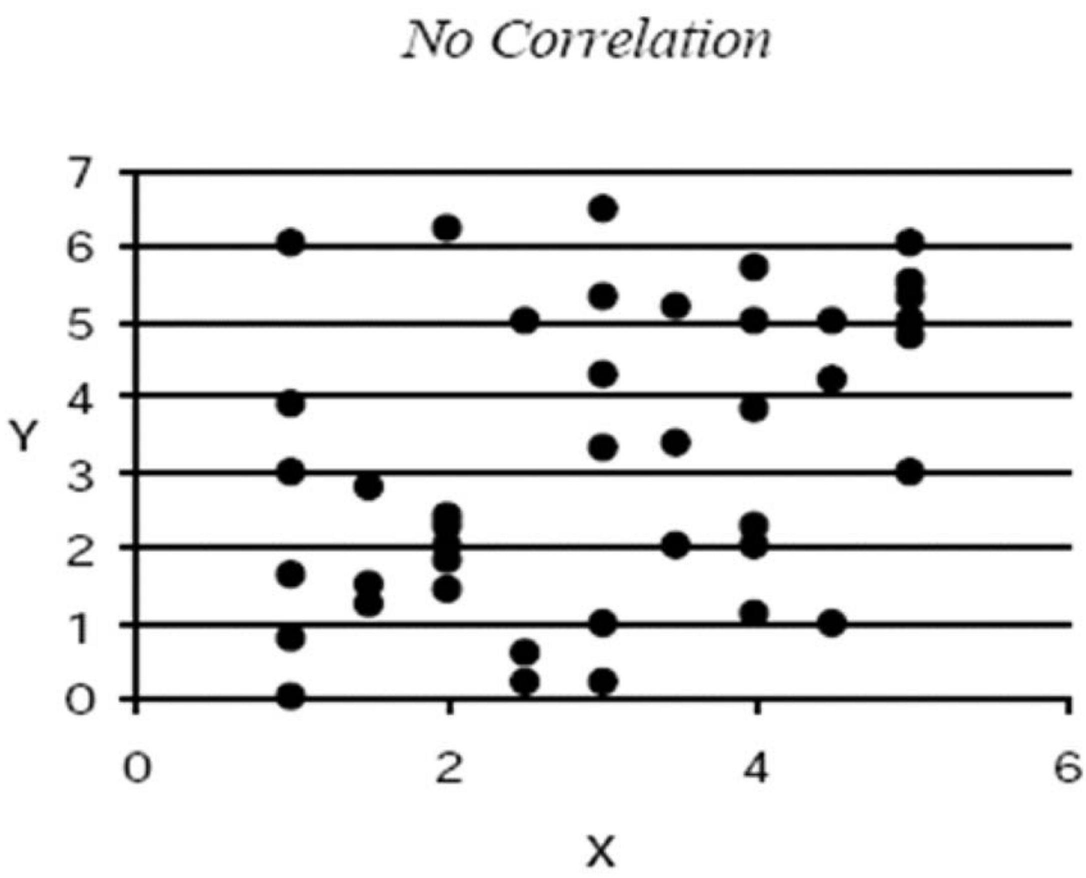



Fig. 6

**Application of a scatter diagram:**

The manufacturing team suspects a relationship between product purity (percent purity) and the amount of iron (measured in parts per million or ppm). Purity and iron are plotted against each other as a scatter diagram, as shown in the figure below.

There are 24 data points. Median lines are drawn so that 12 points fall on each side for both percent purity and ppm iron.

To test for a relationship, they calculate:

A = points in upper left + points in lower right = 9 + 9 = 18

B = points in upper right + points in lower left = 3 + 3 = 6

Q = the smaller of A and B = the smaller of 18 and 6 = 6

N = A + B = 18 + 6 = 24

Then they look up the limit for N on the trend test table. For N = 24, the limit is 6.

Q is equal to the limit. Therefore, the pattern could have occurred from random chance, and no relationship is demonstrated.

