MP-109

Vardhaman Mahaveer Open University, Kota

Operations Management

INTRODUCTION

Operations Management is the management of organization's productive resources. It is a production system which converts inputs into tangible products and intangible services. **Block I :** Operations Management deals with introductory background of the subject which highlights the evolution of the this discipline. It addresses the issues related to facility location and Product/process Design in relevant units. **Block II :** Job Design describes factors affecting job design, procedure for work measurement and operations standards in the relevant units. These aspects help the managers to standardise the job through time study, work study and method study. **Block III:** Inventory Management deals with the units namely Inventory Management: Models and System, MRP and Supply Chain Management. These aspects deals with cost effectiveness and efficiency for managing inventories in a firm. **Block IV:** Operations Systems focuses upon forcasting, operations scheduling TQM and ISO : 9000 in respective units. **Block V :** Emerging Issues highlights the significance and operative aspects of CRM, Six Sigma and Maintenance Management for bringing efficiency in Operations Management.

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Operations Management

Unit -1 Operations Management : An Introduction

Unit Structure

1.0 Objectives

After studying this unit you should be able to understand :

- The concept of conversion system.
- Basic elements of operations system.
- Basic difference between product and service.
- Evolution of current phase of operations management.
- Recent developments in operations management.
- Role of an operations manager.

1.1 Introduction

Amongst all the functional areas of management, operations is today considered as one of the most critical and strategic weapon, in the hands of management, to gain competitive advantage. Operations management is the management of an organisation's productive resources. It is a production system which converts inputs into organization's tangible products and intangible services. In short, the operations system of any organization is the part that produces its products. In some cases the product may be physical goods (automobile, buscuit, soap), while in others, it is services (insurance, health care, banking).

The question which arises is that, what does such diverse organizations as manufacturing companies, financial institutes and educational institute have in common with in their operations system ? The main concept which they share is shown in Fig. 1.1. It indicates the presence of a conversion system or a process, some resources acting as input to the process, output from the system, a feed back mechanism and environmental factors which acts as random fluctuations.

Inputs are in the form of raw materials, labour, machines and equipment, Capital, Land and Building etc. which when processed through this conversion system generates output in the form of product and service. In order to monitor the system, control points are estabilished at input and output. This helps in comparing the planned output and actual output. Random fluctuations which may be internal or external to the system cause the variatons. Once the output is received, it is sold and again inputs are purchased which keeps the system alive.

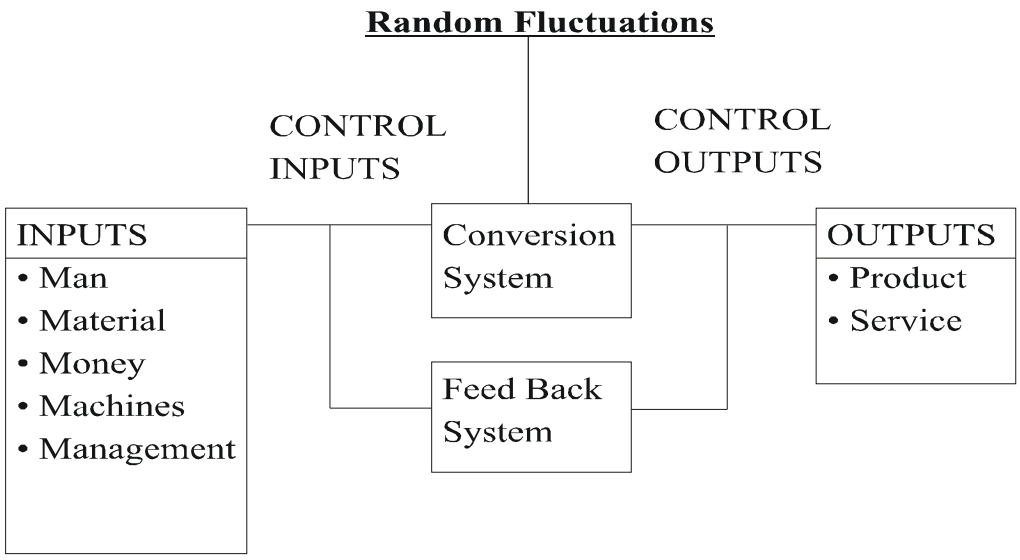
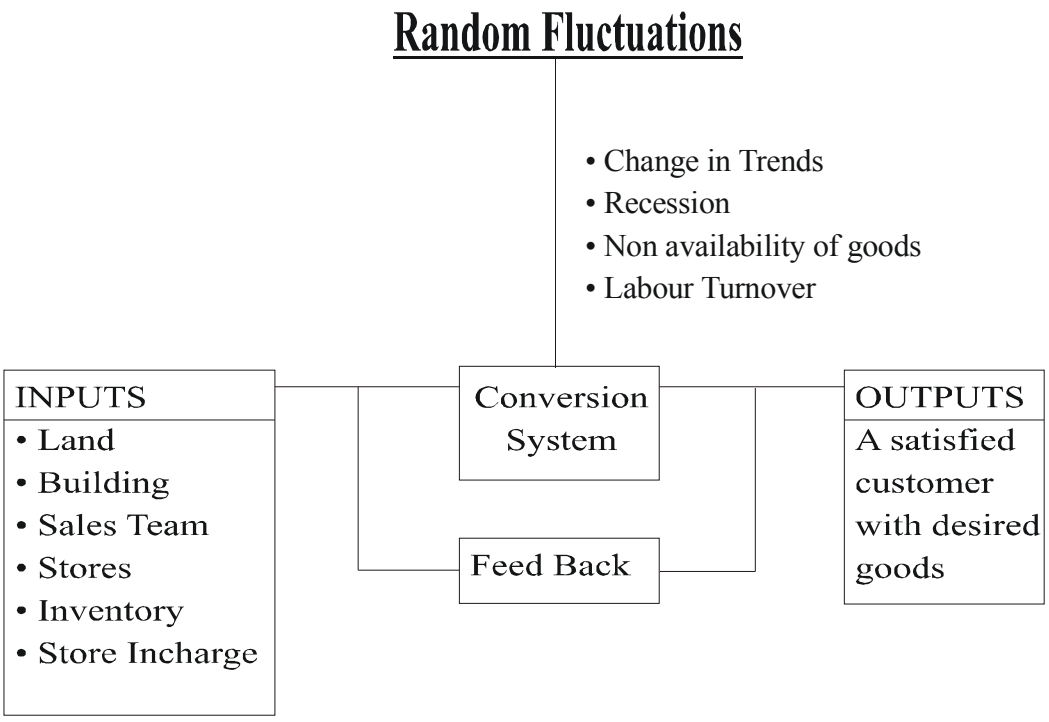


Fig. 1.1 Basic Elements of Operation System

This system can be applied to a variety of organizations. We take two examples, one relating to a departmental store (service) and another to a automobile manufacturer (product).



* Inventroy Levels
* Labour Efficiency
* Sales Volume
* Rising Popularity of Store

Fig. 1.2 Operation System for a Departmental Store

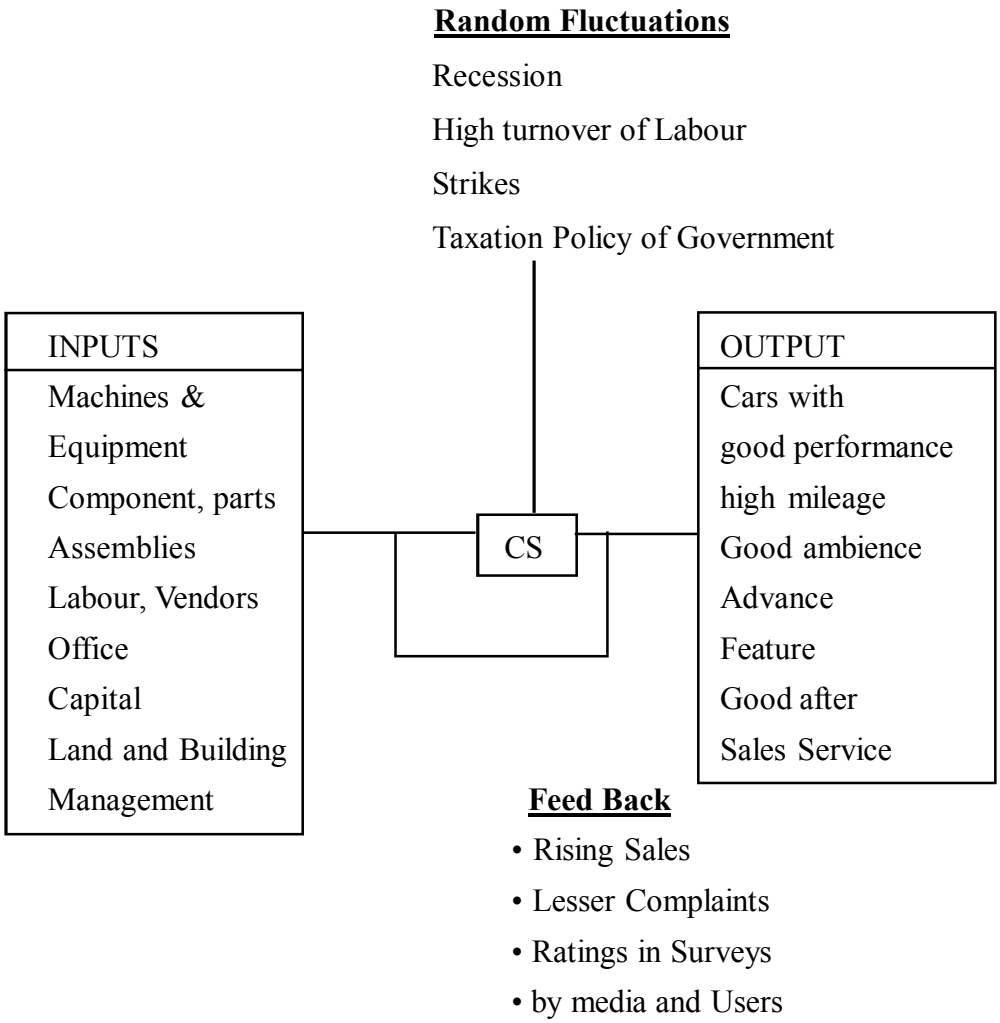


Fig. 1.3 Operations System for an Automobile Manufacturer

1.2 Concept of Product and Services

Before moving further, it is important to understand the conceptual difference between product and service. Table1.1 provides a broad basis of differentiating the two :

Table 1.1

S.No.	Parameter	Product	Service
1.	Tangibility	Tangible	Intangible
2.	Consumption Pattern	Consumed over a period of time	Instantaneous consumption
3.	Storege	Can be stored	Can not be stored
4.	Nature of Job	Less of labour more of equipment Little customer	More of labour, less equipment High customer
5.	Customer contact	Little customer contact	High Customer contact
6.	Customer Participation during the Process of Conversion	No participation of customer	High level of participation of customer
7.	Measurement	Easy to measure using instruments	Difficult to measure

To simplify, a product has tangible characterstics which can be inventoried and consumed over a period of time, jobs that involves less of labour and more of machines, very less customer contact and no participation of customer in conversion (production) process. The features of a product (say pick up of a car, weight of a watch) can be measured with perfection using sophisticated equipments.

In case of service, it is intangible and cannot be inventoried and has to be consumed instantaneously (for example a Haircut), involves job with more of labour and less of machines (say a doctor), high customer contact and frequent participation of customer in the conversion process (in hospital a patient becomes a through put when it goes through tests etc.) The quality of service is difficult to measure, for example it is difficult to quantify the satisfaction derived out of service in a restuarant.

The above parameters give only a broad difference between product and service. It is very difficult to classify organisations as pure manufacturing type or pure service type. Even purest service organizations have some part of product in it. For example an airline industry has a seat as a product to the customer, a consultancy firm has project report, a doctor has a prescription in form of a product. A restaurant is a case of hybrid organization where food served acts a product and ambience, interior, music, service of waiter etc. are part of service.

Thus, various organizations can be placed on a product-service continuum. The two extreme represents pure product and pure service industries. This is shown in Fig 1.4

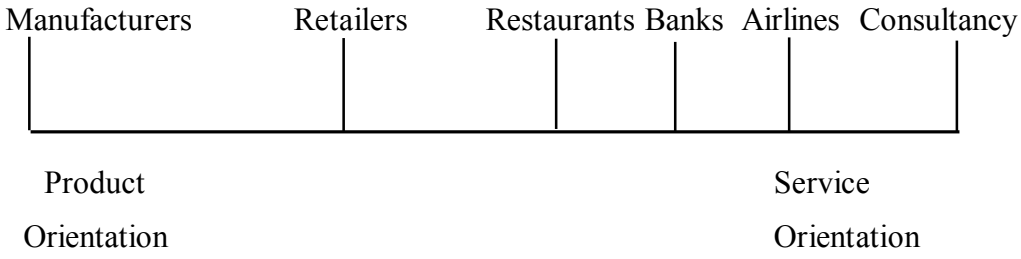


Fig. 1.4 Organizations on a Product-Process Continuum

1.3 Evolution of Operations Management :

The modern concept of operations management has evolved in the following three phases-

Phase -I Manufacturing Phase - This traditional view was evolved in the eighteenth century when Adam Smith came out with economic benefits of specialisation of labour. He called for breaking down the jobs in small tasks and reassigning these tasks to workers so that they would become specialized on them. In the beginning of nineteenth century F.W. Taylor, the father of scientific management came out with time study and work study. This phase prevailed till 1930's.

Phase II - Production Phase- This became a widely accepted term from 1930's and continued till 1950's. With Taylor's contribution being applied by the managers, more and more efforts were made to eliminate wasteful efforts and to achieve higher efficiency. Besides this, management also felt the need to understand workers beyond economic needs. Psychologists and social scientists began to study people and human behaviour. More analytical approaches were suggested by various economists, mathematicians and computer scientists.

Phase III - Operations Phase - This phase emerged in 1970's with the increasing dominance of

service sector in the economy. As the services started to become prominent, the change of production to operations clearly stated broadening of the field. Next change was that, earlier only marketing and finance functions were considered to gain a competitive advantage in industry but this phase of operations identified operations as strategic and vital weapon. The quality revolution and consumer awakening further gave importance to this function.

The summary of major developements is given in Table 1.2

Table 1.2

Period	Contributor	Contribution
1776	Adam Smith	Specialization of labour in manufacturing.
1799	Eli Whitney and others	Interchangable parts, cost accounting.
1832	Charles Babbage	Division of labour by skill; assignment of jobs by skill; basics of time study.
1900	Frederick W. Taylor	Scientific management, Time Study and Work Study devoloped; dividing planning and doing of Work.
1900	Frank B. Gilbreth	Motion study of jobs.
1901	Henry L. Gantt	Scheduling Techniques for employees, machines,jobs in manufacturing.
1915	F. W. Harris	Economic lot sizes for inventory control.
1927	Elton Mayo	Human Relations; the Hawthorne Studies.
1931	Walter A. Shewhart	Statistical inference applied to product quality; quality control charts.
1935	H. F. Dodge and H. G. Romig	Statistical sampling applied to Quality Control. Inspection sampling plans.
1940	P. M. S. Blacket and others	Operations research applications in Worldwar II.
1946	John Mauchly and J.P. Eckert	Digital computer.
1947	George B. Dantzig William Orchard	Linear programming.
1951	Sperry Univac	Commercial Digital Computer; Large-Scale Computations available.
1970	W. Skinner	Integrating Operations into overall Strategy and Policy.
	J. Orlicky and O. Wright	Computer applications to manufacturing over. Scheduling, and Control, Material Requirements.

		Planming (MRP)
1980	W.E. Deming and J. Juran	Quality and productivity application From Japan; robotics, Computer-Aided Design and Manufacturing (CAD/CAM)
1990's	National Institute of Standards and Quality, American Society of Quality Control (US) and International Organization for Stan dardisation (Europe)	Total Quality Management
	Michael Hammer	Business Process Re-engineering
	SAP (Germany) ORACLE (US)	Supply Chain Management
2000's	Amazon, e-bay America online google, yahoo.	E-commerce

1.4 Important Milestones

(1) JIT and TQC - The 1980's saw a revolution in the management philosophies and the technology by which production was carried out. Just in time (JIT) production is the major break through in manufacturing philosophy. Given by the Japanese, JIT is an integral set of activities designed to achieve high volume production by minimising inventory that arrive at workstation exactly when they are needed. This was further coupled with Total Quality Control (TQC) which seeks to eliminate causes of production defects.

(2) Total Quality Management and Quality Certification - One of the major development of 1980's and 1990's was the focus on Total Quality Management (TQM) . This phenomenon took quality out of the production shop to encompass each and every activity in an organization with customer being focus of all thoughts and processes. The massage was forwarded by quality gurus W. Edward Deming, Joseph M. Juran and Philip Crosby. The ISO 9000 certification standards created by the International Organization for Standardization, plays a major role in setting quality standards for global manufacturers.

(3) Business Process Reengineering -The global economic recession in 1990's pushed companies to seek innovations in the processes by which they run their operations. The message of business process reengineering (BPR) was conveyed by Michael Hammer's article in Harward Business Review. The approach suggests to make revolutionary changes as opposed to evolutionary changes. It asks for taking a fresh look at what the organization is trying to do in all its business processes and thus eliminating non-value-adding steps and streamlining to achieve the desired outcome.

(4) Supply Chain Management (SCM)- The basic idea of a supply chain management is to apply a total system approach to manage flow of information, materials and services from raw material suppliers through factories warehouses to end customers. Recent trends as outsourcing is forcing companies to find flexible ways to meet customers demand. SCM helps in maximising the speed of response to changes in customer expectations .

(5) Electronic Commerce - The quick adoption of the internet and world wide web during late 1990's has changed a lot in business practices. The term electronic commerce refers to the use of the internet as an essential element of business activity. The use of web pages , search engines is changing the way people collect information, communicate and shop. It is also changing the way operations managers coordinate and execute production and distribution function.

1.5 Role and Responsibilities of Operations Manager

A production/operations manager has to shoulder a number of responsibilities in any manufacturing organization. Some importamt ones are:

1. To plan location of the Plant.
2. Layout of machinery and equipment in the Plant.
3. Purchasing of production equipments.
4. Design of Product.
5. Process Design.
6. Designing methods of production and establishing standards.
7. Aggregate Capacity planning.
8. Production planning.
9. Production control.
10. Supply chain management.
11. Repairs and maintenance.
12. Health and Safety of personnel.
13. Setting production Standards and getting quality certifications.
14. Measurement of productivity.
15. Industrial relation (Trade union).
16. Budgeting.
17. Research and Development.

1.6 Summary

Operation function of any organization is one which produces its products. The basic elements of this function includes input in the form of raw material, machines and labour, output in form of product and services. The system is subjected to random fluctuations which becomes a cause of deviation between planned and actual output. The growing volume of service sector emphasised the need of broadning of the term production to operations. With this vital function, the companies tried to gain a competitive advantage. Thus an operations manager has a significant role to play in any organisation.

1.7 Self Assesment Test

1. Define the term operations management.
2. What is the difference between product & service ?
3. How does operations management differ from production management.
4. Apply the basic model of operations system to -
   (a) An MBA institute
   (b) A Restuarent
   (c) A Courier Company
5. Explain in detail the historical evolution of operations management.

Unit -2 Facility Location

Unit Structure

2.0 Objectives

After studying this unit you should be able to understand :

- Importance and need of facility location
- Impact of location on profitability of an organisation
- Various factors influencing choice of a location.
- Decision process in location selection.

2.1 Introduction

A factory or a plant is a manufacturing facility of a company. A ware house is the storage facility of a manufacturing or a distribution company. The offices of a service sector company such as a bank, or an investment consultant are its facilities. The facility location decision is very important for business houses who are well established as well as for new entrepreneurs. This is a vital decision in the sense that it involves a long term commitment. Once the buildings are built manufacturer or facility provider must live with these locations decision for a long time. The enormous first cost of most facilities and their subsequent low market value for resale make organizations to continue at the same locations even if they are not optimum.

2.2 Effects of Location on Costs and Revenues

(i) Fixed costs - New or additional facilities entail fixed costs initially, which must be recovered out of revenues to make the investment profitable. Acquiring a new or additional facility involves cost for new construction, purchase of new plant and after acquiring money has to be spent on equipment and fixtures. The size of investment depends upon the site selected. A site with in the main city would be costlier than that in sub urban area.

(ii) Variable Costs : Once built, the new facility must be staffed and operated, and these costs also depend on location. For labour intensive projects cheap and plentiful labour must be

available. Management must also look for proximities to raw material and markets.

(iii) Revenues - In some industries, revenues depend on having the facility near to the potential customer. In number of cases where service is to be directly consumed, location is very critical Movie theaters, Restaurants, Banks etc. must be located conveniently within easy reach of the public.

The above analysis of cost and revenues helps us in defining the problem of facility location. So, an ideal location of a facility is one, where all the factors which minimise the cost of operations will give that enterprise the greatest advantage by virtue of its location. For an optimum location the unit cost of production and supply should be minimum.

2.3 Need for Location Change

The Location Problem is not only for an entirely new business but also equally important for existing business. Some of the factors are-

1. Operations and expansion restricted due to poor site
2. Growing volume of business
3. Variance in labor cost / productivity
4. Shifting of Markets
5. Companies may merge and facility become redundant
6. New Products may be introduced, changing the avaibility of resource and Market.
7. Changes in political and economic situation
8. Availability of new technology, old Plant become obsolete.

2.4 Location Options

There are four options available to managers which can be considered in location planning:

1. Extension of existing Facility This option can be exercised if adequate for expansion is there.This is important when desirable features are not readily availabe elsewhere and cost of expansion is less than other options.
2. To add a new location while retaining the existing one.
3. To relocate facitity to a new location In this case only machines and equipment can be relocated and not the human resource Investment is also required for new location.
4. To maintain the same status If detailed analysis fails to unearth benefits of first three alternatives, a firm may decide to maintain the status.

2.5 Factors for Location

The important factors which influence the selection of location of a facility are

1. Raw material
2. Market
3. Transportation
4. Fuel

5. Power
6. Water
7. Labour
8. Climate
9. Laws and Taxation
10. Finance Facilities
11. Government aid and Policies
12. Existence of similar industries
13. Social and recreational facilities
14. Ancillary Industry

(1) Raw Material : The source of raw material is very important factor in ultimate location of facility. The total requirment of raw material its availablity within economic distance and its uninturpted supply are very critical factors to be considerd for location of any manufacturing unit. If a plant is in proximity of raw material it would result into timely delivery, low transportation cost and at the same time safeguard from loss arising out of situtation like break down of transportation system etc.

Raw materials which have high transport cost attract the industry to the place of their availability, such on Iron ore, Sugarcane, Tea etc. Industries like butter, cheese, meat etc. which are perishable in nature have to strike a balance beetwen market and raw material location. Industry which produce costly but light things and use specialsed or skilled labour, have no attraction for nearness of raw material.

Along with raw material, availability of building material must not be over looked, other wise cost of building might go high. Similarly supplies required for maintenance and operation of factory must be considered.