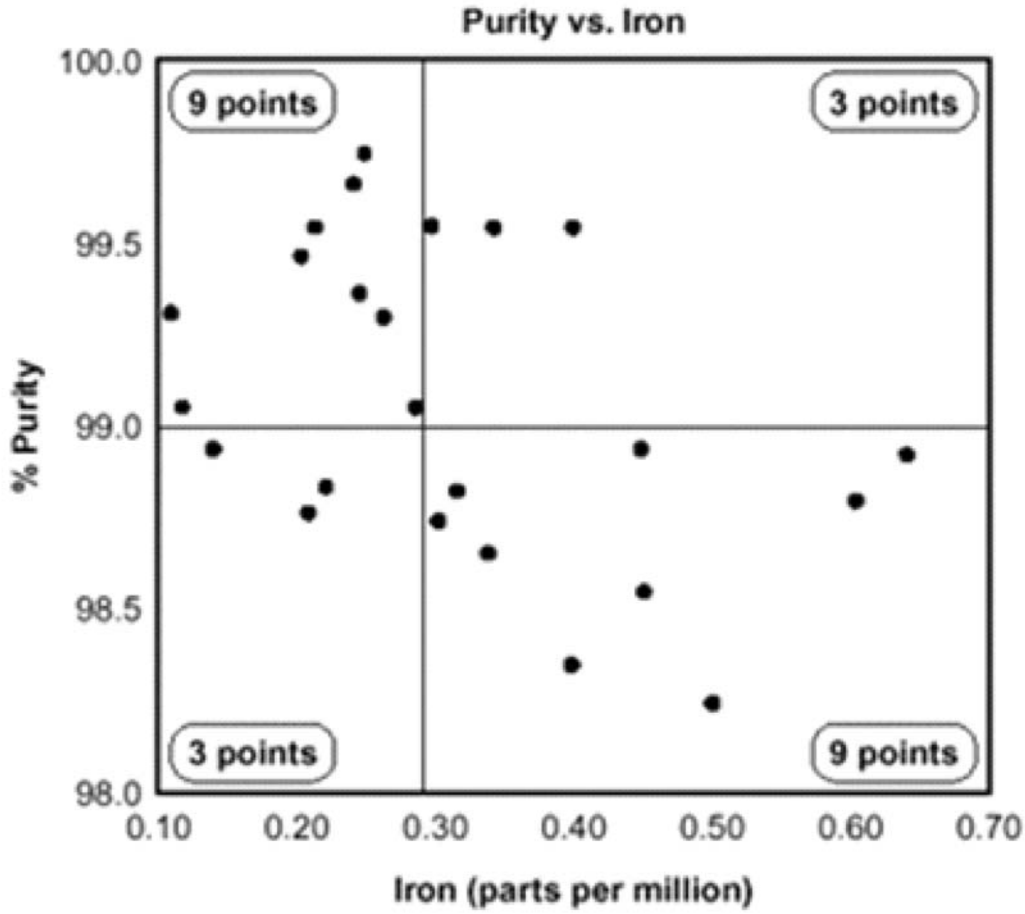



**Fig. 7 Scatter Diagram Example**

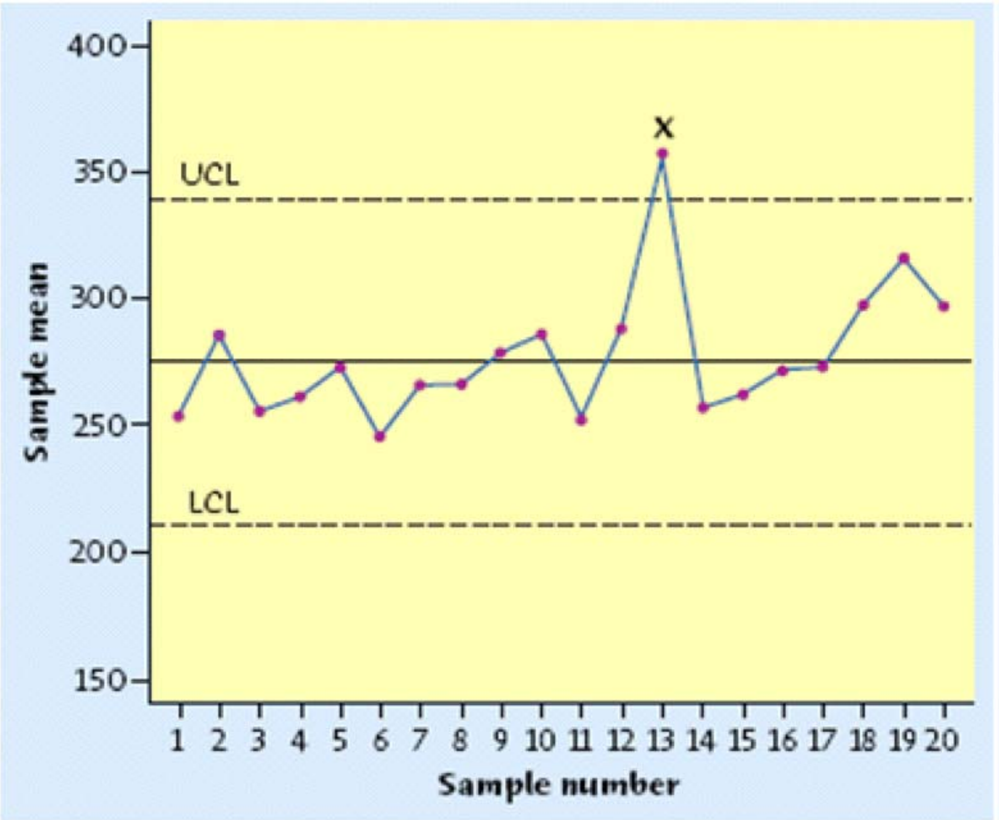
### 7. Control Charts

As we know, no two products or services are exactly alike because the processes used to produce them contain many sources of variation, even if the processes are working as intended. For example, the diameter of two crankshafts may vary because of differences in tool wear, material hardness, operator skill, or temperature during the period in which they were produced. Similarly, time required to process two credit card applications varies because of the load on the credit card department, the financial background of the applicant and the skill and attributes of the employees. Nothing can be done to eliminate variation in process output completely, but management can investigate the causes of variation to minimize it.

There are two basic categories of variation in output: Common Causes and Assignable Causes Common causes of variation are purely random, unpredictable sources of variation that are unavoidable with the current process. For example, a machine that fills cereal boxes will not put exactly the same amount of cereal in each box. If you weighed a large number of boxes filled by the machine and plotted the results in a scatter diagram, the data would tend to form a pattern that can be described as a distribution.

here X axis represents number of boxes weighed and Y axis represent weight which supposed to be 275gms.

Control charts distinguish between the common cause variation and the special cause variation.




$$UCL = \mu + 3\frac{\sigma}{\sqrt{n}}$$

$$LCL = \mu - 3\frac{\sigma}{\sqrt{n}}$$

How do you know if a process is <u>out-of-control</u>?

- One point outside the $\mu \pm 3\frac{\sigma}{\sqrt{n}}$ limits
- A run of 9 consecutive points above the center line (m) or 9 consecutive points below the center line.

## <u>Control vs. Capability</u>

- If a process is in control, we know what to expect in the finished product. Statistical quality control only pays attention to the internal state of the process.
- If a process is <u>c</u>apable, the process can meet or exceed the requirements placed on it by some external source (client demands, goals of the organization, etc.).

Assignable causes of variation include an employee needing training, or a machine needing repair.

**Control Charts for Variables**

As the name indicates, these charts will use the variable data of a process. X Chart gives an idea of the central tendency of the observations. These charts will reveal the variations between sample observations. R chart gives an idea about the spread (dispersion) of the observations. This chart shows the variations within the samples.

**Control chart functions**

- Control charts are decision-making tools - they provide an economic basis for deciding whether to alter a process or leave it alone
- Control charts are problem-solving tools - they provide a basis on which to formulate improvement actions
- SPC exposes problems; it does not solve them!

Control charts are powerful aids to understanding the performance of a process over time

**Control charts identify variation**

- Chance causes - “common cause”
- Inherent to the process or random and not controllable
- If only common cause present, the process is considered stable or “in control”
- Assignable causes - “special cause”
- Variation due to outside influences
- If present, the process is “out of control”

**Control charts help us learn more about processes**

- Separate common and special causes of variation
- Determine whether a process is in a state of statistical control or out-of-control
- Estimate the process parameters (mean, variation) and assess the performance of a process or its capability

**Control charts to monitor processes**

- To monitor output, we use a control chart
- We check things like the mean, range, standard deviation
- To monitor a process, we typically use two control charts
- Mean (or some other central tendency measure)
- Variation (typically using range or standard deviation)

**Control chart components**

- Centerline
- Shows where the process average is centered or the central tendency of the data
- Upper control limit (UCL) and Lower control limit (LCL)
- Describes the process spread

## 18.3 ACCEPTANCE SAMPLING

Acceptance sampling is the inspection and classification of a sample of the product selected at random from a larger batch or lot and the ultimate decision about disposition of the lot.

**Why sampling?**

100% inspection will have the following limitations:

- The cost of inspection is high.
- Destructive methods of testing will result
- Time taken for inspection will be too long.
- When the population is large or infinite, it would be impossible or impracticable to inspect each unit.

**Acceptance plan -** Sample size (n) and maximum number of defectives (c) that can be found in a sample to accept a lot

**Acceptable quality level (AQL) -** If a lot has no more than AQL percent defectives, it is considered a good lot

**Lot tolerance percent defective (LTPD) -** If a lot has greater than LTPD, it is considered a bad lot

**Average outgoing quality (AOQ)** – Given the actual % of defectives in lots and a particular sampling plan, the AOQ is the average % defectives in lots leaving an inspection station

**Average outgoing quality limit (AOQL)** – Given a particular sampling plan, the AOQL is the maximum AOQ that can occur as the actual % defectives in lots varies

**Type I error -** Based on sample information, a good (quality) population is rejected

**Type II error -** Based on sample information, a bad (quality) population is accepted

**Producer's risk (a) -** For a particular sampling plan, the probability that a Type I error will be committed

**Consumer's risk (b) -** For a particular sampling plan, the probability that a Type II error will be committed

## 18.4 STATISTICAL PROCESS CONTROL

Statistical quality control ideas caught on in the 1940's when the commencement of World War II created a huge demand for mass-produced goods. The need to inspect millions of military items led the government to require suppliers to use statistical methods to insure compliance with quality standards. These methods then spread throughout industry.

It would be best not to inspect any chips. You would prefer to obtain chips from a certified or qualified supplier, who had a process for making chips, which is under statistical control. In this case you are getting the minimum variation possible in chip quality characteristics within the supplier's present process capability. If these chips do not meet your needs, you then have the option of inspecting all of the chips and screening out those that are out of tolerance relative to your needs. The other case is where you cannot determine whether the supplier has a stable process within statistical control and you must then resort to sample inspection to determine if the supplier is meeting your specifi-cations or not.

A process is a chain of activities that turns inputs into outputs. Examples would include a manufacturing process in which an item is produced, an administrative process in which a decision is reached, etc.

A process is like a **population** containing all the outputs that would be produced by the process if it ran forever in its present state.

The outputs produced today or this week is a **sample** from this population.

The idea of statistical process control

- ♦ Goal: make a process stable over time and keep it stable unless planned changes are made.
- ♦ All processes have variation.
- ♦ Statistical stability means the pattern of variation remains stable, not that there is no variation in the variable measured. (In control)

Common cause variation

- ♦ A process that is in control only has common cause variation.
- ♦ Common cause variation is the inherent variability of the system, due to many small causes that are always present.

Special cause variation

- ♦ When the normal functioning of the process is disturbed by some unpredictable event, special cause variation is added to the common cause variation.

· We hope to be able to discover what lies behind special cause variation and eliminate that cause to restore the stable functioning of the process.

**Using SPC**

Statistical Process Control may be broadly broken down into three sets of activities: understanding the process; understanding the causes of variation; and elimination of the sources of special cause variation.

In understanding a process, the process is typically mapped out and the variations in the process are monitored using control charts, this is a continuous, ongoing activity. When excessive variation is identified by the control chart, additional effort is exerted to determine the causes of that variance.

Once the causes of variation are understood, if it is wished for the process to return to a state of control then the cause of variation can be investigated further and removed. Once the process is back under control, the points out with the limits should be disregarded in any future calculation of the central line and / or limits.

It is important when using SPC to be aware that not every point identified by a control chart as 'out of control' will be the result of a special cause. As indicated above, by chance alone you would expect one in twenty points to fall out with the two sigma limits and about one in three hundred points to fall out with control limits based on three standard deviations. It is therefore important that when a point falls out with the limits it is investigated in detail to decide whether it is the result of a 'special cause' or just a chance occurrence. This emphasises the need to have a good understanding of the process being measured under SPC to make full use of the technique.

## 18.5 NOTES

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## 18.6 SUMMARY

In this unit we have discussed about various tools that are used to solve quality problems. Quality problems arise due to defect in raw material or in process. 100 per cent inspection of the raw material is always possible hence we go for sampling in many cases. The statistical quality control and statistical process control are extensively used in any organization having concern for quality.

## 18.7 KEY WORDS

- Histogram
- Control chart
- Acceptance sampling
- statistical quality control

## 18.8 SELF ASSESSMENT QUESTIONS

1. Explain acceptance sampling
2. What is stratification?
3. Explain use of control charts
4. Explain the applications of 7 QC tools
5. Discuss the procedure to develop pareto chart

## 18.9 REFERENCES

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2. Production and Operations Management – K. Ashwathappa and K. Sridhara Bhat
3. Production and Operations Management- R. Paneer Selvam
4. Production Management – Manoj Kumar Sarkar
5. Total Quality Management : D D Sharma

# UNIT 19: JAPANEESE TECHNIQUES OF QUALITY IMPROVEMENT

**Structure:**

## 19.0 OBJECTIVES

After studying this unit you should be able to

- ♦ Appreciate the significance of quality awards
- ♦ Explain Demings award
- ♦ Discuss about European quality award
- ♦ Identify the parameters for MBNQA

## 19.1 INTRODUCTION

A national quality award is typically part of a larger effort by a government to make its country's businesses more competitive in the world economy. The awarding institutions are generally either government departments or ministries or not-for-profit organizations with government ties. In many countries, however, the awarding institutions are consortia of businesses. Candidate companies compete in award-specific assessments of business quality and excellence criteria. The assessments are annual and firms who wish to be considered for the awards file applications with the organization that conducts the competition in their home country. Competitors are evaluated by teams of examiners who are volunteers in Germany, the United Kingdom, the United States, and possibly elsewhere. Several examiners separately evaluate company submissions against award criteria after which they meet to discuss their findings and to agree on a consensus score. The highest scoring firms advance to the next phase where examiners perform site visits to compare actual practices against those reported in the company submission and finally, awards are given to companies whose practices best fulfill the criteria of the award models.

While each nation's awards programs only consider businesses within its national borders, there are few notable exceptions: The EFQM Excellence Award is a transnational award open to businesses operating in one or more European countries and the Deming Prize, which began as the Japan Quality Medal, became the first (and as of 2014 the only) global quality award in 1984.

The most widely-recognized quality awards are the Deming Prize (the first of its kind) and the EFQM Excellence and Malcolm Baldrige National Quality Awards (due to their size). The national quality award phenomenon grew out of the Total Quality Management movement of the 1980s.

## 19.2 QUALITY AWARDS

There are number of models, which could help organizations in their journey to excellence - OL, Total Quality, MBNQA, Deming prize, Excellence model, ISO and other national awards.

They are based on the ideas of different countries and have different origin (TQ and Deming prize – Japan, MBNQA, LO – America, Excellence model, ISO – Europe).

All of them are related to quality, however some of them are more focused on delivering quality of products (TQ, ISO), while others concerned with overall organizational performance (MBNQA, Deming prize, Excellence model). Almost all of them concentrated on importance of leadership, commitment and involvement of employees, as well as management based on processes and facts. Although they have many things in common, some models have broader scope. For example, ISO and TQ are more customer-oriented approaches, while other models admit the importance of all stakeholders of the organization (MBNQA, Deming prize, Excellence model). Moreover, Excellence model and MBNQA also have a social responsibility as a significant principle, which is not covered by other models.