(2) Market : If the facility is near to the market, specially in case of consumable service, it definetly helps in gaining a competitive advantage. The cost of distribution is considerly reduced by locating a facility near the market. If products demand aftersales service it is imperative for the enterprises to be located near the market. When the products are perishable (bakeries, dairy products) or service (educational institute, hospital) or weight is added during the process (bottled drink), plant should be near the concentration of the market. If that is not possible a company can adopt for differential pricing policy to serve different markets.

(3) Transportation : All manufacturing units require inwords movement of raw material, and outwords movement of finished goods to the market. While locating a plant full advantage should be taken care of various transportation facilities available at the disposal. Major transportation medium like Rail, Road, Marine, Aircraft, Highway vehicles, Pipelines, Electric cables, Telecommunication(Information Technolgy) should be effectively used to handle the transportation.

Each transportation meduim has its merits and demerits, so in order to select proper meduim following considerations should be given

1. Type and extent of material handling.

2. Relative cost of various media.

3. Urgency.

4. Special facility requirement like refrigration.

Logistcs today has became an important field in this regard and all possible action should be taken to reduce cost.

(4) Fuel : Fuel as a locational factor vary from industry to industry. For those industry and processes which utilize fuel as basic raw material, like coal in thermal power plant and cement manufacturing plant, it becomes very critical in terms of cost, quality and availability. Cost figure should be seen in Rs. per thermal unit rather than Rs. per ton so as to use this efficiently.

(5) Power : Power intensive project will definitely gain advantage if cheap, uninterrupted power is available to them. Industry like Aluminium refinery is an example of it. In industries like pharmaceuticals units uninturrpted supply is must. It would be cheaper to get supply from public electric power company than to generate own electric power.

(6) Water : In number of industries water may be considered an important factor for location. Mineral water plant, nuclear power plant are some of the examples. Water is also required for cooling and waste disposal.While considering the availability of water following points must also be taken care of -

(a) Quantity of water required

(b)Source of supply

(c) Hardness level of water

(d) Danger of water becoming polluted by surrounding plants.

(7) Climate : This factor is very important where the process needs a particular environment and the efficiency of process is affected by it. For example wind mills need open areas with ups and down in topography. A flour mill needs dry climate.

Although atmospheric environment can be created by artificial means, it will have effect on both operation and cost. Climate also influences human efficiency and behaviour. Healthy and clear atmosphere free from smoke, dust and noise is additional advantage to an enterprise.

(8) Labour : Availability of trained and cheap labour is another factor influencing plant location. The labour should not only be adequate in number but it also should have necessary skill in the process. Other important considerations are-

(a)Wages

(b)Labour productivity

(c) Stability

(d) Cost of living

(e) Labour -Management relations

Labour intensive industries are located near thickly populated areas so that regular and cheap labour is easily available.

(9) Laws and Taxation : Although much of labour laws and taxes are uniform throughout the country but some laws and taxes are local and vary from state to state. All labour laws, pollution control laws should be carefully considered before finalising on the location. Many states offer incentives in terms of tax, electricity rate, land rate which helps a new plant to break even faster.

(10) Availability of Finance Facilities : With number of banking companies and financial institutions, this factor is now no more a problem. But cheap financial and insurance charges for a particular zone might lead to a substantial saving. Such locations do attract a number of industries.

(11) Government Aid : Central and state policy regarding taxation (Excise, VAT, Corporate Tax), transportation rates, special assistance in form of subsidies, development of Special Economic Zone (SEZ) or Industrial parks, liberal views in issue of industrial licence are certain factors which can create industrial concentration for a certain area. Many new entrpreneurs and existing industrial giants may tend to move on these location which gives a big monetary benefit in terms of government aid.

(12) Social and Recreational Facilities : Usually big units are located away from public in rural areas which are far from social and recreational centers. During off hours, the employees and their family members require some recreational amenities which are also necessary. It is there fore necessary to have parks, cinema halls, schools, hospitals, clubs libraries, sports facilities etc. near the factory site.

(13) Existence of similar industries : New entreprenurs start the plant at places where there are large number of similar industries so that all the basic things required are easily available.

(14) Ancillary Industries : Sometimes location are selected nearby ancillary industries, meaning industries which produce materials and supplies in connection to the proposed manufacturing, are present. This brings out centralization of industries.

2.6 Decision Process in Location of Facility

Generally while deciding on location for a facility, a three tier approach is followed in qualitative analysis-

(a) Deciding up on region or geographical area

(b) Identifying the community site

(c) Identifying the actual site

(1) Selection of Region : In the first step, the management identifies the region or geographical area where the facility is to be located. Regional location decisions are influenced by factors discussed in the previous section. The importance of these factors can vary from industry to industry and proper weights can be give to various factors in order to make a choice between two or more locations.

(2) Selection of a Community : Once the geographical region has been decided next step is to identify the community where the facility has to be located. Again community selecting is choice between three types :-

(a) City location

(b) Suburban location

(c) Country side location

Most of the factors taken into consideration in regional decision are present in community selection. Other factors include community service, attitude and incentive towards new locations, availability and cost of land, environment impact and management preferences are important factors which are seen in community decision.

(a) City Location : A city loaction has the disadvantage of high cost of land which makes initial investment bigger, at the same time rates of taxes and insurance are also high. But a city site has all other advantages like availability of skilled labour, nearness to market, better transport facitities, better financial facilites good supply of power and water and easy approach to all govemment departments.

(B) Surburban Location : It is a location between city and country side, so it can take advantages of both types of locations. They are chosen so that if large area of land is required it can be obtained and at the same time they are close to large population area. They also get freedom from common city builiding zone and other restrictions found in the city. Female employees can also be found in suburban area as these areas lack employment opportunities. Govemment laws and taxes are also relaxed in these areas social and recreational facility are not too far from the site.

(C) Country-side Location : If a plant is set on country side, land is availabe on cheap rate which can be hlepful in future expansion, Cost of construction, labour taxes. etc are also low and pollution norms are also relaxed but these sites are far from market, customers and skilled labour. Adequate transportation facilities are also not available and social and recreational facilities have to be developed for the employees.

(3) Selection of Actual site : Once the choice of site has been narrowed from region to community the next step in facility location is to select the actual site. While selecting the actual site technical, commercial and financial aspectes must be considered to get the maximum advantage. The main points for selecting a site are-

(A) Topography : This is very important in the sense that the sub soil condition of the site should be such that it can take load of foundation and building. If the site is not levelled, cost of levelling will also be incurred. Also cost of laying water supply line, drainage, sewage disposal, installation of electricity poles etc. must be checked, as if these are excessive, low price land would become expensive.

(B) Site Size : Size of the land should be such that it takes care of current needs of plant plus future expansion. Sufficient space to accomodate parking, transport facility for receipt and shipment of goods and movement should be availble.

(C) Waste Disposal : The facilities required for disposal of process waste needs to be considered. The plant should be positioned such that prevailing winds carry away fumes and solid and liquid waste can be disposed off properly and at reasonable cost.

(D) Transportation Facility : The site should be accessible both by road and rail preferably so that the transportation cost are minimum and movement is easy and quick.

(E) Ecology and Pollution : Before final selection of the site, one should check if there is any restrictions imposed by local self government on issues relating to pollution and ecological balance.

(F) Legal Aspects of Property : It should be made sure that area which is to be acquired is free from any dispute and person selling the land has the clear title of the same. It should be free from any encroachments. The land should be taken into possession easily.

2.7 Choice of Foreign Facility Location

With globalization and removal of trade barriers consumers expect the best products at lowest price. In order to meet competition companies have to engage in global production and service operations. Following factors should be taken care while evaluating international location option for a facility.

(i) Trade Barriers.

(ii) International Customers.

(iii) International Competition.

(iv) Lower cost.

(v) Incentives.

(vi) Economics of scale.

(vii) Additional Resources

2.8 Strategies for Multiple Facilities

An organization may go in for setting multiple facilities i.e setting up plant at more than one location. There are three basic strategies for multiple locations.

(i) Separate facility to serve different areas : Products where cost of distribution has to be controlled and demand pattern are volalite this strategy of having separate facility to serve different geographical areas is very helpful. A number of areated drink manufacturing companies like Pepsi and Coke follow the same strategy. Banks, hospitals, schools, courier companies are some examples in service industries.

(ii) Separate facility for different Products : A company like Godrej has diversified product range from cosmetics to furniture and computers. Similarly white goods manufacturing companies have television, washing machine, refrigerators, micro wave etc. in their product range. For such organizations separate facility for each product is optimum.

(iii) Separate facility for different processes : Many computer manufacturers have separate manufacturing facilities for different sub parts. These parts are then assembled together to make the final product. This strategy helps in avoiding confusion at the main manufacturing setup. At the same time a lot of coordination is required between such plants as these serve as feeder units to the other plants.

2.9 Summary

Location decision for a facility is very important in the sense that it involves a substantial commitment in terms of cost and time. It is not easy to reverse a wrong decision taken in for a location. There are a variety of factors which need to be considered before coming to the final choice of location of a facility. First step is, selecting a region then selecting a community and then selection of the final site. The over all selection procedure is taken by giving due weightage to various factors.

2.10 Self Assesment Test

1. Define facility location : When does the need for a location change arise ?
2. How does location decision affect overall profitablity of any organization. ?
3. Discuss the decision making process in finalizing the facility location.
4. What are the various factors influencing the location decision ?
5. Discuss locations options available to an operations manager.
6. How does location decisions differ in manufacturing and service ?
7. With breaking of trade barriers discuss the option of going for foreign location?
8. When can an organization go for locating multiple facilities ? Discuss with examples.
9. Taking an industry of your choice select the optimum location justifying various factors.

Unit – 3 Product/ Process Design

Unit Structure

3.0 Objectives

After studying this unit, you should be able to understand:

- Process of new product development
- Meaning of process and its types
- Meaning and types of product/ process design
- Aids of process planning
- Factors affecting choice of process design

3.1 Introduction

A product is any thing that a manufacturer or service provider has put in the market for sale**.** It can be a physical good, idea, service, event, news etc. In this chapter we are going to explain how a product takes birth, survives and becomes a hit in the market. What are the different ways in which a product can be produced, whether all the things are to be done by a single company or they can outsource some of the processes and parts. In today's highly competitive world designing a product and getting it to the market has taken a front seat as products are copied very quickly and to recover the total research costs one has to take to capitalize first mover's advantage without which the whole launch can be a loss. So let's see the steps in product development process.

Step 1. Idea Generation – New ideas for products can come from studying consumer demands and requirements, interacting with various groups and using creativity generating techniques. Scientists go on testing new technologies to give birth to new products; any such idea can develop into a profitable product. Other then scientists' ideas can come from employees, competitors, channel members and top management. Employees throughout the company can be a source of ideas for improving production, products, services and processes. Toyota claims that its employees submit 2 million ideas annually, over 85% of which are implemented.

By researching competitors products and services customers likes and dislikes about competitors' product can be found out. Channel members and company representatives have first hand exposure to customers and are first to learn about competitive developments.

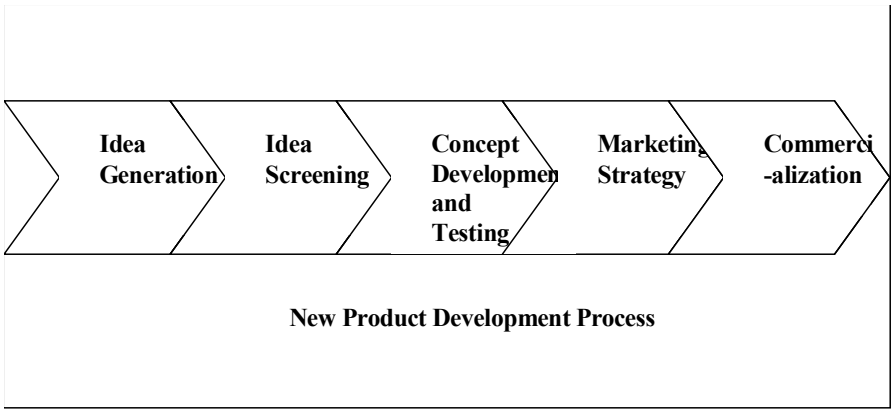
Creativity enhancing techniques like attribute listening, forced relationship, morphologic analysis, mind mapping etc can also be helpful in discovering new product ideas. In a lot of companies like Apple (Steve Jobs), Polaroid (Edwin H. Land), CEO's themselves have taken the responsibility of technological innovation and it has proved to be of billions of dollars.

Step 2. Idea Screening – Not all ideas are feasible or can be converted into a successful product. All the ideas received by the *Idea manager* are reviewed by an *Idea committee* at regular intervals and are grouped under three heads: promising ideas, marginal ideas and rejects. Each promising idea is researched to find out its marketability. Here two kinds of errors can be committed *go error* (moving ahead with a poor idea) and *drop error* (dismissing a good commercially viable idea).

Step 3. Concept development and testing – A *product idea* is a possible product the company might offer to the market. A product concept is an elaborated version of the idea expressed in meaningful consumer terms. For developing a product concept certain questions are to be answered – who is the target customer and what primary benefit will the product give. Concept testing involves presenting the product concept to appropriate target consumers and getting their reactions. The more the tested concept resembles the final product or experience, the more dependable concept testing is.

Step 4. Marketing Strategy – If the product proves to be a success during testing, a preliminary marketing strategy plan is prepared for introducing new product in the market. The plan consists of three parts. First part describes size of the target market, its structure, positioning, expected sales and profit goals etc. Second part outlines the planned price, distribution strategy and marketing budget for first year. Third and the final part describes' the long term sales and profit goals and marketing mix strategy for the product.

Step 5 Commercialization – This stage represents the actual full length launch of the product into the market. It is the most expensive stage as production plant has to be set up, raw material purchased, marketing and supply of the product has to be done at this stage only.



New Product Development Process

3.2 Types of Processes

Process Converts all the input material into finished goods and services. It is any part of an organization that takes inputs and transforms them into outputs or finished goods. This whole process can be done in a lot of different ways like job process, batches, project, line process and continuous process.

1. **Project Process** – A project can be defined as any single, exclusive assignment characterized by long time duration, its own project manager and unique problems etc. Project can be anything from constructing an over bridge, a helicopter or arrangement of an event. Some of the characteristics of a project are as follows:

   a. Unique in nature i.e. no resemblance to any old project.

   b. Has a project manager assigned to it.

   c. Dedicated resources.

   d. Deadline for its completion is decided beforehand.

   e. Has a specific purpose.

   f. These require close coordination between various functions.

   g. These are usually complex in nature.

2. **Job Process -** Product or services are produced in small quantity and resources are organized around the process. Here the quantity produced is small but the type of products produced is huge. Some of the characteristics of job process are as follows:

   a. Company follows make to order strategy.

   b. Products and services are designed as per customer requirements.

   c. Volume of products or services are low.

   d. Requirement of next customer are unknown.

   e. Timings of repeat order is unpredictable.

3. **Batch Process** – This process type is opposite of job process as here the quantity produced is high and the range of products produced is narrow. Some of the characteristics of batch process are as follows:

   a. Company follows assembly to order strategy.

   b. Some of the critical components of the final products are assembled in advance.

4. **Assembly Line Process** – In line process products and services are standardized i.e. they are similar and the production is done in high volumes. Resources to be used during production are organized around the process. Some of the characteristics of line process are as follows:

   a. Material moves from one workstation to other in a fixed sequence.

   b. Each operation is performed repeatedly.

   c. Company follows make-to-stock strategy.

   d. Finished product is kept in inventory.

   e. Product variety is created by addition of standard options to basic products.

5. **Continuous Process** – Continuous process more or less just like line process but the difference lies in the quantities that are produced. Continuous process produces standard product in a very high quantity and the production is carried all round the clock and it follows a rigid line flow. Some of the products which are produced by this process are ceramic tiles, cold drinks etc. Its features are as follows:

   a. Volume of production is very high.

b. Primary material keeps flowing round the clock.

c. Company follows make-to-stock strategy.

d. Process is capital intensive.

e. Process are continuously operated to maximize the utilization.

f. Shutdowns and start-ups are minimized by preventive maintenance.

6. **Make-to-order Process** – In this process, production takes only when company receives an order for production i.e. process is activated only in response to an actual order. This leads to almost no work-in-progress and finished goods inventory. Raw material generally follows just in time approach where at the time of production raw material is received by the company. This helps in reducing losses due to obsolesnce. Services generally follow this approach as products are processed once an order is received by the company. Restaurants, beauty parlors etc. use this approach.

7. **Make-to-stock Process** – It is just the opposite of make-to-order process. Here production goes on continuously and finished goods are stored. The goods produced are standardized products that have high demand in the market. This attracts those who need products very quickly and cannot wait till the product is manufactured. This process is controlled based on actual or anticipated amount of finished goods inventory. It is also used when demand is seasonal, so production is carried during off season and stocked for the peak season on the basis of past year sales.

8. **Hybrid Process** – Hybrid process is a combination of make-to-stock and make-to-order processes. Here a standard or generic product is produced by make-to-stock process and stored at some point then when customer places an order the final product is completed according to individual customer's requirements. For example Maruti offers Wagon R in two standard variants petrol and Deo (LPG). It also offers an accessory package in which buyer can get the vehicle customized by choosing from a list of options such as alloy wheels, rear spoiler, fog lamps, different types of leather colored seat covers, steering cover, foot mats etc. While the production of standard vehicle goes on continuously, it is accessorized only when customer asks for it.

9. **Pacing** – It refers to the fixed timing of the movement of items through the process. In every assemble line the movement of products is timed according to some standard mechanized way in order to coordinate the line. Here a clock starts a backward counting as soon as the product reaches a stage and when the clock tics zero the product moves to the next stage. So time controls the movement of products from one stage to the next stage.

3.3 Factors for Process Design Decisions

As we have seen that there are many types of processes, but how does one decides which process would be appropriate for a product. For deciding this there are some important factors which should be considered before laying the process design which are as follows:

1. **Nature of Demand –** A business exists to serve the needs and requirements of the customers who make the market**.** Demand is the want of a product by the customers accompanied by the capability to pay for it. So a business should be such which understands needs of customers. There are various forecasting methods which are used to estimate the future demand and

accordingly the process is designed and production capacities are established. Inventory level is also maintained accordingly. During estimating the demand for future certain factors like seasonality, growth trend and other such factors should be taken care of.

Influence of Demand Pattern : Fluctuation in demand is due to reasons like seasonal effect, growth trend, customer taste, expectation in future price of products, prices of related goods etc. Example – demand for hot blowers, holiday packages etc. Businesses also have to adjust their production schedule and pattern according to such changes. During sluggish demand the production has to be reduced and on the other hand if the demand is very high production also needs to be increased. So the processes should be flexible enough to incorporate such fluctuations in the demand of the products.

Influence of Price Levels : We all know that there is inverse relation between the price of a product and its demand i.e. if the price increases demand decreases and a fall in price brings about increase in the demand of a product. Price elasticity is another factor which plays a prominent role in the demand of a product. Elasticity is the degree of responsiveness of a quantity demanded to the change in its price. Normal goods have unitary elastic demand while luxury goods have a highly elastic demand, so a small change in the price brings about more than proportionate change in the demand of the product.

2. **Quality Level –** Quality is a very important factor for being successful in today's market as there are a lot of closely related products available in the market and per head income has also increased over the years. So people are ready to pay even a higher price if the quality of product is good. Companies also use a lot of techniques to improve the quality of the products like TQM, CAD/ CAM.
3. **Degree of Automation –** Degree of automation represent the use of machines in the whole process of production. If more of machines are used then it is capital intensive and if more of labor is used then it is labor intensive process. If process is capital intensive then the quality of products would be better and the products will be standardized, which can not be done in labor intensive process. If the process is capital intensive then it is difficult to make any changes in the production process. On the other hand it may be difficult to find labor with right kind of skills.
4. **Flexibility -** An organization is considered as flexible when it adjusts quickly to the changing customers' needs and market conditions. The more flexible a firm is more are its chances to maintain and increase its market share.

Volume flexibility : Volume flexibility is the ability of a firm to increase or decrease production volumes of a firm in response to external changes. This is useful when the demand of a product is fluctuating and keeps on increasing and decreasing. Volume can be adjusted by adjusting labor and equipment. Fluctuating labor is simple by overtime or sub-contracting. But in short run it is difficult to make changes in industrial capacities. It can only be made flexible by running the equipment on full load or less then full capacity.

Product/Service Flexibility : Product or service flexibility is the ability of production system for shifting from producing one product to other. It helps in business strategy focused on custom-designed product and services and low volume products. It represents the process focused design where small quantities are produced of different products. The more flexible a firm is more are its chances to survive in changing market.

5. **Degree of Vertical Integration –** Vertical integration refers to the extent to which production and distribution channel are brought under the ownership of the organization. Integration is of two types – backward integration and forward integration. If a production house acquires the firm that supplies raw material to it, then it is called a backward integration. On the other hand if the firm gets into one step forward in the whole channel that is called forward integration. For example a shirt manufacturing company if gets into business of fabrics then it is backward integration and if it starts its own distribution channel then it is forward integration.

Integration may not be fruitful for all the industries. So operations managers have to decide whether it will be profitable or not, if yes then to what extent. Integration has advantages of low cost inputs, flexibility etc but disadvantages are obsolesce, lack of effective management etc. So operations manager should evaluate all the pros and cons of vertical integration before deciding on its implementation.

3.4 Types of Process/Product Designs

The word ***design*** holds different meanings for different people for some its just the aesthetics of a product like its shape, color, texture etc., some other regard it as basic parameters of a system. For example design of a motor garage might mean establishing the characteristics and placement of various units like paint booth, washing bay, lift, engine repair area, etc. Another interpretation of word design is the detailing of the materials, shapes, and tolerance of the individual parts of a product. So here we are concerned with this last meaning of designing which explains the complete delineation and description of the specific stages of in the production process and the linkages between the different stages of production. The design should be able to meet the quality standards, time deadline and should be produced at the least cost possible.

The quality and homogeneity of a product decide the level of automation required for the production of a product. If the product is highly standardized and mass production is to be done then high level of automation would be there and all the work would be done by machines, hence the critical production resource would be machine. On the other hand if an exclusive product is to be made where expertise of a person is required it would be a labor intensive product where very less pieces would be made. So it becomes very important to decide what kind of process design should be adopted to produce each product and service. The various types of process designs used in the industries are as follows:

1. Product - Focused
2. Process – Focused
3. Group Technology

1. Product Focused

This type of production process is generally used in those production departments which are organized according to the type of product or service being produced. It is also referred to as *Line Flow* production system. This is used for the products like radio, candies etc where products or services tend to flow along linear paths without backtracking or side tracking. These items follow a similar sequence for whole production i.e. same kind of machinery is used like in an assembly line to produce a television. Advantages of a product focused process are low unit cost, high volume of production, ease of planning. A disadvantage of this process is that it requires very high initial

investment as it uses specialized and expensive fixed position processing equipment. As it is a machine intensive production process it requires low labor skills, worker training and supervision, so in total it is easy to control. This is like the admission process in schools and colleges. At the time of admission everything is united at a single place. In a single room you can take admission card, uniform, books and also deposit the fee.

A product focused production system is generally designed for three forms of production: discrete unit manufacturing, process manufacturing and delivery of services.