As far as method of models is concerned, all of them are non-prescriptive, that is to say that models assume that ways of achieving excellence in business could be different, however many of them have the criteria or standard, compared to which they are assessed (ISO, MBNQA, Excellence model).

It is important to say that each model admit continuous improvement as a significant aspect to achieve a sustainable excellence. That is to say in the long run all of the models are intended to build a learning organization. MBNQA, Deming prize, Excellence model and ISO are based on the ideas of Total Quality management. The relationship between models can be presented in the form of pyramid, where the peak is the learning organization, followed by Total Quality as the basis or philosophy and then the EFQM, MBNQA, Deming prize, ISO as different methods or approaches to achieve excellence and learning organization. It depends on the organizations what approach to choose, they are similar in the basis (TQ), have the same goal (LO), however different in the focus and scope.

## 19.3 MALCOLM BALDRIGE NATIONAL QUALITY AWARD

The Malcolm Baldrige National Quality Award is the United States National Award for Quality. The Award was created in 1987 in order to promote quality and the recognition and sharing of quality techniques in American industry, in response to the loss of American leadership in quality to foreign competitors. The Award is named for Malcolm Baldrige, who served as Secretary of Commerce in the Reagan administration until he passed away in 1987. The award is administered by the National Institute of Standards and Technology, an agency under the Department of Commerce. Alternate terms for the award are MBNQA, “the Baldrige” or ‘the Baldy.

Up to two Baldies can be awarded each year in each of five categories: manufacturing, service, small business, education and health care. Applicants are judged for quality in seven areas: leadership, strategic planning, customer and market focus, information and analysis, human resource development and management, process management and business results. Winners are determined by an independent Board of Examiners, comprised of quality expert volunteers from industry, universities and government, who review company applications and company data then conduct site visits in order to reach their decision. Baldy winners typically share their lessons and experience with other firms. Many states now have quality awards that are awarded on a basis similar to the Baldy.

Over its history, the point values for each of the seven judged areas have changed. Today, "business results" represents a disproportionately high portion of the points. This emphasis on "business results first" seems to be highly inconsistent with the process improvement perspective of quality philosophy.

Critics of the quality philosophy often point to several negative events surrounding the Baldrige Award. The Wallace Company, the first small business to win the Award, filed for bankruptcy within a year of receiving the Award. Around 1990, a Baldrige was awarded to IBM for design and development of the midrange AS/400 mid-size computer. Unfortunately, at introduction, IBM found the market for this larger computer had dwindled in favor of the smaller, personal computers that people typically use today. In 2003, Globe Metallurgical, one of the first companies to win the Award, also filed for bankruptcy. Further, a hypothetical stock portfolio of Baldrige Award winners "beat" the S&P 500 for nine years … until 2002. That year the portfolio lost 34% of its value, as compared to a 48% increase in the S&P 500.

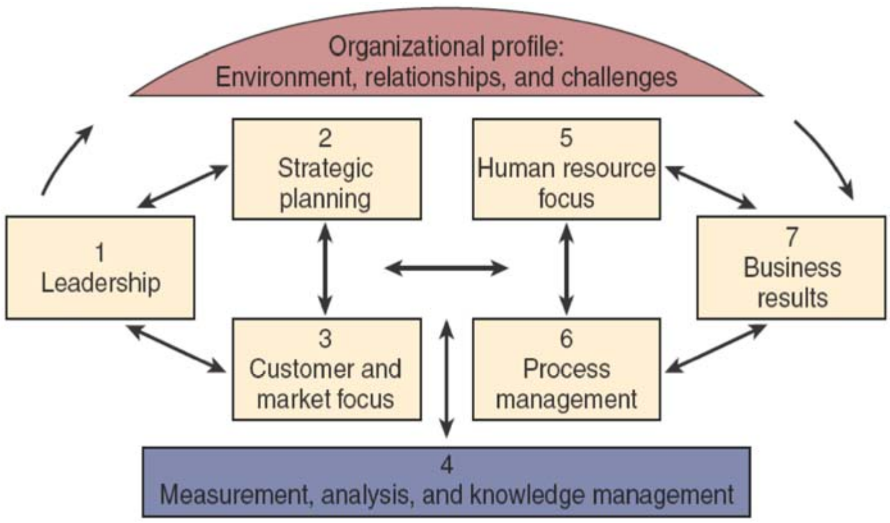


**Fig. 19.1 Award Criteria—Item Listing**

| Categories/Items | Points Values |
|---|---|
| 1.0 Leadership | 120 |
| 2.0 Strategic planning | 85 |
| 3.0 Customer and market focus | 85 |
| 4.0 Measurement, analysis, and knowledge management | 90 |
| 5.0 Human resource focus | 85 |
| 6.0 Process management | 85 |
| 7.0 Business results | 450 |
| Total Points | 1,000 |

## 19.4 THE DEMING PRIZE

The Deming Prize has been awarded annually since 1951 by JUSE, the Union of Japanese Scientists and Engineers, an organization at the heart of quality management in Japan. The Deming Prize is the oldest quality prize in the world as well as the most prestigious quality prize in Japan. Deming prize winners are expected to meet remarkably high expectations in a large number of areas such as quality policies, employee involvement in the organization of quality, use of statistical quality techniques, systematic handling of standards, empowerment and training of employees, methods of customer satisfaction, quality assurance through process control, environmental protection, use of the PDSA cycle, quality circles, and tangible effects such as cost and profit as well as intangible effects. There are several categories for the Prize, including factories, small companies and individual citizens.


**Fig 19.2 Deming**

The prize has three award categories. They are Individual person, the Deming Application Prizes, and the Quality Control Award for factory. The Deming Application prizes are awarded to private or public organizations and are subdivided into small enterprises, divisions of large corporations, and overseas companies. There are 143 companies who won the prize.

Among them, only once has the Deming Prize been awarded to a non-Japanese company: Florida Power and Light in 1989.

In 1989, Florida Power & Light (FPL) became the first American company to win the Deming Prize. FPL's quality initiative resulted in many performance improvements:

- ♦ Using root cause analysis, meter readers determined that one root cause of meter reading difficulties was due to aggressive dogs in home owner's yards. The readers began to carry binoculars for reading meters from a distance. The time required for meter reading was substantially reduced.
- ♦ Line repairmen performed root cause analysis to improve line downtime. They determined that a significant root cause of downed lines was fallen branches. This was because tree branch trimming was not scheduled based on the rate at which branches grow, but rather were being trimmed in rotational order. The repairmen developed a new trimming schedule based on the different growth rates of the trees, trimming branches of faster growing trees more often. Line downtime was reduced by almost half.

Unfortunately, when the next President took the helm of FPL, he found that quality principles (such as worker empowerment) conflicted with his traditional, "top-down" management style and so he dissolved most of the company's quality initiative.

## 19.5 SHINGO PRIZE FOR EXCELLENCE IN MANUFACTURING

The Shingo Prize for Excellence in Manufacturing recognizes companies for excellence in process improvement, quality and customer satisfaction through implementing lean and just in time methods, eliminating waste, achieving zero defects and continuously improving. The Shingo Prize is named for Shigeo Shingo, an industrial engineer who worked with Taiichi Ohno at Toyota as it developed the modern manufacturing practices often referred to as the Toyota Production System. The Shingo Prize has been awarded since 1989 and is administered by Utah State University. Individual states are now presenting Shingo Prizes; the North Carolina Shingo Prize is administered through the Industrial Extension Service of North Carolina State University.

Quality prizes have emerged in many other regions throughout the world. For example, the **European Quality Award** has been awarded by the European Foundation for Quality Management since 1992.

## 19.6 THE EUROPEAN QUALITY AWARD

**EFQM** (formerly known as the **European Foundation for Quality Management**) is a non-profit membership foundation based in Brussels. EFQM is the custodian of the EFQM Excellence Model, a non-prescriptive management framework that is widely used in public and private sector organisations throughout Europe and beyond.

EFQM Membership is open to organizations, rather than individuals. Members include: BMW, EDF, Grundfos, Philips, Ricoh, Robert Bosch, Solvay and Trimo. EFQM runs the annual EFQM Excellence Award, which is designed to recognize organizations that have achieved an outstanding level of sustainable excellence.

**History**

In the 1950s Quality Assurance was gaining ground in Europe. It was a well-developed discipline, practised by many companies in a variety of formats. However, it was believed that an actual European focus on Total Quality Management (TQM), in which the best ideas from around the world could be brought together, was missing. For that reason, 14 CEOs of prominent European businesses created the European Foundation for Quality Management, later referred to as EFQM. On October 19, 1989, the terms of reference of EFQM were established. Mr. Cornelius van der Klugt, then CEO of Philips, was confirmed as the first President of the EFQM.

**Knowledge**

The EFQM Excellence Model was launched in 1991 and is based on eight Fundamental Concepts of Excellence. Today, the EFQM Excellence Model is used by more than 30,000 organisations in Europe.

- Leadership (100 points)
- People management (90 points)
- Policy and strategy (80 points)
- Resources (90 points)
- Processes (140 points)
- People satisfaction (90 points)
- Customer satisfaction (200 points)
- Impact on society (60 points)
- Business results (150 points)

**Activities**

To help organisations to continually improve and achieve higher levels of performance, EFQM provides networking and mutual learning experiences, offers education, recognises achievements and supports the implementation of best in class tools and practices.

## 19.7 GOLDEN PEACOCK AWARD

The Golden Peacock Awards was instituted in 1991 by the Institute of Directors. The institute of directors (india) was established on 13 july 1990 as an apex association of directors to improve their professional competence. The golden peacock awards are given for the recognition of corporate excellence in India.

The Golden Peacock awards are in two categories:

1. Global Awards

2. National Level Awards

Entries are invited for following National Annual Awards

1. Golden Peacock Environment Management Award (GPEMA)

2. Golden Peacock Eco-Innovation Award (GPEIA)

3. Golden Peacock Occupational Health & Safety Award (GPOHSA)

4. Golden Peacock National Training Award (GPNTA)

5. Golden Peacock Innovation Award (GPIA)

6. Golden Peacock Award for Excellence in Corporate Governance (GPAECG)

7. Golden Peacock Award for Corporate Social Responsibility (GPAECSR)

8. Golden Peacock National Quality Award (GPNQA)

9. Golden peacock Innovation Management Award (GPIMA)

10. Golden Peacock Innovative Product/ Service Award (GPIPSA)

The Awards Secretariat has constituted an Expert Evaluation Committee comprising from various sectors are invited to examine the applications. Each of the applications is reviewed independently by assessors and the applications which satisfy the basic review requirements, are short listed for Awards. The applications are assessed on an exhaustive set of parameters as mentioned in the guidelines for a total score card of 1000 marks. Cut-off applied on each application is 80 percent. Entries occupying top positions are recommended for consideration of the Jury.

In some cases the short listed finalist companies by the Assessors for Award are also asked to make a 10 min presentation followed by questions and answers for 5 min during the Jury meeting for the final consideration of Grand Jury.

## 19.8 DISIMILARITIES IN MALCOM BRIDGE, EUROPEAN UNION AND DEMING PRIZE NATIONAL QUALITY AWARDS

The below table indicates the dissimilarities between Malcom Balridge, European Uniion and Deming Prize

| *Baldrige Award* | *Deming Prize* | *European Quality Award* |
|---|---|---|
| Leadership | Policy | Leadership |
| Strategic planning | Organization and operations | Policy and strategy |
| Customer and market focus | Collecting and using information | People management |
| Information and analysis | Analysis | Resources |
| Human resource focus | Planning for the future | Processes |
| Process management | Education and training | Customer satisfaction |
| Business results | Quality assurance | People satisfaction |
| | Quality effects | Impact on society |
| | Standardization | Business results |
| | Control | |

## 19.9 NOTES

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## 19.10 SUMMARY

In this unit we have discussed about various quality awards that are instituted by the respective countries to promote quality not only in their country but also worldwide. The Deming Prize in instituted in Japan where as EFQM in given in Europe. India, having acknowledged the importance of such awards instituted Golden Peacock award in 1991.

## 19.11 KEY WORDS

- MBNQA
- EFQM
- Golden Peacock Award

## 19.12 SELF ASSESSMENT QUESTIONS

1. Explain criteria for MBNQA
2. What are the specifications for EFQM?
3. Explain the concept of Deming Prize
4. Differentiate between MBNQA, EFQM and Deming Prize

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# UNIT - 20 : QUALITY STANDARDS

**Structure:**

## 20.0 OBJECTIVES

After studying this unit,, you should be able to;

- Define quality standards
- Explain the provisions of ISO
- Discuss about ISO 14000
- outline QS 9000 standard
- Appreciate ISI standards

## 20.1 INTRODUCTION

A product is said to be of good quality if it is free from any defect, deficiency or any significant variation. In order to ensure manufacturing of good quality product, there must be certain standards so that uniformity is maintained over the entire range of products manufactured. The standard set should be such that the features and the specifications offered by the product should be capable to meet the implied need of the product.

A standard is a detailed requirement, specification, guidelines or characteristics that can be used consistently to ensure that materials, products, services and processes are fit for their purpose.