(a) Discrete Unit Manufacturing

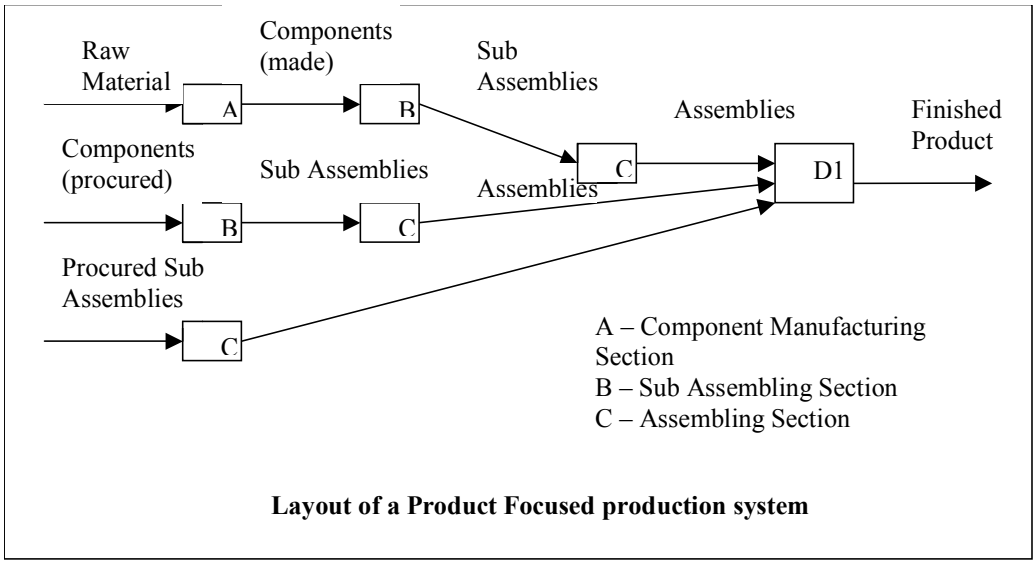
It is a process where production of distinct products like cold drink or branded medicines takes place. The production of these can be done batch wise and then the system can be shifted to produce other products in similar batches. The whole production process moves in a single line and similar process.

(b) Process Manufacturing

In process manufacturing movement of materials among different operations takes place. Operations can involve crushing, screening, mixing, blending etc. So it is generally used by cement, paper, chemical, steel, packaged water and brewing industries.

(c) Delivery of Services

Delivery of services is also done through product focused process design, for example waiters of a restaurant follow a particular linear route while serving the guests.



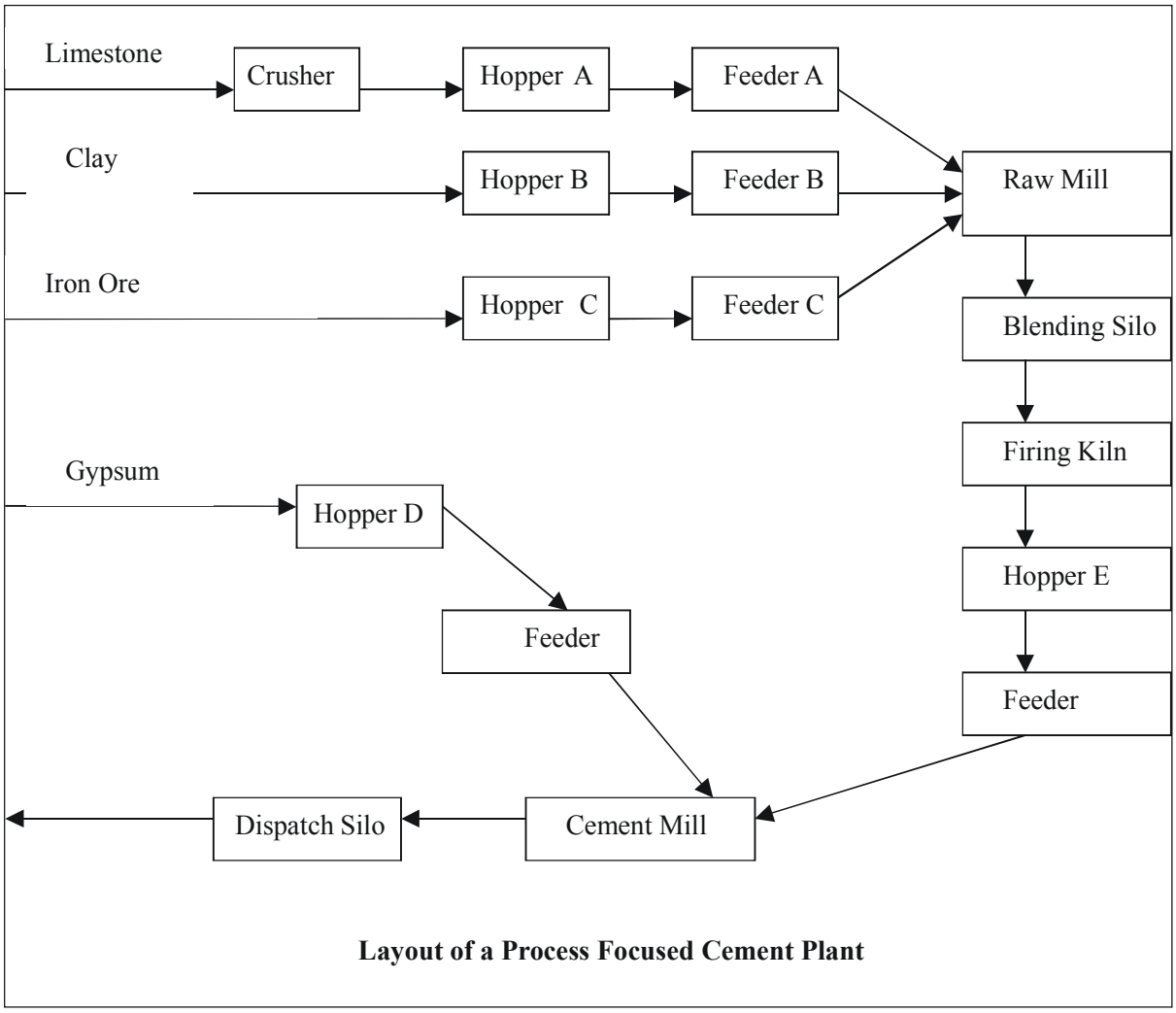
Layout of a Product Focused production system

2. Process Focused

In this method of process design, processes are given more importance then product. So operations are grouped according to the type of process. This system is also referred to as job shop as products move from department to department in batches that are usually determined by customers' orders. Unlike product focused designs which are used for mass production, process-focused design is used to produce small quantities of different items. We can also call it a functional system where equipment and personnel are located according to the functions. Products flow in irregular pattern through the different facilities. For example take the case of the system followed in schools and

colleges. At the end of semester students have to take no dues, they have to go from one department to another i.e. from accounts to library, laboratory, computer lab etc then back to accounts. So a lot of time is wasted.

Basic advantage of this design is flexibility of operations. Here more than one product can be manufactured at a single time. Products move from department to department. If a department receives two products at the same time then one can be put on hold till the first one is worked on. Another flexibility offered by this system is the wide spectrum of products which can be produced at a single time. A major setback of this design is the wastage of time during waiting in departments. Moreover this system also requires a lot of skills in employees, training is also required, more supervision and control.



Layout of a Process Focused Cement Plant

3. Group Technology

It was first used in 1940's in Soviet Union as a production process design. Now it is used everywhere whether it's India, Japan or USA. In this layout dissimilar machines are grouped into a single work center to work on products similar in shape and processing requirements. Group technology is similar to both product and process layout as each cell is dedicated to a limited range of products and each cell is designed to perform specific set of processes. In this technology, each part which is produced is represented by a code which has several digits, each representing a physical characteristic of the part. The benefits of implementing coding system are as follows:

1. Codes very clearly tell the steps taken in producing a part. Hence it is easy to route the parts in production.
2. Parts with similar characteristics can be grouped into families as similar products are generally produced in similar ways.
3. It results in standardization of parts. These codes Collectively Consitute a database having all the specifications of all old parts used in manufacturing that product. So when a new product is to be designed, codes of existing products can be accessed to identify similar parts present.

Cellular Manufacturing :

It is a type of group technology in which the total production area is divided into cells; each cell consists of group of similar machines. Advantages of cellular group technology are:

i. Less changeover time between batches of parts hence high productivity.
ii. Less cost of training as worker works on similar machines.
iii. Better quality.
iv. Reduction in material handling cost.
v. Simplified production planning and control.

3.5 Aids of Process Planning

Planning of production process is very important to fight with any unseen contingency that may come across during production. Production is a continuous process but it has to adapt to the changing demands of the public. Operations manger generally uses assembly charts and process charts to redesign, update and evaluate their production processes. Now let's discuss all these at length.

Assembly Charts :-

Assembly charts give a general understanding of the entire process involved in producing products which involve assembly of a number of parts. They provide an overall view of the movement of components and sub-assemblies. They also show a list of major components, sub-assembly operations, quality checks and assembly operations that are involved in making a mechanical assembly. In these charts operations are indicated by circles and inspections by squares.

Process Charts :-

These are also like assembly charts but they show extra information like description of various steps involved, their frequency of occurrence etc. Other activities like storage, delay and transport are also shown with the help of different signs like " for storage, D for delay and for transport. The major use of process charts is to compare alternate ways of performing operations. Each activity is reviewed by examining whether the whole process can be improved if a particular task is eliminated, combined with some other task, changing the sequence of tasks or modifying the tasks.

Process charts are also useful in new product planning and improving existing operations. Thus process charts help managers analyze the efficiency of processes.

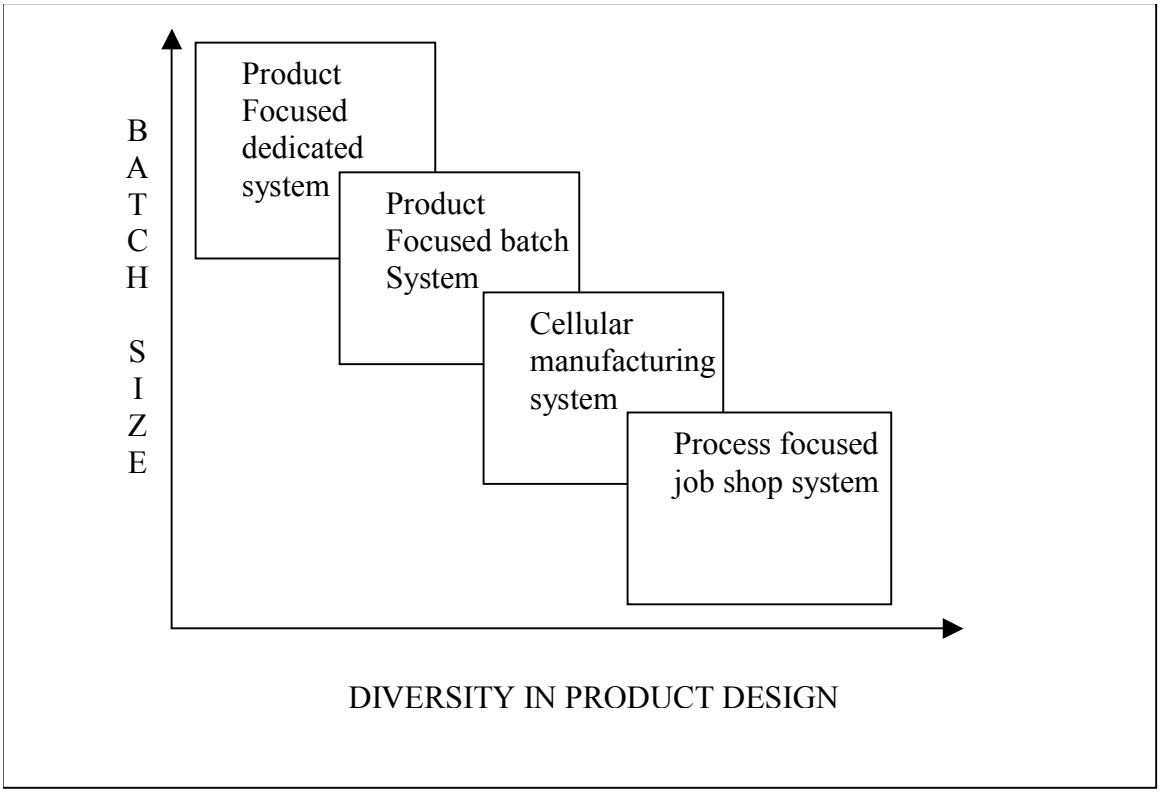
3.6 Factors Affecting Process Design

Investment :-

We have seen that a huge investment is required in product focused process design as complicated machinery is used in this kind of production. On the other hand a process focused design involves less investment. So if a person who wants to set up a production plant but has limited resources then he cannot opt for a product focused design. So the level of investment is defiantly a very important input in selecting a process design.

Variety and Volume

The process design to be applied to a facility layout depends on the range of the product i.e. variety and volume of that particular product. If mass production of standard product is to be undertaken then defiantly we will have to go for a product focused design as it allows standardization and mass production. But if special product in small quantity is to be produced then process focused design is better applicable.



The above diagram shows how to choose the kind of product design depending in diversity of product design and the batch size. It says that if product diversity is high and the number of each kind of product is low then a process focused job shop would be a better option for design. On the other extreme if the product to be manufactured is standard and mass production is to be done then product focused system would yield maximum results. Cellular and product focused batch system lie in between both the designs.

Economic Analysis

There are two kinds of costs involved in any production process, which are – fixed cost & variable cost. Fixed cost does not depend upon the level of production but variable cost is directly dependent upon the level of production. If production is high variable cost is also high and visa-

versa. Fixed expenses are rent of land, cost of machinery etc. While variable costs include cost of raw material, electricity and fuel used to run the machinery, etc. So we can deduct that fixed costs are higher in product focused designs and low in process focused in designs. Same is the case with initial investment, it is high in case of product centered process design and low in process centered design. Moreover if money is not a limiting factor then operations manager can suggest any design based on the targeted production volume of the product.

3.7 Designing for the Customer

In some fields basically the technology intensive fields like electronics it was realized that in the race to producing more technologically advanced products the companies had left consumers behind. When designs are made keeping in mind the user and the aesthetics, it is called as industrial design.

According to Industrial design product should be defined and developed based on customer needs. Less features or advanced features may not suit to the customer and result in failure of the product. Quality function deployment (QFD) is used to identified the customer needs by involving customer in product design function. It helps in reduction of design time. QFD is also known as house of quality. It helps in identifying customer need and the way in which they can be met. Steps taken for QFD are as follows:

Steps in Quality function deployment (QFD) :-

1. As QFD keeps customer at its center so it starts with market research to identify customer requirement.
2. Customer priorities are put in sequence in terms of importance with respect to different parameters/ characteristics of the product or service.
3. Next step rates companies' product vis-à-vis competitors' product.
4. A matrix is drawn between Whats and Hows. Where "Whats" (Customer requirements) refers to list of characteristics that a customer wants and rated by customer on a scale of 10.
5. Hows are design characteristics to meet the customers requirements.
6. Competitors scores are also shown in matrix at right side on a scale of 5.
7. Central matrix shows the relationship between customer requirement and design dimensions
8. Technical Assessment is carried out by finding out absolute importance of design characteristics by multiplying the value of relationship between design characteristics and customer requirements as defined by the customer.
9. Symbols are used in matrix for defining the relation ship. Example:

Whats vs HOWs	**Hows Vs Whats**
Strong relationship 9	Strong positive
Medium relationship 3	Positive
Weak relationship 1	Negative *
	Strong negative

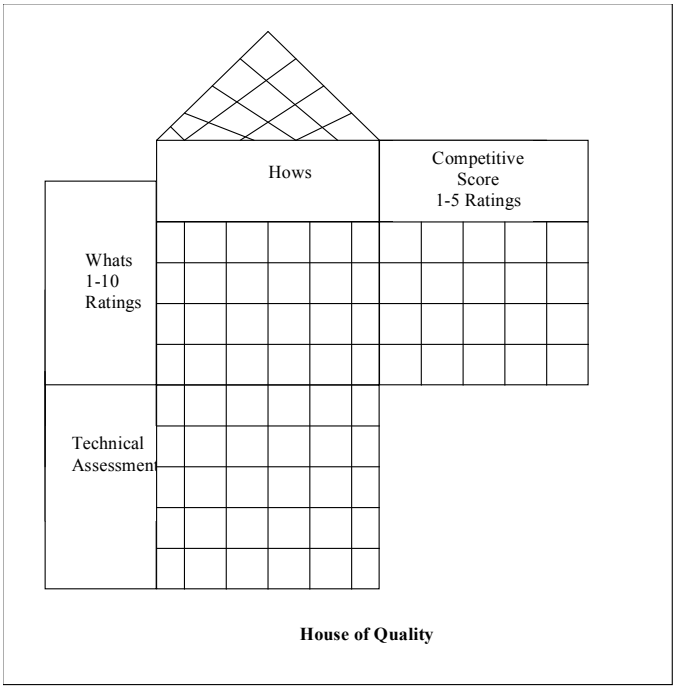
10. Triangular corner at the top shows the correlation among various design characteristics.

House of Quality – House of quality is a matrix made on the basis of customer requirement information. QFD brings about a whole picture of customer likings, dis-likings, etc in front of the management team. But to understand all of it in writing is very difficult, to overcome this problem house

of quality matrix shows all this information in a pictorial form which is very easy to understand. It makes easy to come to a decision in engineering, marketing and design decisions. So the most important quality of this matrix is that it lays full importance on customers' requirements and thus it helps the management team to focus on building a product that satisfies customers.

The matrix helps the team to translate customer requirements into concrete operating or engineering goals. The whole process encourages all the departments involved in product development to work closely and lays down the entire important characteristic which should be included in the product. Matrix also shows the areas that need improvement.

First step in building the house of quality is to develop a list of requirements needed by the customer in the product. In the next step these requirements are ranked in descending order of importance. Customers are then asked to compare company's product with that of its competitors. Then a set of technical characteristics of the product is developed. These technical characteristics should relate directly to customer requirements. An evaluation of these characteristics should support or refuse customer perception of the product. These data are then used to evaluate the strengths and weaknesses of the product in terms of technical characteristics. The diagram on the next page shows a blank diagram of the house of quality.



House of Quality

3.8 Summary

Process Designs are prepared at the time when a new product is launched in the market. Its main purpose is to make proper use of all the production resources like land, labor, material etc and deliver the right product of right quality, at the right time, in the decided budget and in the right quantity. There are different types of processes used for manufacturing which are – project, job, batch, line or assembly, continuous, make-to-stock, make-to-order and hybrid.

Process design helps in developing a detailed blueprint of a manufacturing plant and thus provides foundation and structure of whole facility. Process Designs are of three basic types – product focused, process focused and group technology. Product Focused design is organized

according to the product with linear flow of material, without any backtracking and side tracking. It facilitates high volume production of a standard product.

Process Focused design almost opposite of product focused design and facilitates production in small quantities of customized products. Under group technology process design dissimilar machines are grouped into work centers to work on products with similar shape and processing requirements.

3.9 Key Terms

- **Process –** Set of activities performed by an organization that takes inputs and transforms them into outputs ideally of greater value to the organization than the original inputs.
- **Project** – A group of interrelated tasks with unique characteristics, separate resources which help in achieving predetermined objectives.
- **Make-to-order** – Process that is activated only in response to an actual order.
- **Make-to-stock** –Process that produces standard products that are stored in finished goods inventory. The product is delivered quickly to the customer from the goods inventory.
- **Hybrid** – This Process combines the features of both make-to-order and make-to-stock. Typically, a generic product is made and stocked at some point in the process. The generic product thus produced is customized according to customer' wants and needs before delivery.
- **Pacing** – Movement of items through a process which is coordinated by a timing mechanism. Assembly lines are generally paced.

3.10 Self Assessment Test

1. What are the steps in new product development explain with the help by taking a fictitious product.
2. What is a process? Explain the different types of processes by which products can be manufactured.
3. What are the aids of process design?
4. What is a product/process design? Write down the different types of process designs with diagrams.
5. What are the factors affecting the choice of process design for a manufacturer?

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Unit 4 Job Design Concept

Structure

4.0 Objectives

After reading this unit you should be able to :

- Understand the concept of job design and its relationship with other functions of operations management.
- Study the significance of ergonomics and human engineering in job design.
- Consider design specifications for improving productivity.
- Realize the need for providing high quality of work life to employees.
- Consider the behavioral dimensions of job design
- Understand the need for socio technical approach to job design.

4.1 Introduction

Jobs are the foundation of organizational productivity and employee satisfaction or dis-satisfaction. During the next millennium the success of any organization will depend on how well the jobs are designed. Well designed jobs will help the organizations to enhance the motivation level of employees resulting in retaining the employees. On the other side, it may be noted that poorly designed jobs will result in lower productivity, employee turnover, absenteeism, complaints, sabotage, resignations and other problems. Job-related questions such as what work is to be performed, who is to perform the work, where the work is to be done, why the job is necessary and how should the work be accomplished should be answered by a good job design. For organizational purposes, we divide job design into two basic elements a human element and a work element. Physiological, social and psychological considerations are important human factors relating to job design. The work element will comprise the work study which is covered in next two units. Chase and Aquilano define job design as the function of specifying the work activities of an individual or group in an organizational setting. According to them following decisions are to be involved in job design:-

1. Quality control as a part of worker's job

2. Cross training of workers to perform multi skilled jobs.
3. Employee involvement and team approaches to design and organize work.
4. "Informating" of ordinary workers.
5. Extensive use of temporary workers.
6. Creation of alternative "workplaces".
7. Automation of heavy manual work.
8. Organizational commitment to provide meaningful and rewarding jobs for all employees.

4.2 Factors affecting Job Design

Job design is affected by design, organizational and environmental factors. Now, we will discuss each of them as under :

- **Design Factors**

Layout of Equipment and Seating: - When a person and equipment operate together to perform a productive process, interest focuses on the efficient use of the person's time and equipment time. When the operator's working time is less then the equipment's run time, a worker machine chart is a useful device for analysis. Generally equipment is first designed and then the operator is assigned that equipment to perform his activities. The attitude is that no change is required in the equipment and the person himself will adapt according to the requirements of the equipment.

For good design, the designer should know the details regarding areas for vision, for controls, for sitting, for leg room etc. by taking note of standard anthropometric data of men and women, as the case may be. Job design should consider weather the job is to be done standing or sitting or in both the ways. In many of the cases it is noted that the workers have to change their postures from time to time and make them comfortable enough to relax by leaving the work station though for a very short duration of time.

It is the requirement of good seating that the person while sitting should be able to maintain a good posture. The use of a well designed and positioned back rest may relieve the back muscles of a good deal of postural strain. A well design seat should therefore bear the weight of the body in a good posture. The element of good seating will depend on the length, width and shape of seat; material of which the seat is made; the shape and the height of the seat above the floor.