For example: All bulb holders comes with the same size and any company bulb can fit in that bulb holders. As a result, The customers have freedom of purchasing any company bulb.

## 20.2 QUALITY STANDARDS

In essence, a standard is an agreed way of doing something. It could be about making a product, managing a process, delivering a service or supplying materials – standards can cover a huge range of activities undertaken by organizations and used by their customers.

Standards are the distilled wisdom of people with expertise in their subject matter and who know the needs of the organizations they represent – people such as manufacturers, sellers, buyers, customers, trade associations, users or regulators.

Standards are designed for voluntary use so it’s up to you – you’re not forced to follow a set of rules that make life harder for you, you’re offered ways to do your work better. But being certified to any standard demonstrates your concern for quality and speaks about your quality.

Standards are knowledge. They are powerful tools that can help drive innovation and increase productivity. They can make organizations more successful and people’s everyday lives easier, safer and healthier.

The kinds of things that standards do

Standards cover a wide range of subjects from construction to nanotechnology, from energy management to health and safety, from cricket balls to goalposts. They can be very specific, such as to a particular type of product, or general such as management practices.

The point of a standard is to provide a reliable basis for people to share the same expectations about a product or service. This helps to:

- Facilitate trade
- Provide a framework for achieving economies, efficiencies and interoperability
- Enhance consumer protection and confidence.

Organizations might use:

- A quality management standard to help them work more efficiently and reduce product failures
- An environmental management standard to help reduce environmental impacts, reduce waste and be more sustainable
- A health and safety standard to help reduce accidents in the workplace
- An IT security standard to help keep sensitive information secure
- A construction standard to help build a house
- An energy management standard to help cut energy consumption
- A food safety standard to help prevent food from being contaminated
- An accessibility standard to help make buildings accessible to disabled users
- An interoperability standard to ensure that bank and credit cards fit into ATMs and can be used throughout the world.

## 20.3 ISO 9000

The ISO 9000 quality management systems have been adopted by more than 2,50,000 organizations worldwide. To ensure that all the standards are kept updated and relevant, the International Organization for Standardization (ISO) reviews the standard at least once in five years.

In 1994 revision there were following standards

- ISO 9000:1994 Quality Management Systems: vocabulary
- ISO 9001:1994 Quality Management Systems – Requirements (required for certification for organizations engaged in design, manufacturing, testing, service)

- ISO 9002:1994: Quality Management Systems – Requirements (required for certification for organizations engaged in, manufacturing, testing,)
- ISO 9003:1994 : Quality Management Systems – Requirements (required for certification for organizations engaged in testing)
- ISO 9004-1994 Quality Management Systems – Requirements (required for certification for organizations engaged in service)

In 2000 instead of these entire standards one common standard ISO 9000:2000 was brought into force. ISO 9001 is the only specification to be used by all organization. ISO 9002 and 9003 were withdrawn. There were only three documents there after ISO 9000:2000, ISO 9001:2000 and ISO 9004: 2000 which gave vocabulary, contractual standard and guidelines respectively.

**ISO 9000 Family of Standards**

- ISO 8402 - QA and Quality management vocabulary
- ISO 9000-2 - Generic guidelines for applying ISO 9001, ISO 9002, and ISO 9003
- ISO 9000-3 - Guidelines for applying ISO 9001 to the development, supply, and maintenance of software
- ISO 9000-4 Application for dependability management
- ISO 9004-2 Guidelines for services
- ISO 9004-3 Guidelines for processed material
- ISO 9004-4 Guidelines for quality improvement
- ISO 9004-5 Guidelines for quality plans
- ISO 9004-6 Guidelines for configuration management

A quality management principle is a comprehensive and fundamental rule/belief, for lead' and operating an organisation, aimed at continually improving performance over the long term focusing on customers while addressing the needs of all other stakeholders.

The eight quality management principles are defined in ISO 9000: 2000 standards. These principles are discussed below

**1. Customer focus :** Organisations depend on their customers and therefore should understand current and future customer needs, meet customer requirements and strive to exceed customer expectations.

**2. Leadership :** Leaders establish unity of purpose and directions of the organisation. They should create and maintain the internal environment in which people can become fiilly involved in achieving the organisation's objectives.

**3. Involvement of people :** People at all levels are the essence of an organisation and their fill involvement enables their abilities to be used for the organisation's benefit.

**4. Process approach :** A desired result is achieved more efficiently when activities and related resources are managed as a process.

**5. Systems approach to management :** Identifying, understanding and managing interrelated processes as a system contributes to the organisation's effectiveness and efficiency in achieving its objective.

**6. Continual improvement :** Continual improvement of the organisation's overall performance should be a permanent objective of the organisation.

**7. Factual approach to decision making :** Effective decisions are based on the analysis of data and information.

**8. Mutually beneficial supplier relationships :** An organisation and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

**ISO 9001:2008, Quality management system – Requirements**,

This is the fourth edition of the standard first published in 1987 and which has become the global benchmark for providing assurance about the ability to satisfy quality requirements and to enhance customer satisfaction in supplier-customer relationships.

ISO 9001:2008 contains no new requirements compared to the 2000 edition, which it replaces. It provides clarifications to the existing requirements of ISO 9001:2000 based on eight years' experience of implementing the standard worldwide and introduces changes intended to improve consistency with the environmental management system standard, ISO 14001:2004.

## ISO 9001:2015

The changes made during the ISO 9001:2015 revision are considerably more substantial than those produced during the 2008 revision. Below is a short summary of the main developments. Without debating their benefits, we will attempt to highlight some reasons for these changes.

**1.The standard is rewritten according to the HLS (High Level Structure)**

The ISO 9001:2015 standard has been restructured: chapter and subchapter titles, as well as the order of clauses and paragraphs, were completely revised.


Overall, this restructuring does not affect the standard's content or requirements. When examining the text in detail, however, the structure has changed to comply with new composition guidelines and topic sequences.

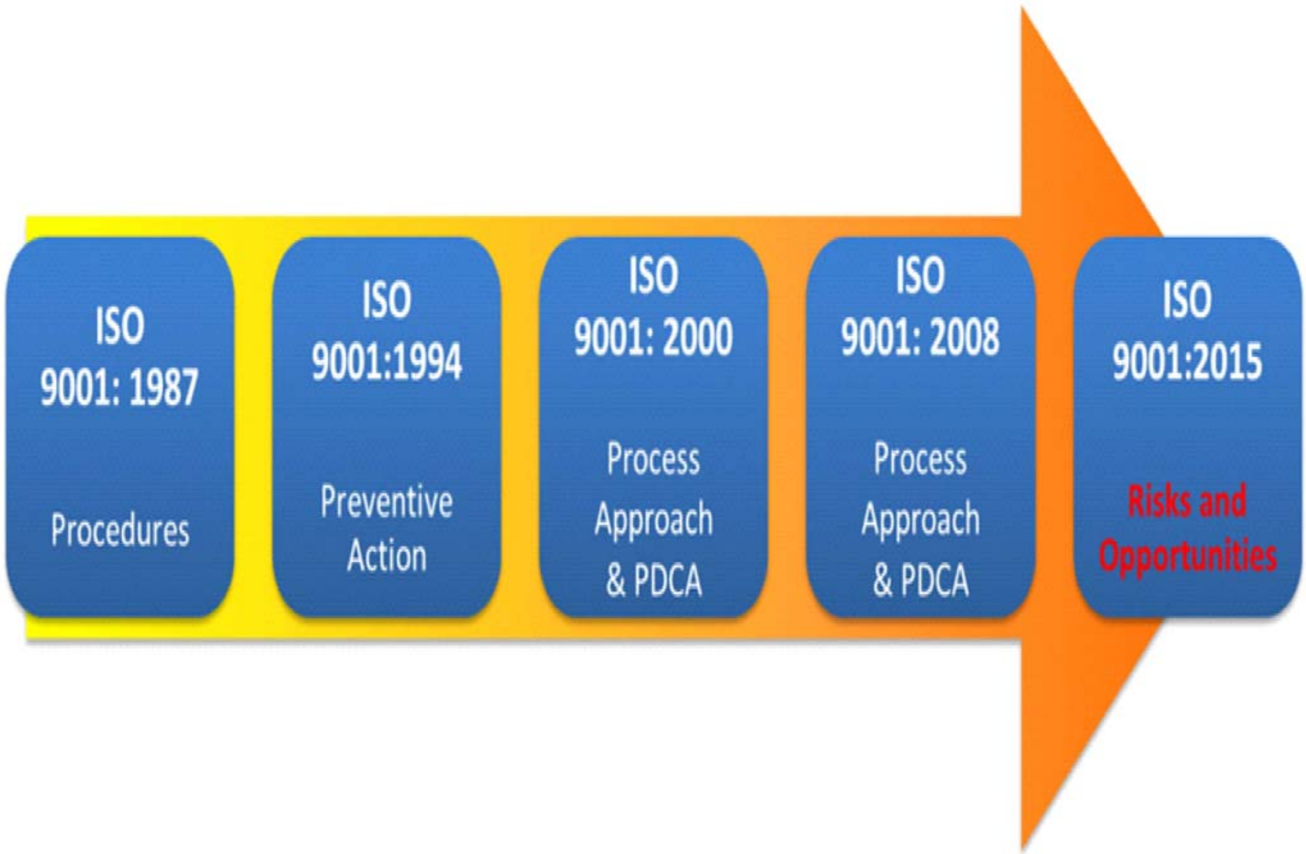
This change reflects a strategic choice that will gradually be applied all ISO standards of management system. Initiated on ISO 55001 (Asset Management System), the new structure is consistent with Appendix SL to the ISO Directives, Part I.

With this new common structure, ISO aims to help businesses and organizations more easily integrate all or parts of their various management systems and ultimately achieve a truly unified management system.

This consistent common structure makes it easier for companies to include components of other standards that it deems relevant: parts of the environmental standard ISO 14001:2015, the asset management standard ISO 55001 and even the future ISO 45001 standard on occupational health and safety management.

**2 Risk management becomes a foundation of the standard**

Each major revision of the standard introduces a concept that allows certified companies to reach a new level of maturity.




Risk management based on a "risk-based thinking" approach has become fundamental in the revised standard: risk identification, qualification and management. Quality results from proper management of these risks, which go beyond the strict scope of the product or service delivered. Quality cannot exist unless the organization can provide its client a conforming product or service over the long term.

Risk has its counterpart: opportunity. The ISO9001:2015 standard also embraces this concept of positive uncertainty.

Of course, risk is an additional concept that in no way supersedes the concept already present in the standard. Risk is incorporated into the fundamentals and rounds out these notions. As such, the process approach and PDCA remain two essential pillars.

Managing risk also means working towards continuous improvement. Corrective action corresponds to an unidentified, wrongly qualified or mismanaged risk; preventive action addresses a risk of possible but un-occurred noncompliance.

**3 Leadership**

The commitment to quality through strong and visible leadership is strengthened:

- The idea of a "management representative" disappears completely.

The quality policy and stated goals must be deeply in keeping with the strategic orientations.

- QMS requirements must be merged into business processes.

**4 A standard purposely open to the service industry**

The context in which organizations evolve has changed and the revision of the standard takes into account the evolutions in the way organizations do their business or activities. Originally drawn up for manufacturing and industrial sectors, ISO 9001 has been a victim of its own success, and many organizations from other areas have made it their own.

The ISO 9001:2015 revision has taken these changes into consideration. Its choice of vocabulary and level of abstraction simplify implementation in all industries, including services.

**5 No more quality manual**

Once an integral part of the ISO standard, will the quality manual disappear?

Indeed, it is quite possible, but not in the near future, as the idea of the quality manual is deeply rooted into the culture of quality.

The revision no longer requires certified organizations to maintain an up-to-date quality manual. Be aware, however, that the documentation requirement is still part of the standard. It is still necessary to document, maintain and preserve relevant information. A quality manual therefore remains one possibility for fulfilling this requirement, albeit not the sole solution.

The purpose of the standard is to take account of technological and societal changes. Information is no longer created, organized, managed, maintained, disseminated and accessed as it was 20 years ago when paper was the primary medium.

This change also allows for greater flexibility in companies' organization. It is now possible to comply with the standard without jeopardizing managerial agility, as long as the fundamental principles are respected.

**6 Importance given to the context surrounding the certified organization and to its stakeholders**

Two new clauses (4.1 and 4.2) require greater consideration of the context surrounding the organization. They require a context analysis, as well as the stakeholder identification and the understanding of their expectations.

**7 Knowledge is a resource like any other**

In its 2015 revision, ISO 9001 is once again adapting to its times. Knowledge has become key to successful projects and business development. The new standard considers knowledge like any other resource to be managed:

- Identify the knowledge necessary to carry out the activity in compliance with the QMS and to achieve the defined objectives.
- Knowledge must be maintained, protected and made available where necessary.
- Anticipate changes in knowledge needs and manage the risk of failing to acquire knowledge in due time.