In many cases workers of categories such as cobblers, tailors, etc. prefer to work at floor level. This is popular among these workers as they have greater freedom to move their legs and bodies. Sometimes stool or bench are provided to them by the management, but usually it is seen that such aids are not used subsequently for sitting purposes; rather the operators would place their tiffin boxes, small bags, shawls etc. on these stools.

In case of controls, information should preferably given to the operators in a binary form of "yes-no" type. If the workers are illiterate then colors can be used. For quantitative information, digital presentation should be used. Important control penal instruments should have a combination of auditory and visual signal scheme. While deciding on the layout of equipments, control panels etc. space should always be kept for their subsequent maintenance and repair. There should be accessibility for regular maintenance. Diagnostic studies on regular basis should be conducted to prevent failures.

Instrument Display Design:- Displays which should be primarily of auditory or visual type help us to give information about a situation which is occurring or has occurred and which cannot be obtained by seeing or hearing directly, and so we might have to resort to the use of instruments, like pressure gauge for instance, which reveal the condition of piece of equipment or instrument. Dials and counters are generally used for quantitative and qualitative reading, and to check reading for comparison in visual displays without controls. Dials and counters may be used for check controlling, setting and tracking when the displays are used for controls.

Studies have shown that counters which give the value directly in numerals are far more superiors than others for quantitative reading. It has further been observed that vertical straight dials are better than circular dials because an upward movement of the pointer will always indicate an increase in value. Horizontal straight dials can be used for setting machines more quickly as compared to other varieties. There seem to be no definite conclusions about the variety of dials best suited for indication and warning purposes. When qualitative information about a situation is to be shown then pictorial displays are the best. These displays could include not only instruments but tables, graphic presentations and even pictorial panels. Today computer graphics is assuming great significance. Auditory signals are also in use for providing warnings of the 'yes-no' type.

Compatibility: - While designing the control knobs, natural movements need to be kept in mind. Learning times for the operation of the equipment on which controls are compatible are much shorter then if the controls are incompatible. The chances of accidents also increase if the control knobs are not compatible with the natural movements. Based on the layout the various instruments are to be arranged so that they are compatible with each other as per the requirements of the jobs and the job holders. Where controls are associated with dials in a panel, the dial and control should be laid out with the same spatial relationship.

Control Design Characteristics:- With the computerization of major industries the control work is done by the computers but still in traditional organizations manual control mechanisms are still prevalent. Controls are the way in which an operator gives his instructions to his machine. Control used for continuous adjustment could be rotary or reciprocating in form. Cranks, hand wheels and knobs are of the rotary type while 'joysticks' and levers are of the reciprocating form. Levers usually give controls in one dimension and joysticks in two dimensions but both types of controls do give speed and accuracy. Controls required for discrete movement will usually be of some 'off-on' type of mechanism.

- **Organizational Factors**

Characteristics of Task: - Job design requires the assembly of a number of tasks into a job or a group of jobs. The complexity in a job depends on the number and variety of tasks, or the scope of decisions to be made or the difficulty of predicting the decisions. The internal structure of each task consists of three elements: (i) planning (ii) executing (iii) controlling. The ideal job design is to integrate all the three elements.

Work Flow: - The product manufactured or the service provided helps the firm to decide the decision of work flow. The sequence and balance between jobs should be done correctly if the work is to be done efficiently. After the sequence of jobs is determined, the balance between jobs is established.

Ergonomics: - Every industrial system consists of some or all of the following components: hardware, software, the physical environment and the organization. An objective of the designer is to arrange these components to give a harmonious and efficient operation. An objective of ergonomics

is to match, or provide the information to match, the various parts of the system to the characteristics and abilities of the people involved in it. By utilizing ergonomics, the designer's opportunities to create a system which reliably achieves its function are improved. Ergonomics can be defined as a term used to describe the study of the physical arrangement of the work space together with the tools used to perform a task. Ergonomics does not alter the nature of job tasks but the location of tools, switches and other facilities, keeping in view that the handling of job is the primary consideration.

Work Practices: - Work practices are set ways of performing work determined by time and motion study which determine the standard time needed to complete a given job. This has been covered in detail in next two chapters. A new technique has now emerged, which introduced, could drastically alter the work practices in industrial settings. This technique known as, Maynard Operating Sequence Technique (MOST), uses a standard formula to list the motion sequences ascribed in index values.

- **Environmental Factors**

Temperature and Humidity: - From the time of classical approach to management major stress has been given on the effect of working conditions on the performance and efficiency of employees. Some studies conducted show an increase in accidents both with decrease and increase of temperature from an optimum of 65°F to 69°F, the increase with cold being somewhat greater. Some studies were conducted on people with different age groups and it was concluded that older men are adversely affected by higher temperatures. The scientists have very clearly proved with the help of various experiments that human tolerance to heat increases gradually with the passage of time.

Vibration: - The effect of movement and vibration upon the person may result in motion sickness through slight discomfort or physical damage. Vibration near the tolerable comfort limit if experienced for long periods may harm and also affects person's efficiency as a worker.

Noise: - Any unwanted sound can be considered as noise. It has been proved quite a number of times that individuals who have been exposed to high noise levels over a long period of time suffer a hearing loss. It is thought that people get used to noise without realizing the long term impact. Earplugs and cotton wool can be used as cheap and effective preventive remedy against unavoidable noise. However, noise could be made helpful in increasing productivity in some cases. Some companies introduce music-will-you-work so as to increase output and to improve workers feeling of satisfaction at job.

Visual Environment: - The efficiency with which tasks are carried out are very much determined by lighting arrangements, the standard of lighting and recommended level of illumination at work place. It is proved that at that normal levels of illumination, the ability to see increase in proportion to the logarithm of illumination,(given in lumens per foot, lm/ft) . This implies that after a defined level of illumination the increase in illumination will not affect the productivity of workers. The contrast between the surroundings and the task being performed, the color schemes and the presence or absence of glare drastically influence the overall efficiency and effectiveness of the worker.

Social and Cultural Expectations:- Literacy, knowledge and awareness among workers have changed the workers expectations regarding the jobs .Hence jobs should be such designed that they meet the expectations of workers. Hours of work, holidays, vacations, rest breaks, religious beliefs, management styles and worker sophistication and attitudes are just some of the predictable differences that can affect the job designs across international borders. Failure to consider these expectations can create dissatisfaction, low motivation, hard to fill job opening and a low quality of work life, especially when foreign nationals are involved in the home country or overseas.

4.3 Behavioral Elements in Job Design

- **Degree of Labor Specialization**

From the time of Taylor the debate always exists whether specialization of labor is advantageous or disadvantageous for the organization as well as for the workers. Specialization of labor is two-edged sword of job design**.** On the one hand it has made possible high speed and low cost production, on the other hand, extreme specialization has lead to adverse effects on the worker, like boredom etc. Recent research suggests that the disadvantages dominate the advantages. Though avoiding specialization is risky. The reason, of course, is that people differ in what they want from their work and what they are willing to put into it. Some workers prefer not to make decisions about their work and are simply not capable of performing more complex work. Two popular contemporary approaches are job enrichment and socio technical systems. These two have been discussed in the chapter at different places.

Advantages of specialization to management are following:

i. Training of the workforce is easy.
ii. Recruitment of workers is simple..
iii. High output due to simple and repetitive work.
iv. Substitutability of labor results in lower wages.
v. Close control over workflow and work load.

Advantages of specialization to labor are:

i. Multiple skills are not required.
ii. Uneducated workers can also perform.
iii. Learning the jobs is easy.

Disadvantages of specialization to management are

i. Controlling quality is difficult.
ii. Worker dissatisfaction arising from turnover, absenteeism, tardiness, grievances, intentional disruption of production process.
iii. No one is concerned for the improvement of the process.
iv. Limited flexibility and so creativity of workers is not seen.

Disadvantages of specialization to labor could be

i. Repetitive nature of work results in boredom.
ii. Small contribution to each item results in little gratification.
iii. No control over the work leading to frustration.
iv. As significant learning is not there in the process opportunity to progress is very little.

- **Autonomy**

It is the freedom to control one's responses to the environment. Jobs that give workers authority to make decisions will provide added responsibilities, which tend to increase the employee's sense of recognition and self esteem.

- **Feedback**

Proper feedback given to the employees will inspire the individuals to work on the complete product or on a significant part of it.

4.4 Approaches to Job Design

- **Job Rotation**

Job rotation refers to moving employees from job to job to add variety and reduce boredom by allowing them to perform a variety of tasks. When an activity is no longer challenging, the employee would be moved to another job at the same level that has similar skill requirements. Employees with a wider range of skills give the management more flexibility in scheduling work, adapting to changes and filling vacancies. According to Herzberg, job rotation is merely "substituting one zero for another zero".

- **Job Enlargement**

Job enlargement refers to the expansion of the number of different tasks performed by an employee in a single job. An enlarged job can motivate an individual for five reasons:

(a) Task Variety

(b) Meaningful Work Modules

(c) Ability Utilization

(d) Work-Paced control

(e) Performance Feedback

Although the benefits of job enlargement are several certain disadvantages cannot be ignored. First, training costs tend to rise. Workers may require additional training for their new enlarged tasks. Besides, if the job enlargement program involves breaking up of the existing production line of work systems, redesigning a new system, and training employees to adjust to it, the costs can be substantial. Moreover the productivity may fall during the introduction of new system. Another drawback is that union often argues for increased pay because of the increased workload. Finally even after enlargement many jobs may still be routine and boring. Fredrick Herzberg was right when he said that job enlargement is simply "adding zero to zero", meaning that one set of boring tasks (zero) is simply added to another tasks of boring tasks (zero).

- **Job Enrichment**

Job Enrichment involves adding more motivators to a job to make it more rewarding. Job becomes enriched when it gives job-holder more decision making, planning and controlling powers. First coined by Herzberg in his famous research with motivators and maintenance factors, job enrichment has become a popular concept. According to Herzberg, an enriched job had eight characteristics:

(a) Direct Feedback

(b) Client Relationship

(c) New Learning

(d) Scheduling Own Work

(e) Unique Experience

(f) Control Over Resources

(g) Direct Communication Authority

(h) Personal Accountability

Increased motivation, performance, satisfaction, job involvement and reducing absenteeism. Meet certain psychological needs of job holders help stimulate improvements in other areas of organization. The concept of empowerment is a by-product of job enrichment. Empowering means passing on authority and responsibility. Empowerment occurs when power goes to employees who, then experience a sense of ownership and control over their jobs.

Some Cautions about Job Enrichment

(a) Job Enrichment is Not a Substitute for Good Management.

(b) 'Enriched' is a Relative Term.

(c) Enriching Jobs may create a 'Snowball' Effect.

(d) Job Enrichment Assumes that Workers Want More Responsibility.

(e) Job Enrichment may have Negative Short-run Effect.

(f) Job Enrichment may become Static.

(g) Participation can affect the Enrichment Process.

(h) Change is Difficult to Implement.

4.5 Socio Technical Approach to Job Design

The socio-economic approach emphasizes the need for integrating the social consequences of work with the traditional cost versus quantity consideration of production. The concept of socio-technical system was first elucidated by Eric Trist and his colleagues at the Tavistock Institute of Social Research in London. The approach attempts to develop jobs that adjust the need of the production process technology to the needs of the worker and work group. The social technical approach has been applied in many countries- often under the heading of "autonomous work groups", "Japanese style work groups", or employee involvement teams. The American manufacturing companies use work teams as the building block of employee involvement teams.

The individual or work group requires a logically integrated pattern of work activities that comprise the following job design principles:

1. Task variety: An optimal variety of tasks within each job should be provided. The optimal level is one that allows the employee to rest from a high level of attention or effort while working on another task or, conversely, to stretch after periods of routine activity.
2. Skill Variety: Research suggests that employee derive satisfaction from using a number of skill levels.
3. Feedback: fast feedback aids the learning process.
4. Task Identity: Whenever possible, a group or individual employee should have responsibility for a set of task that is clearly defined, visible and meaningful.
5. Task Autonomy: Employees should be able to exercise some control over their work.

4.6 Contemporary Issues in Job Design

- **Telecommuting**

Two of every three fortune 500 companies now use telecommuting. It is the use of microcomputers, networks and other communication technology such as fax machine to do work from

home, which was traditionally done in the workplace. The employees have no contact with other employees, but are able to communicate with them using electronic means. A variant of telecommuting is the virtual office, where employees are in the field selling or serving customers. However, there are problems associated with telecommuting. These include the loss of creativity, as employees are not interacting with other employees on a regular basis.

- **Alternative Work Pattern**

Job sharing is an example of alternative work pattern. It involves two people sharing in a full time job. It can be implemented in several ways:

- Each working a half-day, five days a week.
- Each working two or three full days a week.
- Each working every other week.
- Each working alternate months or season.

Companies that use job sharing are primarily in the legal, advertising and financial services sectors.

- **Techno stress**

Techno Stress is caused by new and advancing technologies, particularly by information technology. For example, the widespread use of electronic bulleting board as a forum for rumors of layoffs may cause feelings of uncertainty and anxiety. It is the stress caused by new and advancing technologies in the workplace.

- **Task Revision**

A new concept in the design of work is task revision. Task revision is an innovative way to modify incorrectly specified role or job. Task revision assumes that organizational roles and job expectation may have been correctly or incorrectly defined. Performance suffers because of deviant behaviors which result from incorrectly defined jobs. Task revision helps correct such incorrectly defined jobs.

- **Knowledge Work**

The emergence of knowledge work has transformed the way of designing works. Work is concerned with firm's intangible assets- human brains. The nature of knowledge work is fundamentally different from the traditional mass production.

4.7 Summary

With the advent of 21st century the conditions at the work and at the organizational level are changing at a very rapid pace. The operations manager's task is more complex and challenging with these changes. Job design is one of those functions which have a great significance. The present chapter talks about all the factors which help in designing the job. Along with organizational, design and environmental factors it also discusses the behavioral considerations. In various approaches to job design, job rotation, job enlargement and job enrichment are discussed. In considering the role of work, operations manger must take a Sociotechnical approach. The chapter ends with a discussion on the recent trends in job design viz. techno stress, knowledge work, etc.

4.8 Key Words

- **Job:** Group of related tasks or activities that need to be performed to meet organizational objectives.
- **Job design:** The determination of specific job tasks and responsibilities, the work environment and work methods.
- **Job Enlargement:** Procedure of redesigning jobs or modifying work content to provide greater stimulus variety, autonomy, task identity and feedback for the worker.
- **Job Rotation:** Movement of the employees into a job for a short period of time and then out again.
- **Job enrichment:** Specialized work is made more interesting by giving the worker a greater variety of tasks or by getting worker involved in planning, organization, and inspection.
- **Specialization of Labor:** Simple, Repetitive jobs are assigned to each worker.
- **Sociotechnical systems:** A philosophy that focuses more on the interaction between technology and the work group. The approach attempts to develop jobs that adjust the production process technology to the needs of the worker of a work group.
- **Ergonomics:** Study of the physical arrangement of the work space together with the tools used to perform a task.
- **Anthropometric data:** Data regarding physical characteristics of human being.

4.9 Self Assessment Test

1. Why might practicing managers and industrial engineers be skeptical about job enrichment and Sociotechnical approaches to job design?
2. What are the differences among job rotation, job enlargement and job enrichment?
3. Explain the factors affecting job design?
4. Which approaches of job design is being followed by organizations in the recent time. Explain taking example of any one company.
5. Define job design. Which decisions are involved in job design.
6. write a note on contemporary issues in job design.
7. Taking examples justify the impact of environmental factors on job design.

4.10 Reference Books

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Unit -5 Operations Standards

Structure

5.0 Objectives

After reading this unit you should be able :

- To realize the significance of productivity in operation standards,
- To understand the concepts of work study,
- To understand the concepts of method study and its relation with work study,
- To realize that the approach is scientific method of decision making,
- To understand that method study as one of the technique of productivity improvement,
- To conduct method study with confidence,
- To realize that the concepts are not restricted to manufacturing industries only.

5.1 Introduction

In contemporary industry, responsibility for developing operations standards in large firms is typically assigned either to a staff department designated methods analysis or to the industrial engineering department. In small firms, this activity is often performed by consulting firms that specialize in work methods. But in both the cases the operations manager of the concerned firm plays the vital role in standardizing the operations as he is having the first hand experience of the different operations taking place in the organization.

5.2 Productivity

The ratio of output produced to the input resources utilized in the production.

The input resources in any productive system are one or more among these four: land, material, machines and men. Over and above the overall measure of productivity, where all the inputs are taken together, there is a need to have partial measures relating output to individual input, in order to pin point the areas of deficiency.

- Two basic variations around the above definition have thus evolved.
- Total productivity is the ratio of the aggregate output to aggregate input.
- Partial productivity is the ratio of the aggregate output to any single input.
- The definition applies for an enterprise, an industry or an economy as a whole.

The basic objectives behind productivity measurement are:

(a) to study performance of a system over time;

(b) to attain a relative comparison of different systems for a given level; and

(c) to compare the actual productivity of a system with it's planned productivity.

From the definition of productivity, it is apparent that a higher total productivity may result, if:

(a) more output is produced with the same or lesser input,

(b) the same output is produced with lesser input, and

(c) more output is produced with more input; the proportional increase in output being more than the increase in input.

In the long term it is only through advance in productivity that employees can hope to obtain an increase in real wages, shareholders an increase in the purchasing power of their dividends, and customers lower real prices. It is equally true that the future economic strength of the nation in a competitive world depends on the management's success in achieving this aim, wherever the provision of goods or services is involved. With the increase in scientific knowledge and development of better management techniques this advance should not only be continuous, but should take place at a ever increasing pace.

Factors affecting productivity :-

- Nature and quality of raw materials
- Basic nature of processes employed
- Amount of plant and equipment employed
- Efficiency of the plant and equipment employed
- Volume, continuity and uniformity of production
- Utilization of manpower

The Six lines of attack :-

To improve productive efficiency, some positive lines of action are :-

(1) Improve basic processes by research and development

(2) Provide more, and improved, physical means of producing

(3) Simplify and improve the product and reduce the variety.

(4) Improve methods of operation

(5) Improve organization, planning and control.

(6) Increase manpower effectiveness at all levels.

5.3 Introduction to Work Study

The objective of the work study is to assist management to obtain the optimum use of the human and material resources available to an organization for the accomplishment of the work upon

which it is engaged. Fundamentally, this objective has three aspects-

(1) The most effective use of plant and equipment

(2) The most effective use of human effort

(3) The evaluation of human work

Work study is one of the major techniques in the group coming to be known as Productivity science. A number of techniques have evalved which help management to create a prescribed output with a reducing input of the three real resources- manpower, materials and capital equipment. Work study, as the name implies, is the study of work: of human work in the deepest sense and dignity of the word, and not merely in the restricted meaning used in physical sciences.

The term 'Work Study' is defined in British Standard 3138:1969 as: 'A management service based on those techniques, particularly, method study and work measurement, which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.'

While the linkage between work study and productivity is apparent from the above, it is not exactly clear as to what makes it different from other productivity raising techniques. So now we examine the two definitions:

- Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.
- Work measurement is 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.

Basic Procedure :

There are eight steps in performing a complete work study .They are:

- Select the job or process to be studied.
- Record from direct observation everything that happens, using the most suitable of the recording techniques, so that the data will be in the most convenient form to be analyzed.
- Examine the recorded facts critically and challenge everything that is done, considering in turn: the purpose of the activity; the place where it is performed; the sequence in which it is done; the person who is doing it; the means by which it is done.
- Develop the most economic method, taking into account all the circumstances.
- Measure the quantity of work involved in the method selected and calculate a standard time for doing it.
- Define a new method and the related time so that it can always be identified.
- Install the new method as agreed standard practice with the time allowed.
- Maintain the new standard practice by proper control procedures.

Steps 1, 2 and 3 occur in every study, whether the technique being used is Method Study or Work Measurement. Step 4 is part of Method Study practice, while step 5 calls for the use of Work Measurement.

Work study is not a substitute for good management and never can be. It is one of the tools in the manager's tool kit. If work study is to contribute seriously to the improvement of productivity,

relations between the management and the workers must be reasonably good, and the workers must have confidence in the sincerity of the management towards them.

5.4 Introduction to Method Study

Method Study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

The objectives of Method Study are:

i. Improvement of processes and procedures.
ii. Improvement in the design of plant and equipment.
iii. Improvement of plant layout.
iv. Improvement in the use of men, materials and machines.
v. Efficient materials handling.
vi. Improvement in the flow of production and processes.
vii. Economy in human effort and the reduction of unnecessary fatigue.
viii. Method standardization.
ix. Improvement in safety standards.
x. Development of a better physical environment.

Procedure

The solution of any problem follows the following sequence of phases in that order:

1. DEFINE the problem.
2. RECORD all the facts relevant to the problem.
3. EXAMINE the facts critically but impartially.
4. CONSIDER the courses of actions (possible solutions) and decide which to follow.
5. IMPLEMENT the solution.
6. FOLLOW UP the development.

We have already discussed the basic procedure for the whole of work study, and work measurement. Let us now examine the basic procedure of method study.

They are as follows:-

(a) SELECT the work to be studied.
(b) RECORD all the relevant fact about the present method by direct observation.
(c) EXAMINE those facts critically and in an ordered sequence, using the techniques best suited to the purpose.
(d) DEVELOP the most practical, economic and effective method, having due regard to all contingent circumstances.
(e) DEFINE the new method so that it can always identify.
(f) INSTAL that methods and standard practice.
(g) MAINTAIN that standard practice by regular routine checks.

5.5 Method Study: Select, Record and Examine

Selection of Job

When a method study investigation of a particular job is carried out, certain factors are kept in mind. These are:-

(1) Economic consideration: The cost of the study, the loss of time due to the investigation, the cost both short-term associated with the prospective changes in the recommended working method of the job should be carefully estimated and examined. If the accumulated estimated benefits from the recommended method outweigh the estimated total cost we should take up the job under study. Discounted Cash Flow Technique (DCF) or Pay-back period method may be used for this purpose. Under preliminary considerations the early job choices are:

Bottlenecks which are holding up other production operations. Movements of material over long distances between shops or operations involving a great deal of man power or where there is repeat handling of material. Operations involving repetitive work using a great deal of labor liable to run for a long time.

(2) Technical considerations: The most important point is to make sure that adequate technical knowledge is available with which to carry out the study. For eg. a) A speed machine tool constituting a bottleneck in production is known to be running at a speed bellow that which the high speed or ceramic cutting tools will operate effectively. Can it be speeded up or is the machine itself not robust enough to take faster cut? This calls for the advice of machine tool expert.

(3) Human reactions: These are among the most important factors to be taken into considerations since mental and emotional reactions to investigations and change of method have to anticipate. Trade union official workers" representatives and the operators themselves should be educated in the general principles and objectives of method study .Participative management may facilitate overcoming the negative human reactions to investigations the changes of method. If, however, the study of a particular job appears to be leading to unrest or ill feeling, leave it alone, however promising it may be from the economic point of view. If other jobs are talked successfully and can be seen by all to benefit of people working on them, opinions will change and it will possible in time, to go back the original choice

The need for record

In order that the activities selected for investigation mat be visualized in their entirety, with a view to improve them by subsequent critical analysis, it is essential to have some means of placing on record all the necessary facts for the existing method. A record is also essential if a "before and after' comparison is to be made to assess the effectiveness of the investigation and the subsequent installation of the new method.