**Advantages of ISO 9001**

The adoptation of ISO 9001 leads to

- Well defined and documented procedures improve the consistency of output
- Quality is constantly measured
- Procedures ensure corrective action is taken whenever defects occur
- Defect rates decrease
- Defects are caught earlier and are corrected at a lower cost
- Defining procedures identifies current practices that are obsolete or inefficient
- Documented procedures are easier for new employees to follow
- Organizations retain or increase market share, increasing sales or revenues
- Internal operational efficiency
- Lower production costs because of fewer nonconforming products, less rework, lowered rejection rates, streamlined processes and fewer mistakes.
- Access to new markets
- Some markets require ISO 9001 Registration, some markets favor companies with ISO 9001 Registration
- Customer request
- Many organizations are asked by a customer to obtain registration as a requirement to continue or to start doing business with them.

**Benefits to society**

- **For businesses**, suppliers can base the development of their products and services on specifications that have wide acceptance in their sectors. This, in turn, means that businesses using International Standards are increasingly free to compete on many more markets around the world.

- According to leading experts, the ISO 9000 standards result in greater operational efficiency, increased productivity, reduced overtime payments, reduced administrative costs and the elimination of unnecessary procedures.
- And while some people think that ISO 9000 benefits are mainly for large organizations, studies have shown that they also produce significant savings for smaller companies, such as sub-contractors
- **For customers**, products and services are based on International Standards brings them an increasingly wide choice of offers, and they also benefit from the effects of competition among suppliers.
- **For governments**, International Standards provide the technological and scientific bases underpinning health, safety and environmental legislation
- **For trade officials** International Standards create “a level playing field” for all competitors. International Standards are the technical means by which political trade agreements can be put into practice
- **For developing countries**, important source of technological know-how. By defining the characteristics that products and services will be expected to meet on export markets, International Standards give developing countries a basis for making the right decisions when investing their scarce resources and thus avoid squandering them.
- **For consumers**, conformity of products and services to International Standards provides assurance about their quality, safety and reliability.
- **For everyone**, International Standards can contribute to the quality of life in general by ensuring that the transport, machinery and tools we use are safe.
- **For the planet** we inhabit, International Standards on air, water and soil quality, and on emissions of gases and radiation, can contribute to efforts to preserve the environment.

**Disadvantages ISO**

- Not all countries accept ISO registrars
- Mainly for exporting firms
- Barrier to trade

- ♦ Time consuming
- ♦ Costly
- ♦ Difficult for small firms to afford
- ♦ Discourages free thinking and employee empowerment

## 20.4 ISO 14000

A continual cycle of planning, implementing, reviewing and improving the actions that an organization takes to meet its environmental obligations

- ♦ Serves as a tool to improve environmental performance
- ♦ Provides a systematic way of managing an organization's environmental affairs
- ♦ Is the aspect of the organization's overall management structure that addresses immediate and long-term impacts of its products,services and processes on the environment
- ♦ Gives order and consistency for organizations to address environmental concerns through the allocation of resources, assignment of responsibility and ongoing evaluation of practices, procedures and processes
- ♦ Focuses on continual improvement of the system

An EMS follows a Plan-Do-Check-Act Cycle, or PDCA. The diagram shows the process of first developing an environmental policy, planning the EMS, and then implementing it.

The process also includes checking the system and acting on it. The model is continuous because an EMS is a process of continual improvement in which an organization is constantly reviewing and revising the system.

This is a model that can be used by a wide range of organizations from manufacturing facilities to service industries and government agencies.

**Environmental management system model**

**1.Environmental policy**

Initially, the organization's top management should have commitment and define the policy on EMS which is used for the direction of implementing and improving its EMS.

**2.Planning**

In order to achieve environmental policy, at least, the organization should :

- Identify the environmental aspects of its activities and specify those which have significant impacts on the environment.
- Identify legal and other requirements to which the organization involved.
- Establish objectives and targets of its activities having impacts to environment.
- Establish environmental programs for achieving its objectives and targets.

**3.Implementation**

In order to achieve environmental planning, at least, the organization should :

- Define roles, responsibilities and authorities for facilitating EMS effectively.
- Communicate to the staffs at each level for the importance of conformance to the environmental policy; provide appropriate training to personnel performing the tasks to gain their knowledge and competence.
- Establish and control documentation relating to EMS.
- Control operations and activities to meet the specified objectives and targets.
- Identify potential accidents and emergency situations for preventing and mitigating the environmental impacts that may be associated with them and periodically test such procedures where practicable.

**Some unique and important characteristics of ISO 14001 are:**

It is **comprehensive**: all members of the organization participate in environmental protection, the EMS considers all stakeholders, and there are processes to identify all environmental impacts.

It is **proactive**: it focuses on forward thinking and action instead of reacting to command and control policies.

It is a **systems** approach: it stresses improving environmental protection by using a single environmental management system across all functions of the organization.

**Legal and other requirement**

- Compliance to laws and regulations
- Issuance of consent and permit conditions
- Organization – specific codes and programmes that it voluntarily subscribes.
- Standards and guidelines in the regions where the organization undertakes business.

## 20.5 CASE STUDY

Novacroft develops, implements, and manages smartcard programmes, online application systems and customer care services. With the objective of "taking smartcards to the next level", it aims to make them not only easier for consumers to use, but also gives the organizations that operate them the chance to develop new opportunities and save costs. By working with clients such as the Royal British Legion and Transport for London, Novacroft has shown how streamlining smartcard systems and moving online can result in lower administration costs, and time savings, particularly when it comes to application processing or membership management

With regard to ISO 14001 in particular, the main hurdle to overcome was one of perception. "We're not a manufacturer so our staff couldn't initially see the relevance of ISO 14001," says Charles. "But now they understand the importance of focusing on the environmental aspects of the business," she says. As a result, for example, the company has increased its recycled waste from 50% to 75% and reduced waste to landfill from 50% to 25%. Energy management has also been tackled head on. An office move earlier this year was driven not only by the need for more space but also for energy efficiency, as Charles explains: "Part of our remit was to ensure our new office was fit for purpose in terms of adhering to ISO 14001 requirements. We needed a 'smart' office, where, for example, lights will automatically turn off in rooms that are unused for a certain amount of time." Although adopting standards requires effort from team members, Charles says there has been strong buy in from the team at Novacroft, with general acknowledgement that certification is a vital ingredient in the company's success. "Standards actually make our lives easier," says Charles, "and although they impact on team time and workload, the payback is clear to see."

Questions:

1. Identify the challenges to implement ISO in any company of your choice
2. Do you agree that the standards makes lives easier? Substantiate

## 20.6 NOTES

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## 20.7 SUMMARY

In this unit we have discussed about quality standards that the organizations adopt to ensure quality. ISO 9000 and ISO 14000 are the two major quality standards that are highly implemented by the organizations.

## 20.8 KEY WORDS

- ISO 9000
- ISO 14000
- Quality manual

## 20.9 SELF ASSESSMENT QUESTIONS

1. Explain the concept of quality standards
2. What is ISO 9000?
3. Identify the major changes in ISO 9000: 2015 standards
4. Explain ISO 14000

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