Recording Techniques-

According to the nature of the job studied, and the purpose for which the record is required, the technique chosen will fall into one of the following categories- (1) Charts (for process and time records) (2) Diagrams and models (for path of movement records)

Sometimes more than one technique may have to be used to provide all the necessary information. This information may be obtained by visual observation, by calculation, or by means of a photographic technique. In the case of micro motion studies, elaborate equipment and specialized knowledge may be necessary. The different types of charts and diagrams are-

Charts

Outline process chart	-	principle operations and inspection
Flow process chart	-	activities of men, material, equipment
Two handed process chart	-	activities of worker's two hands
Multiple activity chart	-	activities of men and/or machines on a common time scale
		Simultaneous motion
cycle (sumo) chart	-	activities of worker's hands, legs and other body movements on a common time scale
Travel chart	-	movement of materials between departments.

Diagrams and Models

Flow and string diagram	-	paths of movement of men, materials or equipment
		Two and three
Dimensional models	-	layout of workplace or plant
Cyclegraphs and chrono cyclegraphs	-	high speed, short cycle operations

Examine critically :

The questioning technique

The questioning technique is the means by which the critical examination is conducted, each activity being subjected in turn to a systematic and progressive series of questions. The five sets of activities recorded on the flow process chart fall naturally into two main categories, namely-

- Those in which something is actually happening to the material or workpiece under consideration , i.e. it is being worked upon, moved or examined; and
- Those in which it is not being touched, being either in storage or at a standstill owing to the delay.

Activities in the first category may be subdivided into three groups:

(i) MAKE READY activities required to prepare material or workpiece and set it in position ready to be worked on.

(ii) DO operations in which a change is made in the shape, chemical composition and physical condition of the product.

(iii) PUT AWAY activities during which the work is moved aside from the machine or workplace. The put away activities of one operation may be the make ready activities of the next- as, for example, transport between operations from the degreaser to the cleaning benches. Putting parts into storage, putting letters into an Out tray and inspecting finished parts are other examples.

It will be seen that, while make ready and put away activities may be represented by transport and inspection symbols, do operations can only be represented by operation symbols.

The Primary Questions :-

In the first stage of the questioning technique, the purpose, place, sequence, person, means of every activity recorded is systematically queried and the reason for each reply is sought.

The primary questions are-

PURPOSE -	What is actually done?
	Why is the activity necessary at all?
PLACE-	Where is it being done?
	Why is it done at a particular place?
SEQUENCE-	When is it done?
	Why is it done at a particular time?
PERSONAL -	Who is doing it?
	Why is it done by that particular person?
MEANS-	How is it being done?
	Why is it done in that particular way?

Secondary Questions :-

The secondary questions cover the second stage of questioning technique, during which. The answer to the primary questions are subjected to further query to determine whether possible alternatives to Place, Sequence, Person and / or means are practicable and preferable as a means of improvement upon the existing method. Thus, during this second stage of questioning (having asked already, about every activity recorded, what is done and why is it done), the method study man goes on to enquire: what else might be done? And hence: what should be done? In the same way, the answers already obtained on Place, Sequence, Persons, and Means are subjected to further inquiry.

Combining the two primary questions with the two secondary questions under each of the heading purpose, place, etc, yields the following list, which sets out the questioning technique in full:

PURPOSE:	What is done?
	Why is it done?
	What else might be done?
	What should be done?
PLACE:	Where is it done?
	Why is it done there?
	Where else might be done?
	Where should it be done?
SEQUENCE:	When is it done?
	Why is it done then?
	When might be done?
	When should it be done?
PERSON:	Who does it?
	Why does that person do it?
	Who else might do it?

Who should do it?

MEANS: How is it done?

Why is it done that way?

How else might it be done?

How should it be done?

These questions, in the above sequence, must be asked systematically every time a method study is undertaken. They are the basis of successful method study.

Develop the Improved Method

Once the questions have been answered, it is the job of the method study man to put his findings into practice. The record on the flow process chart is made so that it can be compared with the original method and can be checked to make sure that no point has been overlooked. This will also enable a record to be made in the summary of the total number of activities taking place under both methods, the savings in distance and time which may be expected to accrue from the change and the possible savings in money which will result.

5.6 Method Study: Define, Install and Maintain

Defining the Improved Method :

The Written Standard Practice

It is desirable to prepare a written standard practice, also known as an operative instruction sheet. This serves several purposes:

(a) It records the improved method for future reference, in as much detail as may be necessary.

(b) It can be used to explain the new method to the management, foreman and operatives. It also advises all concerned, including the work engineers, of any new equipment require or of changes needed in the layout of machines or workplaces.

(c) It is an aid to training or retraining operatives and can be used by them for reference until they are fully conversant with the new method.

Three sorts of information will normally be required:

(a) The tools and equipment to be used and the general operating conditions.

(b) A description of the method. The amount of detail required will depend on the nature of the job and the probable volume of production, For a job which will occupy several operatives for several months, the written standard practice may have to be very detailed, going into finger movements.

(c) A diagram of the workplace layout and, possibly, sketches of special tools, jigs or fixtures.

Installing the Improved Method :

The final stages in the basic procedure are perhaps the most difficult of all. It is at this point that active support is required from the management and the trade unions alike. It is here that the personnel qualities of the work study man, his ability to explain clearly and simply what he is trying to do and his gift for getting along with the other people and winning their trust become of the greatest importance.

Installation can be divided into five stages:

- Gaining acceptance of the change by the departmental supervision.
- Gaining approval of the change by the management.
- Gaining acceptance of the change by workers involved and their representatives.
- Restrain the workers to operate the new methods.
- Maintaining close contact with the progress of the job until satisfied that it is running as intended.

Maintaining the New Method

To be maintained, a method must first be clearly defined and specified. This is especially important where it is to be used for setting time standards for incentive or other purpose. Tools, layout and elements of movement must be specified beyond any risk of misinterpretation. The extent to which it is necessary to go into minute details will be determined by the job itself.

5.7 Summary

Productivity is defined as the ratio of output produced to the input resources utilized in the production. It is important to have proper productivity measurement systems in place in order to have an idea about the current productivity levels. The organization can set reasonable goals with respect to increase in productivity and take appropriate steps to achieve them. Methods analysis is a technique which can be applied to a new job design as well as to the improvisations of jobs established earlier by using tools such as flow process chart, employee machine activity chart and various other diagrams and models. The chapter covers the complete process of method study.

5.8 Key Words

- **Productivity:** The ratio of output produced to the input resources utilized in the production.
- **Work Study:** A management service based on those techniques, particularly, method study and wok measurement, which are used in the examination oh human work in all its contexts and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.
- **Method Study:** Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.
- **Flow process chart**: Analyses infestations activities to capture the flows of products through the overall production process.
- **Process chart:** A graphic representation of a sequence of events that occur in the work method, classifying them by symbols according to the nature of the events.
- **SIMO chart:** A chart used to record against a time scale performed by operator.

5.9 Self Assessment Test

1. What is method study? How are flow process charts and diagrams helpful in method study?
2. Define productivity. How can it be measured?
3. Explain the various ways by which productivity of an organization can be improved?

4. Explain the various techniques for recording in method study?
5. Explain the relation between work study and productivity?
6. "Selecting the right job is the most important step in method study." Comment.
7. Give specific applications of various charts covered in the present chapter?

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Unit - 6 Work Measurement

Structure

6.0 Objectives

After reading this unit you shold be able to :

- Understand the concepts of work measurement and its relation with work study.
- Realize that the approach is scientific method of decision making.
- Understand that work measurement is one of the technique of productivity improvement.
- Conduct time studies and work sampling with confidence.
- Realize that the concepts are not restricted to manufacturing industries only.

6.1 Introduction

The measurement of human work has always been a problem for management, as plans for the provision of goods or services to a reliable program and at a predetermined cost are often dependent on the accuracy at which the amount and time of human work involved can be forecast and organized. Work measurement by enabling target times to be set , into which are incorporated rest allowances appropriate to the type of work involved, provides a far more satisfactory basis on which to plan. It has been defined by the British Standards Institution 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."

International Labor organization defines it as "Work measurement is the application of techniques design to establish the time for a qualified worker to carry out a specific job at a defined level of performance."

The fundamental purpose of work measurement is to set time standards for a job. It can also be used for the following purposes:

a) To evaluate a workers performance

b) To plan the work-force needs

c) To determine available capacity

d) To determine price or cost of a product

e) To compare work methods

f) To facilitate operations scheduling

g) To establish wage incentives schemes.

6.2 Procedure for Work Measurement

SELECT- The work under study should be selected.

RECORD - The data related with the methods and the elements of activity is being recorded.

EXAMINE – The step of examination is to be done with the help of recorded data to ensure that the most effective method and motions are being used and the unproductive and foreign elements are separated from the productive elements.

MEASURE - The quantity of work involved in each element is to be measured in terms of time, using the appropriate work measurement technique.

COMPILE - The standard time for operation will include time allowances to cover relaxation, personal needs, etc.

DEFINE - the series of activities and method of operation for which the time has been compiled is to be defined precisely. After this time is considered as standard for the activities and methods specified.

6.3 Work Measurement Techniques

For the purpose of work measurement, work may be regarded as repetitive or non repetitive. When the main operation or the group of operations repeats continuously during the work time, the work is considered to be repetitive for example, light press work jobs. Types of maintenance and construction work in which hardly the job is repeated may be considered as non repetitive work.

British Standard 3138:1969; define the following techniques of work measurement-

Time Study : A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions, and for analyzing the data so as to determine the time necessary for carrying out the job at a defined level of performance.

Synthesis : A work measurement technique for building up the time for a job or parts of job at a defined level of performance by totaling element times obtained previously from time studies on other jobs containing the elements concerned , or from synthetic data.

Predetermined Motion Time System PMTS : A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and under the conditions in which it is made) are used to build up the time for the job at a defined level of performance.

Analytical Estimating : A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elementsconcerend and partly from synthetic data.

Comparative Estimating : A work measurement technique in which the time for a job is evaluated by comparing the work in it with the work in a series of similar jobs – benchmarks- the work content of which has been measured. The arranging of jobs into broad bands of time is referred to as slotting.

Estimating : A means of assessing the time required to carry out work, based on knowledge and experience of similar types of work, without a detailed breakdown of the work into elements and their corresponding times at a defined level of performance.

Activity Sampling : A work measurement technique in which a large number of observations are made at random intervals over a specified period of time of a group of machines, processes and workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity or delay of the measure of the percentage of time during which that delay occurs.

Rated Activity Sampling : An extension of activity sampling in which rating is applied so that , where the frequency is known, work content may be established in addition to the proportion of time occupied by other activities or delays.

6.4 Work Sampling

The origin of this technique is LHC Tippet. He used the method of 'snap reading' for determining the causes of loom stoppages in Textile factories in 1935 while working for the British Cotton Industry research Institute. Since then, the technique has been successfully applied in many different situations under such names as Ratio Delay Study, Random Observation Method, Observation ratio Study, Activity Sampling and work sampling.

Work sampling is defined as a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.

Work Sampling Procedure :-

1. Define the problem - It is essential to state the main objective, purpose or goal of the project or problem. This would provide a frame of reference and help place a limit on the costs for the study to secure the desired results. It is better to identify what group of people and/or machines is to be studied, what sub groups are to be included and what accuracy is desired from the study and which other agencies must benefit from the results of the work sampling.
2. Preliminary survey of work activities- A good deal of public relations effort might be called for at this stage. The person making the study must be familiar with the activities of the subjects being considered.
3. Activity Classification- The procedure of breaking of activities is indicated by the problem definition. There is no rule to specify the levels of breakdown.
4. Design of necessary forms for recording study data- the different forms of observation sheets are to be considered. For every study a unique observation form is designed.
5. Develop properly randomized times of observation- A single observation consists of an instantaneous operation in order to determine the state in which it is defined. The times of observation for any given sampling must be selected without bias. The selection is done using random numbers which are taken from random tables.
6. Select and Train Observers – The proper selection of observers is must for a good work sampling. The observers should be trained to get an understanding of study rules and specific

limitations. The observers should be trained such that he objectively records explicitly instant snapshot observation. All clarifications should be sort out and solved before actually conducting the final study.

7. Estimate Number of Observations- The tradeoff is required between the sample size to be taken and the accuracy level required of the study. The confidence level chosen is usually 95% and the desired accuracy level will range from 1% to 10%.

Determination of sample size :-

The work sampling technique is similar to the technique applicable in inferential statistics where conclusion about the proportion 'P' in a large population is to be drawn after observing the proportion 'p´' in a suitably selected sample of size 'n' from a large population. How far the actual proportion 'P' may 'p´' is found in a sample size 'n' can be answered by finding a suitable indicator for measuring the sampling variations. These variations are given by the sampling error which is

$$ó = ? p (1-p)/ n$$

Errors in Work Sampling :-

(a) Observational Error- This is due to the presence and behavior of the observer, the observed and/or the environment in which the observations are made. Further, the study is made on the finite period of time, and the period may not be representative.

(b) Experimental Error- Due to finite number of random observations on a specified activity, an experimental error is introduced which is a measure of the sampling variations in terms of the standard error of proportion.

Applications of work sampling are :-

1. Ratio delay to determine the activity time percentage for personnel or equipment.
2. Performance measurement to develop a performance index for workers. This is useful for periodic performance evaluation.
3. Time standards to obtain the standard time for a task.
4. For manpower planning
5. For safety performance.
6. For assisting in engineering economy studies.

6.5 Time Study

Time study is the original technique of work measurement and it is concerned with the direct observation of work while it is being performed. An important feature of time study is the way in which the accuracy of the results obtained improves as the number of occasions upon which the operation is observed increases. ILO defines time study as -

"Time study is defined as a work measurement technique for recording the times and rates for working for the element of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at the defined level of performance."

The following are the essentials for the time study of any job-

1. An accurate specification of where the job begins and where it ends, and of the method by which it is to be carried out, including details of material, equipment, conditions, etc.

2. A system of recording the actual times taken by workers to do the job while under observation.
3. A clear concept of what is meant by standard rate of working.
4. A means of assessing the amount of rest which should be associated with the job.

Standard rate of working- Standard performance results when the work in a job is done at ideal degree of effectiveness and the appropriate relaxation allowance is taken in full. While neither the worker nor the amount of work which will make him no more than reasonably tired are definable in a strictly scientific sense, it has been found that , in the long run , standard performance can be maintained throughout the year without over exertion and consequent detriment to health. A scale has therefore been fixed giving this ideal of effectiveness a value of 100. The 100 is designated as the standard rate of working./ observers are trained to be able to recognize the conditions of standard rate of working, and to assess to the nearest five points the degree to which a worker's observed speed and effectiveness vary from the '100' concept. The procedure in which this assessment is noted simultaneously with the observed time is known as rating.

Breaking Task into Elements

It is found in practice that a worker's rates of working may vary not only from cycle to cycle of a job, but frequently also within each cycle itself. As this would make it difficult to make an overall rating for the period of the study, or even a separate rating for each cycle, it is customary before starting a time study to break down into what are called elements all jobs but those having a very short cycle time. Breaking the job down into elements it is essential that they should each be clearly distinguishable. Observation of the following principles will be of assistance-

1. Separate elements which are identical from those which are variable in the work they comprise.
2. Separate heavy work from light work.
3. When convenient use audible points in the work.

The elements are classified into eight broad groups; a repetitive element; an occasional element; a constant element; a variable element; a manual element; a machine element; a governing element; a foreign element.

Factors Effecting Ratings –

Variations in actual times for a particular element may be due to factors outside or within the control of the worker. Those outside his control may be-

(1) Variations in the quality or other characteristics of the material used, although they may be within the prescribed tolerance limits.

(2) Changes in the operating efficiency of tools or equipment within their useful life.

(3) Minor and unavoidable changes in methods or conditions of operation.

(4) Variations in the mental attention necessary for the performance of certain elements.

(5) Changes in climatic and other surrounding conditions.

Factors within his control may be-

- Acceptable variations in the quality of the product.
- Variations due to his ability.

- Variations due to his attitude of mind, especially towards the organization.

Basic Steps in Time Study :-

The following eight steps constitute the time study process excluding the selections of the job for the worker which have to be done before the steps:

(a) Obtaining and recording all the available information about the job, operator and the surrounding conditions likely to affect the execution of the work.

(b) Recording the complete description of the method, breaking down the operation into 'elements'.

(c) Examining the detailed breakdown to ensure the most effective method and motions are being used and determining sample size.

(d) Measuring with a time device (most commonly a stop-watch) and recording the time taken by the operator for each 'element' of the operation.

(e) At the same time, assessing the effective speed of working the operator relative to the observer's concept of the rate corresponding to standard rating.

(f) Extending observed time to "basic times".

(g) Determining the allowances to be made over and above the basic time for the operation.

(h) Determining the "standard time" for the operation.

Time Study Equipment

The equipment logistic support required to carry out time study activity basically belongs to two groups. The first group represent those which are to be used at site, i.e., during the data collection. Such a set of equipment which is essential, are:

i. A stop-watch

ii. A study board, and

iii. Documentation.

While the second group of equipment, representing those which are used as supplementary ones, usually not carried to the site always, includes:

i. A small calculator

ii. A reliable clock with seconds hand

iii. Set of measuring instruments such tape, steel rule, micrometer, spring balance and tachometer (to measure rational speed) and such other items relevant to and useful for the particular type of work being measured.

(a) The Stop-Watch

Usually three types of stop-watches are used for performing time study:

i. The flyback time

ii. The non-flyback time

iii. The split hand stop-watch type.

However the first two types are used for a large majority of cases.

(b) The Study Board

A study board is used to hold the time study observation record sheets during the study. It

should be made so as to give a good surface for writing without being large enough to interfere with observation of the worker being studied.

(c) Documentation

The documentation reflects the responsibility the work study officer brings to his job. Long experience and practice suggest that five documents are necessary- (1) Element Breakdown and Work Content, sometimes termed as Set Up Sheet; (2) Study Summary, sometimes called as Study Summary Record; (3) Time Study Observation Record which has been entitled as Observation record; (4) Time Study Analysis and (5) Standard Time.

The first, Element Breakdown and Work Content, uses both sides of the sheet; the others use only one side. Work Sampling compared to time study-

Work sampling offers some advantages-

1. Several work sampling studies may be conducted simultaneously by one observer.
2. The observer need not be a trained analyst unless the purpose of the study is to determine a time standard.
3. No timing devices are required.
4. Work of a long cycle time may be studied with fewer observer hours.
5. The duration of the study is longer, which minimizes effect of short period variations.
6. The study may be temporarily delayed at any time with little effect.
7. Because work sampling needs only instantaneous observations, the operator has less chance to influence the findings by changing his or her work method.

6.6 Predetermined Time Standards

One more approach to work measurement was created with the publication of the idea of basic human motions termed as 'therbligs' given by Gilbreth. In 1927 A B Segur put forward the idea that within practical limits the time required by all experts to perform true fundamental motions would be a constant. If these constants could be determined the measurements would at least be consistent. So, predetermined time standard is a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a definite level of performance. PTS systems are techniques for synthesizing operation times from the standard time data for basic elementary motions comprising the operation. The five elementary operations reach, grasp, move position and release in different forms of feasible combinations represent a large number of operations. In a PTS system one time is indicated for the basic elementary motions irrespective of where it is performed. Further the PTS systems which avoid both rating and direct observations invariably lead to more consistent standard times arrived at relative to their counterpart. PTS systems are usually simple, easy to apply and are very fast particularly for operation shaving very short repetitive times. Due to the various advantages this system has been accepted by different industries all over the world.

The existence of a very large number and a variety of systems often results in confusion which is further increased by the fact that many of such systems are of a proprietary nature. Another point of criticism is that PTS systems fail to recognize the effect of the influence of the immediate

predecessor and follow a basic elementary motion, on the time indicated as standard time for the intervening basic elementary motion. Direction of motion like downwards, upwards, clockwise, anti- clockwise, away from body and near to body also influence the duration of basic motions but are not considered in PTS. The last point of criticism is that even with most of advanced PTS system it would not be possible to obtain 100% coverage of all operations carried out in any organization.

PTS systems can be applied either through direct observation of the motions used by the worker or through mental visualization of the motions required to accomplish a new or alternative work method. This method is particularly suited to situations where direct observations may not be possible or it may be some entirely new method of working which, however, is composed of work of basic elements which are standard with a new combination or mix. It is suited to both repetitive as well as non repetitive work.

6.7 Work Study Applications

The fields of application of the work study that are most highly developed at the present time are-

(a) Incentive Schemes : Because standard times enable jobs of differing type and duration to be expressed in terms of the same denomination, they provide an exceptionally useful basis for the operation of a system of payment by results. The availability of the work specification for use as the contract between management and worker in this connecion is particularly convenient, since it establishes precisely the conditions under which a job is to be performed as well as the method to be employed. In the event of a change in either or both of these it can be a routine matter to determine the extent and efeect on the work content or standard times and make the necessary adjustments. From the worker's point of view the ability to calculate bonus earnings is important. Incentives scheme of these type have the added advantage that there is every encouragement for workers to pay attention to delays and record waiting time, thus making it apparent to management when and where action may be necessary to prevent their recurrence.

(b) Labor Control : Measurement of work is essential in order to deploy, and record the effectiveness of labor. By proper analysis of deviation from standards, the true causes and extents of losses are disclosed and supervision can see what action, if any, should be taken to improve labor utilization and performance. Further more, the greater confidence thereby is generated by the removal of frustration for the men and the doubt regarding performance. It results in improving labor relations.

(c) Materials Handling : Material handling concerns the movement of both material and people throughout complex concern- raw materials, components between the various activities, finished products, materials for maintenance and scrap. Activities can be broadly classified in to two headings- process operations and handling operations. Work study is, in effect, the tool which has been developed to analyze and measure these operations and thereby devise ways and means of increasing productivity. In this form of analysis, process operations, referred to in work study as "do" operations, are the first to be considered because if these are changed in nature and sequence, combined or eliminated at any point, the associated handling and movement operations are at once affected.

(d) Planning : The techniques which have developed in to modern work study were evolved to meet the need for a more accurate knowledge of two fundamental planning requirements- the methods to be adopted to achieve specified objectives, and the time required to carry out such methods

(e) Plant and Product Design : The following targets are aimed at in the application of work study to design a new plant or project or modify and extend the existing one- (i) shorten project time; (ii) reduce capital and operating cost; (iii) ensure efficient maintenance;(iv) reduce alterations;(v) improve quality of design;(vi) reconomize technical man power. The work study techniques used to help achieve these aims are all based on work measurement and method study, but adapted to the particular needs of designer.

6.8 Summary

The prime objective of any organization is to reduce cost and increase profit. These twin objectives can only be achieved if the work system is such designed that it increases productivity. The chapter covers work measurement part of work study in detail. The three basic techniques of work measurement viz. work sampling, time study and predetermined time standard are explained and their processes are discussed with applications. Work study applications show that the technique can be effectively applied to a large variety of situations; it is just not limited to the manufacturing system.

6.9 Key Words

- **Allowed Time :** The leveled time as well as the allowances for fatigue and delays.
- **Standard Time :** Calculated by taking the normal time and adding allowances for personal needs, unavoidable work delays and worker fatigue.
- **Work Measurement :** 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.
- **Time Study :** It is a work measurement technique for recording the times and rates for working for the element of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at the defined level of performance.
- **Work Sampling :** a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.
- **Predetermined Time Standards:** a work measurement technique in which, times established for basic human motions are used to build up the time for a job at a definite level of performance.
- **Work Cycle:** the complete sequence of the elements necessary to perform a specified activity to yield a unit of production.

6.10 Self Assessment Test

1. Compare work sampling and time study?
2. Write the various applications of work measurement in management?
3. Comment-:

(a) "It's best that our workers don't know that they are being time studied. That way, they can't complain about us getting in the way when we set time standards."

(b) "Rhythm is fine for dancing, but it has no place on the shop floor."

4. Write the merits and demerits of PTS?
5. Explain the procedure for work sampling?
6. How will you determine sample size in work sampling?
7. Write a note on equipments used in time study?

6.11 Reference Books

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Unit - 07 Inventory Management: Models And Systems

Structure:

7.0 Objectives

After completion of this unit, you should be able to :

- Achieve a trade -off between the conflicting consideration of holding higher inventory and lower inventory.
- Optimize the firm's investment in inventory striking a balance between cost of holding inventory and stock-out costs.
- Ensure adequate maintenance of supplies of raw material, stores and spares and finished goods so as to maintain production levels and meet the varying requirements of the customer.
- Understand the effective control over the inventory, their purchase, use, store, etc. with clear accountability.
- Learn about various types of inventory models.
- Minimize/prevent loss due to deterioration, obsolescence, pilferage, theft,etc.

7.1 Introduction

The term 'inventory' refers to the stock pile of the product which a firm is offering for sale and the components that are essential for the product.

There are three types of inventories (1) Raw materials, (2) Work in Process (Semi-finished goods) and (3) Finished goods.

Raw materials are inputs, which are purchased by the firm from the others and are converted in to the final product through production (manufacturing) department.

The Work –in-process is also called stock-in-process, refers to partially or semi-finished goods at the various stage of production in the multi stage production process.

Finished goods represent final or completed product, which are available for sale. The inventory of such goods consists of items that have been produced but are yet to be sold.

While manufacturing firms generally hold all three types of inventories, distribution firms hold mostly finished goods. Inventories generally represent the second largest asset category for manufacturing companies, next only to plant and equipment. Given substantial investment in inventories, the importance of inventory management cannot be overemphasized.

Inventory as a current asset, differs from other current assets because it is not finance manager alone who are involved here. Rather, all the functional areas in finance, marketing, production, and purchasing are involved. Yet, as investment management has important financial implications, the financial manager has the responsibility to ensure that inventories are properly monitored and controlled. He has to emphasize the financial point of view and initiate programmes with the participation and involvement of others for effective management of inventories

Inventory Management involves an interface between all the departments along the productive distributive channel of the firm. It involves reconciling the interest of the different departments involved in the production distribution function. For example the Purchase department in order to benefit from the economies of scale indulges in bulk buying which may cause overstocking of raw material. whereas the production department would always want sufficient inventory of Work –In – progress for unhindered production output maximization.Similarly, the marketing department with its objective of maximization of sales and would focus on maximization investment in the finished goods, investment as it enables the firm to exploit to opportunity any sudden increase in demand. The role of finance department is significant, it not only reconciles the varied goal of the purchase, production, and marketing department in inventory investment, it also looks at inventory management from the broader perspective of share holder's wealth maximization.

The objective of inventory management is primarily to achieve a trade off between the conflicting consideration of holding higher inventory and lower inventory. The issue of optimal investment in inventory is decided in the light of incremental gains from inventory investments and the incremental costs of holding inventory management.

7.2 Motives for Holding Inventory

Specifically there are three motives for holding inventory:

Transaction Motive: A firm is required to maintain inventory on regular basis in order tofacilitate the smooth and uninterrupted production and sales operations. Due to the time lag present between the placement of order and its receipt, an optimum amount of inventory is always required to be maintained by the organization.

Precautionary Motive: Apart from holding stock for regular transactions, an organization is required to hold the inventory to meet the sudden changes in demand and supply forces like delay in supply of material due to strike, transport, short supply etc. Similarly, demand for finished goods of seasonal nature may increase suddenly. Therefore, company is required to maintain a sufficient supply in the

form of inventory.

Speculative Motive: The Company may like to purchase and stock the inventory in the quantity which is more than needed for production and sales purpose. This may be with the intention to get advantage in term of quantity discounts connected with bulk purchasing or anticipating price rise.

7.3 Objectives of Inventory Management

The main objective of inventory management is to achieve maximum efficient in production and sales with the minimum investment in inventory. The other objectives are as follows-

- To ensure the availability of supply of raw material, stores and spares, Work-in process, and finished goods to maintain production levels and meet various requirements of the customers.
- To minimize loss due to deterioration, obsolescence, pilferage, theft etc.
- To maintain investment in inventory at optimum level striking a balance between cost of holding inventory and stock out costs.
- To ensure effective and full utilization of storage capacity and other facilities related to inventory holding.
- To have effective control over in inventory purchase, uses, storage etc.
- To provide basis for short term and long term plan.
- To improve the customer service needs adequately.

7.4 Principles of Inventory Management:

The underlying principles that govern inventory management are-

Principle of efficient business operations- Firm should always maintain that level of inventories, which is adequate for ensuring uninterrupted business operations. Inventory holding takes place at the different stage of operations, therefore higher the investment in the inventory, shows the stronger possibility of the firm to absorb supply and demand shock due to uncertain market conditions. However the increased inventory slow down inventory turnover, moreover increasing the risk of obsolesecence,change in technology should also take into account.

Principle of cost minimization-The inventory levels must be adequate and not excessive as the funds blocked in the inventory ties with the cost. These funds can be put to other alternative uses. Firms tries to minimize the cost of holding inventory (carrying cost) without affecting smooth operating. Various innovative techniques purchaser-vendor –based inventory management, improvements in the supply chain, outsourcing etc. are used to minimize inventory holding. Although reduced investment in inventory saves funds but there is always a risk of delay in production and supply, due to inadequate level of inventory, which may result in loss of sales for the firm. Therefore, as the firm increases its level of inventory, the risk of running out of inventory is lessened but cost of holding inventory (carrying cost) increases. Thus, deciding the optimum level of inventory investment assumes significant. That is why Reorder point and inventory control are two points given attention in inventory management.

Activity :-

1. What are the motives to hold inventory?
2. What are the main components in inventory?
3. What are the objectives of effective management of inventory?

7.5 Inventory Related Problems and Solutions

Following table focuses on some key problem areas and their probable solutions related to inventory management. Right from the stage of procurement of raw material and its usage in production to stocking of finished goods in ware house the store keeper encounters numerous situations. Order size of the material poses a major problem area as it may lead to the overstocking and under stocking of inventory resulting in resulting in unnecessary blockage of funds in inventory or loss of sales respectively.

S.No.	Inventory Related Problems	Solution
1.	Overstocking and under stocking	Max. and Min. Level, Re-order Quantity
2.	Order quantity problem	EOQ, EOQ (Qty. Discount
3.	Stock out Problem	Safety Stocks
4.	Classification problem to determine the type of control required	ABC, VED etc.

7.6 Setting Inventory Levels

Setting inventory levels or proper inventory management requires achievement of balances between inventory carrying cost and ability to adequately meet demand. Extreme levels of inventory –too high or too low are not desirable. High levels of inventory enhance the firm's capacity to meet demand, but also result in high carrying cost. Too little inventories, resulting in lower carrying cost, increase the opportunity cost of being out of stock and increase customer dissatisfaction. The decision to keep the level of inventory of **raw material** at particular level is taken after considering a number of factors. They can briefly be stated as under-

- Nature of the product/raw material, If perishable ,or subject to deterioration in quality or obsolescence; less will be stored.
- Availability –if seasonal, bulk purchase may be made.
- Rate of consumption in production.
- Cost-higher the cash move will be controlled and lesser quantity will be stored.
- Lead time-time taken for purchase order to materialize.
- Storage Cost, Insurance Cost, Economic Order Quantity, Govt. Restrictions if any, fluctuations in price.
- Availability of credit from suppliers.

Work-in –Progress is based on the production cycle. More inventories in stock may be stuck up in work –in –progress due to production bottlenecks .Investment in WIP can be reduced by removing, bottlenecks and adopting a production process of shorter duration.

Finished Goods storage determined by-Nature of demand-seasonal and production plan, credit policy of the firm, competition and demand for the product. For effective control, different levels of inventories are determined.

7.6.1 Reorder Level :

This level is between minimum and maximum levels, such that before the material ordered is

received into stores, there is sufficient quantity in hand to cover with normal and abnormal consumption situation. It is the level at which order for replenishment of stock should be placed.

Re-order Level = Maximum reorder period x Maximum usage Or = Minimum level + (Average Rate of consumption x Average time to Obtain fresh supplies.

Under the assumption that the replenishment is made instantaneously (Lead Time =0), the relationship between the quantity of inventory used along a time with the time period takes the form as shown in Fig.1

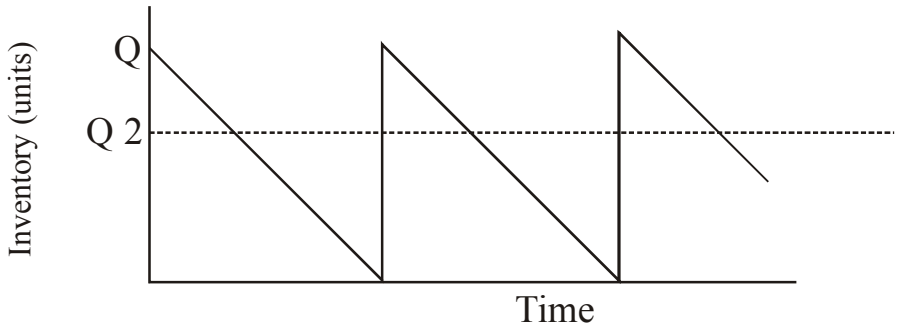


Figure:1

7.6.2 Maximum Level :

It indicates maximum level of inventory quantity held in stock at any time. This is the limit beyond which the stock of an item should not exceed. Fixation of maximum level is governed by following considerations:

1. Its reorder levels. The reorder itself depends on the maximum rate of consumption and maximum delivery period.
2. Minimum consumption and minimum delivery period for each inventory item.
3. The economic order quantity
4. The availability of funds, storage, space, government regulations, nature of items and their price per unit are also important.
5. For imported material since of their irregular supply. The maximum level should be high.

The main purpose in fixing maximum level is to control investments in inventories.

Maximum level of inventory = Reorder level + Reorder quantiy - (Minimum Consumption x Minimum reorder period)

7.6.3 Minimum Level:

It indicates the lowest level of inventory which must be maintained in hand at all times, so that there is no stoppage of production due to non-availability of inventory. This is the limit below which the stock should not be allowed to fall.

Main consideration for fixation of minimum level of inventory-

1. Information about maximum consumption and maximum delivery period in respect of each item to determine its reorder level.
2. Average rate of consumption for each inventory item.

3. Average delivery period for each item.

Average delivery period= ½ (Maximum Period+ Minimum Period)

Minimum level of inventory = Reorder level - (Average rate of consumption x Average time of inventory delivery)

Sufficient margin will be built into the minimum level to take care of increase in consumption or delay in delivery. Longer the lead time (delivery period) and higher the fluctuation in the delivery schedule of the supplies, higher will be the minimum level. The level will be kept as low as possible in case of it being subject to obsolescence and high value items.

7.6.4 Average Level:

This level indicates the average stock which is required to be maintained in the store house. This is generally, taken as the average of the maximum and the minimum stock level.

Now, Average inventory level = Minimum level+1/2 Re-order quantity

Or

$$= \frac{\text{Maximum level} + \text{minimum level}}{2}$$

7.6.5 Danger Level

Generally the stock level is not allowed to fall below the minimum level, but in special circumstances it may fall below this level. Danger level is the level at which normal issues of raw material inventory are stopped and emergency issues are only made. The storekeeper should take immediate action to replenish the stock in case the inventory reaches to danger level.

Danger Level = Average consumption x lead time for emergency purchases

Example 1 : Two components X and Y are used as follows-

Normal Usage-200 units/week

Maximum Usage-250 units/week

Minimum Usage-150 units/week

Re order quantity- X=600 Y=1000

Re order Period- X= 4 to 6 weeks

Y= 2 to 4 weeks

Calculate -1. Reorder level

2. Minimum level

3. Maximum level

4. Average stock level

Solution: 1. Reorder level = Maximum usage/week X Maximum Delivery period

Re order level for X = 250X 6 =1500 units

Re order level for Y= 250X 4 =1000 units

2. Minimum level = Reorder level-(Normal Usage X Average Period)

$$\frac{\text{Minimum level for X} = 1500 - 150 \text{ X } 4 + 6}{2} = 750 \text{ units}$$

$$\text{Minimum level for Y} = \frac{1000 - 150 \text{ X } 2 + 4}{2} = 550 \text{ units}$$

3. Maximum level= Reorder level + Reorder quantity –(Minimum consumption x Minimum reorder period)

Maximum level for X = (1500+600) – (150X 4)

2100 - 600 = 1500 units

Maximum level for Y = (1000+1000) – (150X 2)

2000 - 300 = 1700 units

4. Average Stock level = 1/2 (Minimum stock level + Maximum stock level)

X = 1/2 (750 + 1500)

= 1125 units

Y = 1/2 (550+1700)

= 1125 units

7.7 Economic Order Quantity (EOQ)

The quantity of inventory to be ordered and the timing of order are the underlying issues that need to be resolved to arrive at the optimal level of inventory. Therefore, it involves a tradeoff between profitability and liquidity. The two questions that the inventory theory related are-

(a) How much should be ordered? (b) When should be ordered?

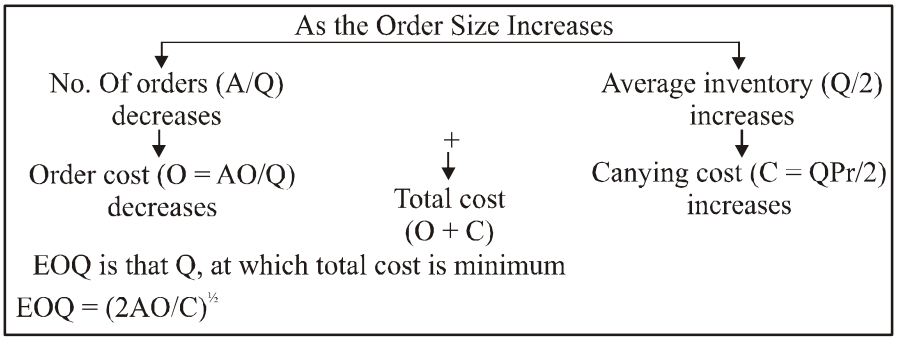
First question, how much, arises due to the presence of ordering costs and other issues which depend on the frequency of order. The smaller the order size, more orders will be placed and consequently the more the ordering costs.

The second question confronts with the when to order, arises due to supply side uncertainties.

7.7.1 What is EOQ?

Economic order Quantity (EOQ) is the order size for some particular inventory item that results in lowest total inventory cost for the period. It refers to the lot size of inventory that is most economical to procure and hold.

Total inventory cost consists of inventory ordering cost and inventory carrying cost. An EOQ may be computed for each inventory item. EOQ assumes that the relevant costs of inventory can be divided into order cost and carrying costs.(The model excludes the actual cost of the inventory) Each of them has certain key components and characteristics.



Inventory Carrying cost – The carrying cost is the cost of maintenance of inventory in the company's warehouse. It is also known as holding cost and has two parts-

(a) The cost related with physically carrying and handling inventories. Such as –Warehouse rent

- Cost of insurance of inventory
- Cost of handling, inspection and supervision of inventory
- Cost of spoilage, obsolescence and deterioration
- Cost of theft, shrinkage and damages

(b) Financial cost of funds tied up in the inventory which is the cost of alternative investment.

Relationship between the carrying Cost and EOQ :

Larger the order size	Higher is the carrying cost due to high average inventory.
Smaller the order size	Lower is the carrying cost due to low average inventory.
Eg : The annual requirement is 20000 units. If order size is 10000 units; carrying cost = ? If order size is 5000 units; carrying cost = ? If the carrying cost per unit per annum is Rs. 5, Price per unit is Rs. 50, Calculate the carrying cost in both cases. Carrying Cost = Average order size x Carrying cost per unit per annum.	

Total carrying cost increases as inventory increase. It has a positive correlation with the level of inventory.

Inventory Ordering cost:

Cost which is incurred at the time of placing an order is called Ordering cost. These costs are also known as ordering cost or setup cost. These costs are as follows-

- Cost of writing and placing an order
- Cost of processing of order
- Cost of follow up with the vendor
- Cost of receiving new shipment
- Cost of acquiring recent price quotations

Larger the order size	Lower is the ordering cost due to less no. of orders.
Smaller the order size	Higher the ordering cost because of more orders
Eg : The annual requirement is 20000 units. If order size is 10000 units; n = ? If order size is 5000 units; n = ? If the cost per order is Rs. 50 calculate the ordering cost in both cases. Ordering Cost = No. of orders × cost per order	

7.7.2 Assumptions of EOQ

The model rests on the following assumptions:

a. There is a known constant demand

b. Ordering costs are known and remain constant.

c. Carrying costs are known and remain constant

d. Production and inventory capacity is unlimited.

7.7.3 Methods to Compute EOQ

Trial & Error

This method requires computing the total inventory cost at various order size. Eventually the EOQ can be found or closely approximated by repeating the computation. The limitation of this method is time consuming.

A	Annual usage (in units)			
B	Order size (Rs.)			
C	No. of orders (A/B)			
D	Cost per order			
E	Total ordering cost (C × D)			
F	Average inventory (B/2)			
G	CC per unit per annum			
H	Total carrying cost (F × G)			
I	Total of ordering cost & CC (E + H)			
J	Total purchase price (A × purchase price per unit)			
K	Total cost (I + J)			

Formula Method :

Optimum order size can be calculated mathematically using the Economic Order Quantity (EOQ) formula method. Each method yields the optimum order quantity with a single set of calculations. The models is-

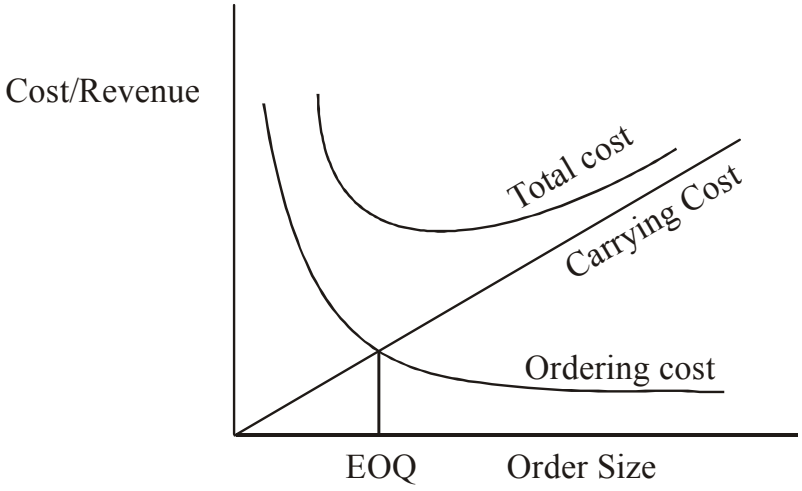
$$EOQ = \sqrt{\frac{2AO}{C}}$$

Where, A = Annual demand in Units

O = Ordering cost per order

C = Carrying cost per unit per period

Graphical Method : Both costs are depicted on graph. The EOQ is a point at which both ordering costs and carrying costs are equal. At this point the Total cost of inventory shall be lowest. Hence,



this is the most economical quantity that combining the carrying and ordering costs shows that total inventory cost decrease up to a point with the increase in inventory. Beyond the EOQ point, total inventory cost increase with increasing inventory. This method also lacks precision.

7.7.4 Modified EOQ (for varying unit prices-discount on bulk purchases)

Many Suppliers encourage their buyers to place large orders by offering them quantity discounts. With quantity discounts the firm saves on its purchase price per unit but has to order more than its EOQ size. This will reduce the number of orders but will increase the average inventory holding. Thus the firm saves an amount equal to the discount available and reduction in ordering cost, but incurs additional carrying costs. The net incremental benefits are equal to the difference between the additional savings and additional costs. If the net difference is positive, the order size should be equal to the quantity necessary to avail the discount and if negative its order size should be equal to EOQ.

Steps for incremental cost benefit Analysis:

- Calculate Q* (EOQ) without considering the discount and compare it with the minimum order size Q' for utilizing discounta.

a. if Q* > Q', then EOQ remains valid.

b. If Q*< Q', then incremental analysis is to be done whether to avail discount or not.

- **Incremental analysisa.**

a. incremental benefits:

- Discount available = AD
- Savings in ordering cost due to decrease in no.of order = [(A/Q*) - (A/Q')]x O
- Total incremental benefits = AD + [(A/Q*) - (A/Q')]x O

b. Incremental carrying costs:

- Carrying cost at Q* = Q*PC/ 2
- Carrying cost at Q' = Q'(P-D)C/ 2
- Incremental carrying cost = CC at Q' – CC at Q*

c. Net incremental benefits = incremental benefits – incremental costs

d. Decision: If net benefits are positive, EOQ= Q' and one should avail the bulk discount.

Inflation and EOQ :

Buying in anticipation of price increase :

Cost : added carrying cost of inventory

Benefits : buying inventores at low price

Increased carrying cost :

Interest rates move up due to incrrease in inflation, as a result carrying cost of inventory increases. Therefore under the conditions of inflation here is a decline in EOQ

Example -2 A unit manufacturing plastic container consumes 50 units of molded plastic daily. The firm operates the total of 240 business days a year.The current cost of acquisition is 60 Rs. per container and carrying cost for the firm 20% of unit cost. The firm has to bear Rs.500 per order when

it places an order. The selling price is Rs. 95 per unit. Compute the optimal inventory level for the year ahead using EOQ model.

Solution:

Annual Demand A = 50 x 240 = 12,000 units

Cost of Order O = Rs. 500 per order

Carrying Cost C= 20% × Rs. 60 = Rs. 12 Per order

Hence, EOQ(Q) = $\frac{\sqrt{2}\times 1200\times 500}{60\times .2} = 1000\,units$

Thus, the firm will be able to minimize its total cost if it places oder for 1000 units (EOQ).

Number of Order = $\frac{A}{EOQ} = \frac{12{,}000\,\text{units}}{1{,}000\,\text{units/order}} = 12\,\text{order}$

Order Cost = $\frac{N\times O}{EOQ} = \frac{12\times 500}{1{,}000} = \text{Rs.}6{,}000$

Carrying cost is function of average amount of inventory on hand multiplied by the carrying cost rate.

Average Inventory = $\frac{EOQ}{2} = 500$

Carrying cost = $\frac{EOQ}{2}\times C = \frac{1000}{2}\times 60\times 0.2 = \text{Rs. } 6{,}000$

At the EOQ, the cost of ordering for the period (RS. 6,000) equals the carrying cost for the period (Rs. 6,000).

The result given by the EOQ model can be cross checked using Trial and Error \Iterative Process for determining optimum inventory level.

Schedule of Inventory costs at various order sizes

A	Annual usage (in units)	12000	12000	12000	12000	12000	12000	12000
B	Order size (Rs.)	400	600	800	1000	1200	1400	1600
C	No. of orders (A/B)	30	20	15	12	10	8.6	7.5
D	Cost per order	500	500	500	500	500	500	500
E	Total ordering cost (C ×D)	15000	10000	7500	6000	5000	4300	3750
F	Average inventory (B/2)	200	300	400	500	600	700	800
G	CC per unit per annum	12	12	12	12	12	12	12
H	Total carrying cost (F × G)	2400	3600	4800	6000	7200	8400	9600
I	Total of ordering cost & CC (E + H)	17400	13600	12300	12000	12200	12700	13350
J	Total purchase price (A × purchase price per unit)	1140000	1140000	1140000	1140000	1140000	1140000	1140000
K	Total cost (I + J)	1157400	1153600	1152300	1152000	1152200	1156500	1153350

It is evident from the table in example that total cost is higher at any order quantity .other than 1000 units. Thus the result from the iterative process matches with that achieved using the EOQ model. The above statement also shows that total inventory cost is least at order size of 1,000. Any order size other than EOQ level yields a higher total Inventory cost..

7.8 Economic Batch Quantity (EBQ)

Economic Batch Quantity:

- The two costs involved are:

a. Set up cost: it is fixed in nature and is incurred at the beginning of each production run

b. Inventory carrying cost

- Cost Behavior:

Larger the size of production run-

- Lower will be the set up cost
- Higher will be the inventory carrying cost.
- Optimum production size:

It is that level at which total cost is minimum or we can say that at this level, the two cost will be equal.

$EPQ = (2UP/S)^{1/2}$

Where,

U= annual (monthly) output

P= Set up cost per production run

S= Carrying cost per unit per annum (month)

Activity	
Given the answers in true of false	
1	Inventory management is the subject matter of finance department only
2	Inventory carrying cost is directly proportional to the level inventory.
3	If the carrying cost of inventory is more than stock out cost, the company should produce and keep an inventory.
4	In danger level of inventory only emergency issue of raw material made.
5	At the point of EOQ. invnetory carrying cost and inventory ordering cost are equal.

7.9 Safety Stock

The reorder point has been determined under the situation of certainty. However, it may not be so in reality. In practice, uncertainty is likely to exist with respect to delivery times, production cost rates, sales rates. Due to strikes, delayed supply of raw materials or usage increases unexpectedly, a stock out is likely to occur. To reduce the likelihood of stock out, firms hold, safety stock, additional inventory over and above prescribed by the EOQ.

Safety stock is an additional level of inventory intended to enhance the firm to continue to meet demand in case sales level turn out to be higher then predictive and in case there are unexpected delays in either receiving raw material or in producing goods.

If we incorporate uncertainty in the reorder point formula become as follows-

Reorder point = Lead time × Average usage + safety stock

Determining the optimal level of funds to be blocked in safety stock assumes importance, since the holding of safety stock is imminent. It is important to note that having safety stock does not eliminate the possibility of stock out. The safety stock is intended to give a known probability of a stock out.

Inventory Stock out Cost:

This type of cost is the cost of being out of stock. Such cost occurs when the firms has the shortage of finished goods inventory. It is also known as back order cost. Following costs are included in these costs, such as-

- Cost of lost sales
- Cost of inefficient production
- Penalty cost for late completion of the contract
- Cost of substituting more expensive raw material
- Loss of goodwill due to poor customer service.

This cost varies inversely with the inventory level .Firms control these cost by procuring safety stock and maintain it. The relationship of carrying cost and stock out cost is helpful to determine the inventory level, whether the firm has over production or under production. If the carrying cost of inventory is less than stock out cost ,the company should over produce and keep an inventory.

Activity

Fill in the blanks

1 _____ is the point, at which the firm should place an order to replenish the invoentory.

2 If annual demand is 12,000 units, order cost is Rs. 90 per order and inventory carry cost is Rs. 15 per annum. The EOQ will be _____.

3 In the situation of uncertainty, a firm keeps ____ to meet unexpected demand.

4 The formula of maximum level of inventory is _____

5 Inventory ordering cost increases with the _____ in the per order invenoty level.

7.10 Inventory Systems

There are two inventory systems, namely

- Periodic inventory system
- Perpetual inventory system

Periodic Inventory System:

Under this system the quantity and value of inventory is ascertained on the basis of actual physical count or measure or weight of all the inventory items in hand at the end of specific period. This system does not facilitate continuous stock taking. The cost of material issued is calculated as:

Cost of Material issued = Opening Inventory + Purchases – Closing Inventory

Perpetual Inventory System:

Under this system the value of inventory is ascertained after every receipt and issue. This system facilitates regular checking and obviates closing down for stock taking. The objective of perpetual inventory system is to provide a continuous quantitative – cum- value record of receipts, issues and balances of each item of stores followed by continuous stock taking.

Activity
1. What is periodic and perpetual system of holding inventory?
2. Differentiate between periodic and perpetual system of inventory.

7.11 Inventory Control Systems

Application of inventory control system is imperative for effective inventory management. There are several inventory systems adopted by the organization based on their need. The two major factors determining the choice of inventory control system are size of the business and its nature. The common inventory control systems in vogue are discussed below:

Double Bin System:

Bin refers to a rack, an almirah or space wherein inventory is kept. A separate bin is maintained for each item of inventory and is assigned an identification number. Bin system is generally maintained by small organizations.

- Under double Bin System each bin is divided into two parts namely the smaller part and the larger part.
- Smaller part is used to store the inventory equal to the minimum level or sometimes equal to the re ordering level and the larger part is used to store the remaining quantity.
- Once the inventory in the larger part is used an order is made and meanwhile inventory in the smaller part is used.
- On receipt of fresh supply of inventory, the inventory used from the smaller part is replaced from the fresh receipts.

Smaller Part	Minimum Stock Level or Reorder Level
Larger Part	Remaining Inventory

Double Bin System

ABC Inventory Control System:

In case of large firms inventories maintained are not uniform in terms of value and number. Therefore, it is not desirable to keep the same level of control on all the items of inventory. For the purpose of effective control mechanism, firm needs to classify inventory based upon the investment

required and efforts to be made in controlling them. ABC Analysis measures the proportion of each item of inventory in the total inventory in terms of its value. ABC Analysis is also known as Control by Importance and Exception (CIE) and Proportional Value Analysis (PVA)

- This technique is based on the assumption that the firm should not exercise the same degree of control on all the items of inventory.
- More rigorous control is required on the items that are (i) the most costly and (ii) the slowest turning.
- On the basis of cost involved , inventory items are categorized into

  - A: involves large investment, are less in number hence requires rigorous control. To avoid overstocking and shortage, the stock of material is controlled by fixing maximum, minimum and reorders levels.

  - B: involves small investment, are large in number hence requires minimum control.

  - C: stands midway, deserves less attention than A but more than C

Practical Steps involved in ABC Analysis:

Step 1: Classify the items of inventory on the basis of their expected use. Determine their units and price per unit.

Step 2: Calculate the total value of each item (units x price per unit)

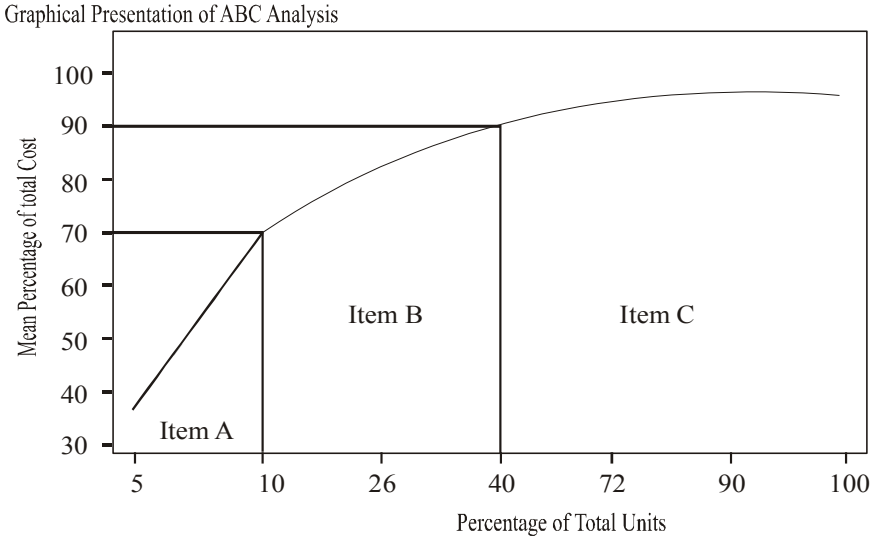
Step 3: Rank and arrange the items in descending order of their value.

Step 4: Compute the proportion of each item of inventory in the total inventory in terms of number and value.

Step 5: Categorize the items on the basis of their relative value into A, B and C.

Following table indicates that 'item A' forms the minimum proportion (10%) of the total units of inventory, but represents the highest in term of value ie 70%. On the other hand 'Item C' represents more than half the total number of inventory and is merely 10% in terms of investment required. No strict control is therefore required in case of 'Item C'

Group	Number of items (%)	Inventory Value (%)
A	10-20	70-50
B	20-30	20-30
C	70 – 50	10-20



Just In Time (JIT) Inventory Control System:

Just In time (JIT) system of inventory management gained popularity from Japan. It is one of the important components of Total Quality Management (TQM). In a JIT system, inventory is not maintained. Material, manufacturing parts and other components are ordered as and when the need arise and arrives at the site just before few hours they are put into use. Successful implementation of JIT ensures savings in warehousing cost, the cost of deterioration and the cost of funds blocked in inventory. Implementing JIT is not a very easy task. It requires perfect synchronization between the delivery of material and manufacturing cycle. The relationship between the supplier and the manufacturer also has a crucial role to play in terms of timing of delivery and quality of the material. Delay in delivery of material or substandard quality supply may result in stoppage of production. This system creates lot of pressure on the manufacturer as well as the supplier and demand for a strong supply chain management.

VED Inventory Control System:

VED analysis is based on the criticality of an item. "V" is for vital items without which an Organization cannot function, "E" for essential items without which an organization can function but may affect the quality of the services and "D" stands for desirable items, unavailability of which will not interfere with functioning.

The vital items are stocked in abundance; essential items are stocked in medium amounts, and desirable items we stocked in small amounts. By stocking the items in order of priority, vital and essential items are always in stock which means a minimum disruption in the services offered to the people.

VED Analysis is generally used in Service industry like Hospitals.

Computer based Inventory Control Systems:

With the increasing business size and the nature of work , more and more companies have now started using computerized systems to control their inventory. A computerized system of inventory is an automatic system of taking an account for the flow of inventory. The computer system is programed to identify the various levels of inventory like the maximum level, minimum level and the reorder level. As soon as the inventory reaches any of the above threshold limits the computer program notifies the same and the store keeper/ operator may take necessary action to replenish the same. In case of large departmental stores / retail stores computerized systems for inventory are must. In some advanced cases, computer system of buyer and suppliers are linked. As soon as the supplier's computer receives order from the buyer's computer, the supply process is activated.

Outsourcing Inventory:

Outsourcing inventory means procuring parts and components from outside rather than manufacturing them internally. Outsourcing decision involves cost benefit analysis to be undertaken.

Stock Turnover Ratio:

- It is control technique
- Gives the relationship between cost of material consumed and average stock held.
- Formula:
- Cost of Material Consumed during the year
- Cost of average stock held during the year

- Where, Cost of material consumed = Opening stock+ Purchases – Closing stock
- Average Stock = ½ (opening stock + closing stock)
- Inventory holding period = 365/ Inventory turnover
- It indicates the speed with which the inventory is consumed.
- A too high and a too low ratio is a matter of concern.
- A satisfactory level of inventory should be maintained.(Intra firm comparison and inter firm comparison)

Nature of stock	Meaning	Stock turnover ratio
Fast Moving Stock	Stock in great demand	Very High
Slow Moving Stock	Stock in low demand	Low
Dormant Stock	Stock having no demand at present	Too low
Obsolete Stock	Stock no longer in demand	Too low

7.12 Summary

Inventory forms a major component in the total current assets of the company, especially in the manufacturing companies. There are three motives of holding inventory namely, transaction, speculation and precautionary motives. The main objective of inventory management is to achieve maximum efficiency in production and sales with the minimum investment in inventory. Three types of costs are involved in management of inventory:

(i) Ordering cost,

(ii) Carrying cost, and

(iii) Stock out cost. The firm should try to minimize its total cost of holding inventory by ordering at EOQ. EOQ occurs at the point where the total cost is minimum (ordering+carrying cost) is minimum. Setting inventory levels enable the store keeper to know the maximum and minimum level of stock required to be maintained at all times. The stock level at which the firm places an order to replenish the inventory is known as reorder level or reorder point. Under perfect certainty reorder point is equal to Lead time x Usage rate. Under uncertain conditions, a firm has to maintain a safety stock which serves as a cushion to meet contingencies. Reorder point under such conditions is calculated as safety stock + lead time x usage rate. There are two systems of keeping the record of inventory; period system and the perpetual system. A firm which carries a number of items of inventory that differs in value may follow a selective approach such as ABC analysis in managing its inventory. There are many other techniques like JIT, VED and computerized system of managing inventories.

7.13 Key Words:

- ABC Analysis
- Carrying Cost
- Economic Production
- Quantity
- Economic Order Quantity
- Lead Time

- Maximum Level
- Ordering Costs
- Re order point
- Safety Stock
- Set up Cost

7.14 Student Activity:

Select any two manufacturing organizations from any sector and compare their inventory management process.

7.15 Self-Assessment Test

1. Describe the objectives of inventory management and discuss its relevance in in different types of organizations.
2. Enumerate and discuss different types of cost associated with inventory management.
3. "There are two extreme dangerous situations that management should avoid in controlling inventories." Explain.
4. Explain and illustrate the EOQ model with the help of graph. Also examine the relationship between risk and cost with respect to inventories.

Practical Problems:

5. The average annual consumption of a material is 18,250 units at a price of Rs. 36.50 per unit. the storage cost is 20% on an average inventory. Ordering cost is Rs. 50. How much quantity is to be purchased at a time?Ans. 500 Units
6. A company buys its requirement of 36000 units in 6 installments. Each unit costs Re. 1 and the ordering cost is Rs. 25. The inventory carrying cost is estimated at 20% of unit value. Find the total cost of existing inventory policy. How much money can be saved through EOQ?

   Ans. (a) Rs.750 (b) Savings due to EOQ Rs. 150
7. PQR ltd. Produces a product which has a monthly demand of 52000 units. The product requires a component X which is purchased at Rs. 15 per unit. For every unit of finished output 2 units of component X are required. Order cost is Rs. 350 per order.carrying cost is 12% pa

   Calculate:

   (i) EOQ for component X

   (ii) If the minimum lot size to be supplied is 52000 units, the company has to incurr?

   (iii) What is the minimum carrying cost the company has to incur?

   Ans. (1) 22030 units, (ii) Rs. 55200 (iii) Rs.15545
8. X Ltd. is committed to supply 24000 bearings per annum to Y Ltd. On steady basis. It is estimated that it costs 10 paise as inventory holding cost per bearing per month and set up cost per run of bearing manufacture is Rs., 324.

   - What would be the optimum run size for bearing manufacture?

- Assuming that the company has a policy of manufacturing 6000 bearings per run, how much extra cost would the company be incurring as compared to the optimum run suggested in (a) above?

- What is the minimum inventory holding cost?

Ans. 3600 bearings, Rs. 576 , Rs. 2160

9. Monthly demand of product X – 1500 units

- Input required to produce 1 unit of X: 5 units
- Ordering, receiving and handling cost: Rs. 10 per order
- Trucking cost: Rs. 5 per order
- Deterioration and obsolescence cost: Rs. 10 per unit per annum
- Interest rate: 15% pa
- Storage cost: Rs. 450000 for 90000 units
- Purchase price of component: Rs.100
- Calculate EOQ.

Ans. 300 units

7.16 References

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Unit – 8 Materials Requirement Planning

Structure

8.0 Objectives

After studying this unit you should be able to understand :

- The Concept of Material Requirement Planning
- The History and Scope of MRP
- MRP planning systems
- MRP Systems Inputs and outputs
- Disadvantages and Advantages
- Problems of MRP

8.1 Introduction

Material management is the detailed study of complete material flow process of firm. The American Production and Inventory Control Society defines materials management as "the grouping of management functions supporting the complete cycle of material flow from the purchase and internal control of production materials to the planning and control of work-in-process to the warehousing, shipping and distribution of finished products." Materials management helps operations managers assess the requirements of materials at various stages of production process and maintain control over the firm's production and distribution functions.

The scope of materials management is broad, as it considers the entire flow of materials in and out of an organization. Its scope can be viewed in two contexts – trouble avoidance and opportunistic. Managers in any organization are worried if the materials function does not perform

well. The proper management of materials enables smooth operation of the firm's functions. Moreover the proper management and control of materials leads to reduction in production costs and inventory levels, coupled with an increase in the efficiency of production. Therefore, materials management can be viewed as an opportunistic tool to improve a firm's profits.

The responsibilities of materials managers include activities like determining the materials requirements at various stages of the production process, procuring materials in the most effective and economic manner, and receiving and storing them safely.

8.2 Materials Requirement Planning

Materials Requirement Planning (MRP) is both an inventory control and a scheduling technique. It consists of a series of steps which start by determining what finished products are needed to meet the demand by time periods and are completed with a schedule of the finished product components needed at each assembly level for each timePeriod.

Material requirements planning (MRP) is a production planning and inventory control system used to manage manufacturing processes. Most MRP systems are software-based, while it is possible to conduct MRP by hand as well.

Material Requirements Planning (MRP) uses the MPS as a starting point and computes derived demands for all components required for the production of the end products. The planning data used are the bill-of-materials structure (BOM structure, Gozinto structure), the current inventory status (including planned receipts) and planned lead times. Within this planning step lot sizes are computed under the assumption that infinite capacity is available. Result of these computations is planned production quantities.

Conventional Inventory Systems are based on –

1. ABC Classification
2. Reorder Models
3. Safety Stock
4. EOQ

An MRP system is intended to simultaneously meet three objectives:

- Ensure materials and products are available for production and delivery to customers.
- Maintain the lowest possible level of inventory.
- Plan manufacturing activities, delivery schedules and purchasing activities.

In project situation and Batch production the demand is not uniform but discrete. As the demand is clearly known and so also the time frame, it is also known as 'Time-phased requirements planning." MRP is based on concepts like,

1. Independent versus Dependent demand
2. Lumpy demand
3. Lead times
4. Common use items

The use of computer has helped MRP to gain the popularity because the numerous calculations for the product explosion are readily handled with the direct access capability of the disc systems.

The on-line capabilities of computers is another reason for the increased interest, in MRP.

MRP systems are appropriate for dependent demand items. Dependent demand means the demand for an item is directly related to or the result of demand for "higher level" items. Thus, while the demand for the final product may be continuous and independent, the demand for lower-level, subordinate items composing the product tend to be discrete, derived and dependent. Dependent demand items need not be forecasted, but are calculated by the MRP system from the Master Schedule.

The key features of an MRP system are the time phasing requirements, generation of lower-level requirements, planned order releases and rescheduling capability. Planned Order releases indicate when orders should be placed by purchasing and manufacturing

Activity.

Based on the demand for the end product, MRP system disassembles the end product into component parts and subassemblies. MRP is a backward scheduling process that estimates requirement of materials starting with the date of requirement and working backward to estimate date of receipt keeping in view production and waiting time, and estimating date of order based on delivery lead time.

An MRP system helps in coordinating orders from external and internal sources. External orders are referred to as purchase orders and internal orders are referred to as jobs. The system studies the future production requirements and disassembles the end product into required amount of raw materials parts, subassemblies and assemblies required in each time bucket (time period) of the planning horizon. It then determines the existing level of inventories for each item and the required order quantities. Finally a schedule is generated that specifies the time when the items are required. This schedule takes into consideration the time when each item is needed in production, the lead times available for procuring the items etc... This ensures the availability of parts and materials exactly when they are required in the production process. Ideally, an MRP system aims at replenishing the material stocks when they are required. But in real world situations, this may not be feasible. As a result, the MRP system regularly examines the production schedule to identify schedule disruptions and adjusts the material flow to reduce the levels of in-process inventories. Decisions regarding the installation of the MRP system and the features required in the system depend on the type of production and the time considerations in delivering the products to meet the market demand.

8.3 History of Materials Requirement Planning

Prior to MRP and before computers dominated the industry, reorder-point/reorder-quantity (ROP/ROQ) type methods like EOQ had been used in manufacturing and inventory management. In the 1960s, Joseph Orlicky studied the TOYOTA Manufacturing Program and developed Material Requirements Planning (MRP), and Oliver Wight and George Plossl then developed MRP into manufacturing resource planning (MRP II).[1]. Orlicky's book is entitled *The New Way of Life in Production and Inventory Management* (1975). By 1975, MRP was implemented in 150 companies. This number had grown to about 8,000 by 1981. In the 1980s, Joe Orlicky's MRP evolved into Oliver Wight's manufacturing resource planning (MRP II) which brings master scheduling, rough-cut capacity planning, capacity requirements planning and other concepts to classical MRP. By 1989, MRP II software sold to about one third of the software industry was American industry ($1.2 billion worth of software).

8.4 Scope of MRP in manufacturing

The basic function of MRP system includes inventory control, bill of material processing and elementary scheduling. MRP helps organizations to maintain low inventory levels. It is used to plan manufacturing, purchasing and delivering activities. "Manufacturing organizations, whatever their products, face the same daily practical problem - that customers want products to be available in a shorter time than it takes to make them. This means that some level of planning is required."

Companies need to control the types and quantities of materials they purchase, plan which products are to be produced and in what quantities and ensure that they are able to meet current and future customer demand, all at the lowest possible cost. Making a bad decision in any of these areas will make the company lose money. A few examples are given below:

- If a company purchases insufficient quantities of an item used in manufacturing, or the wrong item, they may be unable to meet contracts to supply products by the agreed date.
- If a company purchases excessive quantities of an item, money is being wasted - the excess quantity ties up cash while it remains as stock and may never even be used at all. However, some purchased items will have a minimum quantity that must be met, therefore, purchasing excess is necessary.
- Beginning production of an order at the wrong time can cause customer deadlines to be missed.

MRP is a tool to deal with these problems. It provides answers for several questions:

- *What* items are required?
- *How many* are required?
- *When* are they required?

MRP can be applied both to items that are purchased from outside suppliers and to sub-assemblies, produced internally, that are components of more complex items.

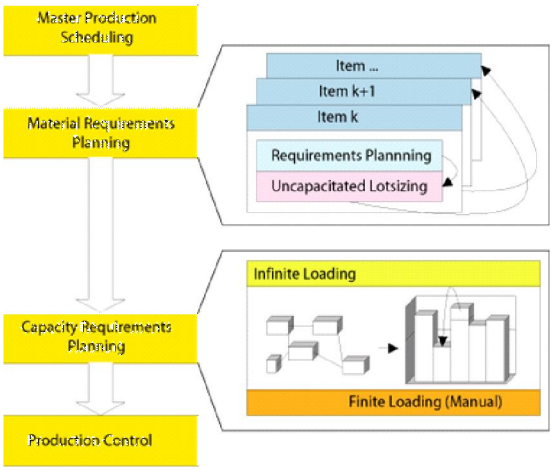
The data that must be considered include:

- The *end item* (or items) being created. This is sometimes called Independent Demand or Level "0 on BOM (Bill of materials).
- How much is required at a time.
- When the quantities are required to meet demand.
- Shelf life of stored materials.
- Inventory status records. Records of *net* materials *available* for use already in stock (on hand) and materials on order from suppliers.
- Bills of materials. Details of the materials, components and sub-assemblies required to make each product.
- Planning Data. This includes all the restraints and directions to produce the end items. This includes such items as: Routings, Labor and Machine Standards, Quality and Testing Standards, Pull/Work Cell and Push commands, Lot sizing techniques (i.e. Fixed Lot Size, Lot-For-Lot, and Economic Order Quantity), Scrap Percentages, and other inputs.

8.5 Is MRP a Planning System?

The MRP (Material Requirements Planning) concept exists since the 60s of the last century. It is the basis for most software systems supporting production planning and control in industrial practice. Most of these so-called MRP systems provide good assistance for order processing, data handling and inventory book-keeping, but they do not support planning.

A typical MRP system follows a successive planning concept, as depicted in the following figure.



Master Production Scheduling :- Based on existing customer orders and a medium-term aggregate production plan Master Production Scheduling (MPS) prepares a short-term production plan for end or rather main products. The planning result is the Master Production Schedule, which is commonly referred to as the MPS.

Capacity Requirements Planning :- Next, for each operation required to make the products the planned starting time and ending time are computed with the help of standard project planning algorithms, such as the Critical Path Method (CPM). Again, capacities of the resources are neglected (infinite loading). Following this planning step, the capacity requirements resulting from infinite loading are tabulated and graphed. Usually the comparison with the available capacities shows that the production plan developed so far is infeasible.

This is the point in time when adjustment of the production plan by the human planner comes into play. Usually based on experience, the planner tries to shift operations on the time axis in order to generate a feasible production schedule. If this is not possible due to conflicts between the resource requirements of different operations, the capacity is extended by overtime, if possible. In general, a human does not have the capability to solve this complicated combinatorial optimization problem, which is a variant of the so-called Resource-Constrained Project Planning Problem (RCPSP).

Production Control :- For the upcoming short-term planning horizon production schedules are released and assigned to the resources. For each resource orders are scheduled with the help of simple priority rules.

8.6 MRP System Information Processing

After the collection of requisite data from the bills of material, the inventory records file and the master production schedule, the data is entered into a computer program where it is processed, and the production and inventory requirements are generated. MRP system uses information from product structure file and lead-time information to develop purchase and production schedule for the

component, so that the materials are available exactly when they are required in the production process. The Steps are:

Step 1- Explosion

Step 2- Netting

Step 3- Offsetting

(1) Explosion : The first step in the MRP information processing is that of explosion, in which end product is disassembled into components required for its production. It starts with the time when the product is required and then proceeds backward to determine each production or purchasing activity that is necessary to make each higher level item in the product structure chart. Explosions use the information from MPS and BOM to generate the sequence followed to produce the end product.

(2) Netting : The next step in MRP information processing is to develop a materials requirements plan for each item in the BOM file for each time bucket. The system first identifies the gross product requirement from the master production schedule. It then calculates the net product requirements by subtracting the available units of the item and the quantity on order from gross product requirement.

Net Requirement = Gross Requirement – On hand space inventory – Quantity on order. In case both on hand inventory and quantity on order are zero, then the net requirement is equal to the gross requirement.

(3) Offsetting : The system then uses the information obtained from explosion and netting process to determine planned order releases, ie, the quantities to be ordered so that the materials arrive just when they are needed. The planned order releases for the finished product or component becomes the gross product requirement for items at the next lower level in the product structure chart.

8.7 Steps in MRP

STEP 1: Determine the Gross Requirement.
STEP 2: Determine the Nett Requirements.
Net Requirements = Gross requirements – Available Inventory.
STEP 3: Develop the Master Schedule.
STEP 4: Explode the Bill of Materials.
STEP 5: Screen for ABC items.
STEP 6: Determine net requirements for an item.
STEP 7: Adjust requirements by Scrap or Shrinkage factor.
STEP 8: Schedule planned orders.
STEP 9: Explode the next level.
STEP 10: Aggregate Demands and Determine Order Quantity.
STEP 11: Write and place the planned orders.

8.8 Where to Use MRP ?

MRP is the most useful scheduling technique for many industries engaged in fabricating and assembling products like automobiles, tractor-trailer equipments, Rail coaches, etc. It is especially suitable for situations where one or all of the following conditions exist:

(a) The final product is complex and made up of several levels of assemblies.

(b) The final product is expensive.

(c) The lead times for components and raw materials are relatively long.

(d) The manufacturing cycle is long for the finished product.

(e) Consolidation of requirements for several products is desirable so that economic lot Sizes are applicable.

The MRP seeks to achieve the following objectives in a simultaneous manner:-

(i) Ensure the availability of materials, components and products for planned production and for customer delivery.

(ii) Maintain the lowest possible levels of Inventory.

(iii) Plan manufacturing activities, delivery schedules and purchasing activities.

MRP systems are appropriate for dependent demand items. Dependent demand means the demand for an item is directly related to or the result of demand for "higher level "items. Thus, while the demand for the final product may be continuous and independent, the demand for lower-level, subordinate items composing the product tend to be discrete, derived and dependent. Dependent demand items need not be forecasted, but are calculated by the MRP system from the Master Schedule.

The key features of an MRP system are the time phasing requirements, generation of lower-level requirements, planned order releases and rescheduling capability. Planned Order releases indicate when orders should be placed by purchasing and manufacturing

8.9 MRP System Inputs & Outputs

Inputs :-

- Inputs of an MRP system include master production schedule, bills of material and inventory records file.
- Master Production Schedule – The Master production schedule file contains information about when and how many units of finished products are required. It also contains information about the available cumulative lead-time for purchasing, receiving, fabricating and assembling. This information is derived from an aggregate production plan and is based on demand forecasts. Based on this information form MPS, MRP system generates a replenishment plan for items needed in the production of the final product. The time horizon in the MPS is divided into time buckets. Managers can use shorter time buckets such as a day or two to plan short term requirements and longer time buckets such as a fortnight or a month to plan long-term requirements. However the most frequently set period for practical purpose is about a week. MRP system based planning is based on the assumption that production capacity is sufficient to produce everything on or before the pre-designated dates given in the MPS. To make the schedule feasible, operations managers run the MRP program repeatedly, each time making some changes in the master production schedule, lead times, or material requirement, until the schedule attains feasibility.
- Bills of Material: The Bills of Material (BOM) contain the list of materials along with the quantity required to produce one unit of a product. The BOM file shows the hierarchical levels or phases a product goes through during production. It consists of the complete list of

all end products, the structure of the products and the quantity of each item required for producing each higher-level item in the product hierarchy. It also contains information about whether a particular item was produced internally or purchased from external sources. The Purchase or production lead time to acquire the item is also mentioned. The file is also referred to as the product structure file or indented parts list.

- Inventory Record Files: In a typical production organization that uses MRP, many items (often ranging in thousands) are purchased, withdrawn from stock, moved to other departments of distribution outlets, processed and assembled. Sometimes system for all inventory transactions. these items do not reach their intended locations in time or items received are defective or rejected. All these issues complicate the task of inventory management and necessitate an effective filing system for all inventory transactions. The inventory records file is a computerized file with a complete record of each material held in the inventory. It contains information about inventory levels- levels at the beginning of the planning horizon and the details of the expected arrivals of inventory during that period. It also contains information about vendors like their names and addresses and the time required for supplying materials, parts, etc... Organizations hold some components and parts as end products that are supplied to customers as replacement parts or spare parts. These parts are not included in the MPS, as they have no role in the production process. They are recorded directly into the inventory records file, and become a part of the MRP system. Though accuracy is important for all the elements of the MRP system it is most crucial for the inventory records file. For instance, if an organization by mistake, does not record the removal of an item from stock, it may alter schedule considering the out-of-stock components. This would lead to inconsistencies in the future schedule.

Outputs :-

There are two outputs and a variety of messages/reports:

- Output 1 is the "Recommended Production Schedule" which lays out a detailed schedule of the required minimum start and completion dates, with quantities, for each step of the Routing and Bill of Material required to satisfy the demand from the Master Production Schedule (MPS).
- Output 2 is the "Recommended Purchasing Schedule". This lays out both the dates that the purchased items should be received into the facility and the dates that the Purchase orders, or Blanket Order Release should occur to match the production schedules.

Messages and Reports:

- Purchase orders. An order to a supplier to provide materials.
- Reschedule notices. These *recommend* cancelling, increasing, delaying or speeding up existing orders.
- Primary Reports : Primary reports are the main reports that are used in inventory and production control.
- Planned Orders: It is a simple report that defines the quantity of inventory required in a specific time bucket. It includes information about all inventory requirements during the planning period. Examples : Inventory forecasts, purchase commitment report and long range materials requirement planning information.

- Order Releases: These documents empower the purchase department to procure a specific quantity of inventory items required within a specific period.
- Changes in due date : These reports are generated to revise purchase orders if the orders are not completed on time. These reports include revision in delivery periods and order quantities. They also contain information based on which orders can be advanced, delayed, suspended, or canceled if needed.
- Cancellation or Suspension : These reports are generated when the order is to be canceled or suspended because of changes in the MPS.
- Secondary Reports : These are optional reports that assist operations managers in assessing the performance of the inventory management system.
- Exceptions Reports : Exception reports contain information about errors, late or overdue orders, or any other deviations from the normal planned objectives. Exception reports are automatically generated whenever actual delivery of parts, sub-assemblies, etc. differs from the planned schedule.

Note that the *outputs* are *recommended*. Due to a variety of changing conditions in companies, since the last MRP / ERP system Re-Generation, the recommended outputs need to be reviewed by *trained* people to group orders for benefits in set-up or freight savings. These actions are beyond the linear calculations of the MRP computer software.

8.10 Advantages and Disadvantages of MRP system

MRP is a comprehensive system used for planning and scheduling and materials requirement. It assists in improving the materials handling capability of the organization. But it has certain disadvantages. Some of the advantages and disadvantages of MRP have been discussed below :

Advantages – Some of the key benefits that can be derived from using an MRP system are :

- Reduced per unit cost of production thus enabling an organization to price its products competitively.
- Low inventory levels, especially for in-process materials
- Better response to market demand
- Better customer service
- Reduced set-up and tear-down costs
- Comprehensive material tracking and optimized production scheduling
- Improvement in capacity allocation and planning

Disadvantages : Following are the disadvantages of an MRP system

- High costs and technical complexities in implementation. In addition, organizations which use an MRP system need to spend considerable effort on installing necessary equipment (computers), training personnel, modifying the software to serve their specific needs, validating, testing, and eliminating possible errors, and maintaining the software.
- The time required for planning and implementing an MRP system is generally very long.
- Data entry and file maintenance requires considerable inputs in the form of training and education of the personnel.

- Dependence on forecast values and estimated lead-time can sometimes be misleading.

The implementation of an MRP system can be effective only when there is a high degree of accuracy in the organization's operations. It requires high commitment from the top management of an organization. The management should educate its executives on the importance of MRP as a strategic planning tool. The success of an MRP system, like that of any other system depends on proper implementation and right application. MRP needs enormous human efforts and care in continuously collecting the required information for the system. However, many organizations prefer to adopt MRP systems, as the advantages of the system outweigh its disadvantages

8.11 Problems with MRP systems

- Integrity of the data : If there are any errors in the inventory data, the bill of materials (commonly referred to as 'BOM') data, or the master production schedule, then the outputted data will also be incorrect. Most vendors of this type of system recommend at least 99% data integrity for the system to give useful results.
- Requirement that the user specify how long it will take to make a product from its component parts (assuming they are all available). Additionally, the system design also assumes that this "lead time" in manufacturing will be the same each time the item is made, without regard to quantity being made, or other items being made simultaneously in the factory.
- Organizing Inventory : A manufacturer may have factories in different cities or even countries. It is no good for an MRP system to say that we do not need to order some material because we have plenty thousands of miles away. The overall ERP system needs to be able to organize inventory and needs by individual factory, and intercommunicate needs in order to enable each factory to redistribute components in order to serve the overall enterprise. This means that other systems in the enterprise need to work properly both before implementing an MRP system, and into the future. For example systems like variety reduction and engineering which makes sure that product comes out right first time (without defects) must be in place.
- ERP system needs to have a system of coding parts : Production may be in progress for some part, whose design gets changed, with customer orders in the system for both the old design, and the new one, concurrently. The overall ERP system needs to have a system of coding parts such that the MRP will correctly calculate needs and tracking for both versions. Parts must be booked into and out of stores more regularly than the MRP calculations take place. Note, these other systems can well be manual systems, but must interface to the MRP. For example, a 'walk around' stock intake done just prior to the MRP calculations can be a practical solution for a small inventory (especially if it is an "open store").
- Takes no account of capacity in its calculations : This means it will give results that are impossible to implement due to manpower or machine or supplier capacity constraints. However this is largely dealt with by MRP II.
- Inadequate employee training and involvement : Inadequate employee training and involvement is one of the major obstacles in implementing MRP systems. If the employees are not trained properly, they will not be able to understand the system and hence cannot use it properly. In order to derive maximum benefits from an MRP system, employees should be made aware of a the functionalities provided by the system. While instaling an MRP system, employees suggestions should be taken into consideration. Workers' involvement helps create better systems and injects a sense of ownership among them.

- Use of Inaccurate and Obsolete Data – An MRP system cannot yield good results if the data is either inaccurate or obsolete. In other words, the system will not yield the desired results if the BOM records are not updated regularly. To improve the accuracy of the system each inventory item should be assigned with a unique item code so that it can be identified easily and the complexities in data maintenance is reduced. Common items required in the production of different products are identified and pooled together into a single category to avoid discrepancies in inventory management. The inventory database should be updated on a regular basis to ensure timely and accurate recording of all transations.
- Inappropriate Product Environment: The success of an MRP system usually depends on the product environment. The system is useful only when an organization needs to purchase many items, a majority of which are components and parts. The demand pattern of these items should be dependent in nature and irregular in timing. Moreover, the lead times for purchase of these items should be consistent. If any of these criteria are not satisfied, the functioning of the system may not be economical and satisfactory.

8.12 Critique of the MRP concept

Basically, the MRP concept is nothing else than the automation of order processing procedures that in earlier days have been done manually. The MRP concept has been criticized by many scientists as well as practitioners in a large number of publications. Its flaws are system-immanent and cannot be deleted.

8.13 Summary

The American Production and Inventory Control Society defines materials management as "the grouping of management functions supporting the complete cycle of material flow from the purchase and internal control of production materials to the planning and control of work-in-process to the warehousing, shipping and distribution of finished products."

Material requirements planning (MRP) is a production planning and inventory control system used to manage manufacturing processes. Most MRP systems are software-based, while it is possible to conduct MRP manually as well. An MRP system is intended to simultaneously meet three objectives:

- Ensure materials and products are available for production and delivery to customers.
- Maintain the lowest possible level of inventory.
- Plan manufacturing activities, delivery schedules and purchasing activities.

8.14 Key Words

- **Action Bucket** – In the MRP record for the current week, a cell calling for immediate actin to meet the MPS goal.
- **Back Scheduling** – Subtracting lead time from the due date to find the time to start processing or to place an order with a supplier, a basic MRP calculation.
- **Critical Path Method** – (CPM) A network based project management technique initially used on construction projects; about the same as PERT.
- **Demand Management** – Recognizing and managing all demands for products and services in accordance with the master plans
- **Gantt Chart** – a graphic display of the duration of a set of activities. Charts are simple bar charts that can be used to schedule in any of operation.

8.15 Self Assessment Test

1. What do you understand by Material Requirement Planning?
2. Explain the objectives of MRP.
3. Discuss the MRP system.
4. Elaborate the MRP input and Output systems.
5. Describe the Problems of MRP systems.
6. Write an Essay on MRP.

Unit – 9 Supply Chain Management

Unit Structure

9.0 Objectives

After studying this unit you should be able to understand:

- The Concept of Supply Chain management.
- Elements of SCM
- Evolution of SCM
- Business Process which connects various elements of SCM
- Manufacturing Process choices
- Demand Management Concept
- Financial Fundamentals
- Financial Analysis
- Electronic Supply Chain Management
- Just in Time
- Total Quality Management

9.1 Introduction

In any manufacturing company, material flow can be basically classified into three phases.

- Flow of raw material, from suppliers into the manufacturing facility.

- Flow of material within the manufacturing facility as they are processed.
- Flow of finished goods from the manufacturing facility to the end customers.

To be responsive to the global competition, organizations must be able to manage the complete flow of material from the suppliers, through manufacturing, till the end product reaches, the customers. Hence organizations must be involved in the management of management of suppliers who provide direct and indirect material inputs, must increase the manufacturing competitiveness and must effectively manage the network of distribution systems responsible for delivery of the product to end customers. From this realization emerged the concept of supply Chain.

9.2 Supply Chain Management

Supply Chain: The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to end users, as well as the associated information flows.Material and information flows both up and down the supply chain. The supply chain includes new product development, systems management, operations and assembly, purchasing, production scheduling, order processing, inventory management, transportation, warehousing, and customer service. Supply chains are essentially a series of linked suppliers and customers; every customer is in turn a supplier to the next downstream organization until a finished product reaches the ultimate end user.

Supply Chain Management (SCM): SCM is the integration of all the activities in the supply chain to achieve a sustainable competitive advantage. Supply Chain can be broadly classified into three networks – Supplier, Firm and Distribution. The supplier network consists of all organizations that provide inputs, either directly or indirectly, to the focal firm (i.e., the purchaser). Focal firm's network is involved in the conversion of input material to the output material. The distributive network consists of all downstream organizations from the focal firm that ensure that the right quantity of goods is delivered to the appropriate customer location in a timely manner.

9.3 Supply Chain Management vs. Logistics

Logistics: Logistics, also called as physical distribution, focuses on the physical movement and storage of goods and materials. Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption. Typical issues in logistics are evaluation of various transportation options, packaging options, inventory management for different channels, develop and manage networks of warehouses when needed, and manage the physical flow of materials into and out of the organization. Therefore, logistics is a subset in the broader scope of SCM.

9.4 Elements of SCM

Following are the key elements in Supply Chain Management:

- Customers
- Producers (includes Retailer, Distributor, and Manufacturer)
- Suppliers

Customers, Producers and Suppliers are interconnected in the supply chain interrelationship of the elements

- A number of companies can be linked in the supply chain network.
- A supplier to one manufacturing facility can be a customer to another manufacturing facility and so on... hence a number of supplier / customer relationships exist in the supply chain network.
- A number of intermediaries (distributors, wholesalers, retailers etc.,) form part of the supply chain network.
- In defining the supply chain network and the integrations between the elements, the following decisions must be made.
- Identifying the key supply chain elements in the network to link the processes.
- Identifying the processes that are to be linked with the key elements.
- Identifying the level of integration and management control to be applied for each of the processes.

9.5 Evolution of Supply Chain Management

Organizational structure from the fifties to the late eighties was marked by the functional silos where the decisions were made keeping in mind the narrow view of the business functions and the repercussions of the decisions on the other functions were ignored. These often created conflicting objectives within the various functions of a company. The late eighties saw the advent of Business Process Reengineering and ERP concepts. The corporate houses started analyzing the importance of aligning their business with the developments in the information technology capabilities to collaborate effectively with its stakeholders, integrate its functions and decision making and to remain competitive in the market. There are three distinct phases in evolution of SCM:

Pre-1970 era:

- Supply Chain was not considered as a competitive unit. Companies seek more profit by maneuvering their suppliers and customers.
- Scientific methods like EOQ and SPC were applied.
- Companies attempted at Vertical integration – themselves.

1970 – 1980 era:

- Holding inventory becomes key due to oil shock
- TQM and JIT practice becomes popular in Japan
- Distribution is not yet the focus area
- MRP systems gain popularity in US and Europe

Post 1980 era:

- Inventory profits dry up as inflation reigns in
- US manufacturers embrace JIT philosophy. JIT pushes inventory upstream.
- Lower setup times, lower batch quantities result in reduction in lead times and drastic improvement in customer responsiveness.
- Suppliers and customers considered as part of the organization network. ‘We against them’ philosophy fades away.

- MRP systems give way to MRP II systems, ERP and then to advanced supply chain systems involving optimization.

9.6 Business Process and SCM

Following are the typical business that connects various elements in the SCM:

- Product Development
- Order Fulfillment
- Demand Management
- Customer Relationship Management

Product Development Process

As customer demands are ever increasing with respect to quality, delivery and options, organizations are increasingly finding it difficult to meet the customer's expectations. It is often noted that customers want:

- Faster delivery
- Least price
- 0 % rejection rate

And as customer's preference keeps changing, organizations are forced to reduce the product development lead-time as well as costs. Organizations are increasingly employing the following strategies in the Product Development Process

- Integrate customers and suppliers early in the development process
- Reduce time to market
- Incorporate supply chain considerations into product design
- Employ Concurrent Product Development Practices

Order Fulfillment Process:

Organizations need to deploy appropriate production systems depending on the product and demand environment in which they operate. Main objectives, which need to be considered, are:

- Production must shift from a supply/ push method of operation to a demand/pull method based on customer needs.
- Manufacturing process must flexibly respond to market changes with rapid changeover possibilities for mass customizations.
- Minimum lot sizes are planned to move toward a make to order environment.
- Required delivery dates rather than EOQ drive production priorities.
- Specific supply strategies are developed for each customer segment.
- Customer needs, dates and requirements drive the process.
- Manufacturing, distribution and transportation plans are integrated.

Organizations can employ following Production Typologies to accomplish the objecties:

Product /market relations and production typology

Make and assemble to stock	Flow productio (large batches)
Make to stock, assemble to order	Batch Production
Make to order	Job shop (small batches)
Engineer to order	Project-based (unique)

9.7 Manufacturing Process Choices

Considering the demand for the items, range of products, product design, equipment, material movement, etc., manufacturing process choices can be categorized as follows:

- Lot/Batch/Intermittent
- Flow Line / Repetitive / Continuous
- Project

Lot/Batch/Intermittent: In the batch/intermittent process, goods are produced in batches / lots. Work centres are generally organized into groups/departments having the similar equipment and skills. Ex., all milling machines in one group, all Lathe machines in one group etc., these work centers can perform a variety of operations due to the different machine's and skills present and hence are capable of producing different products. The products move along the various machines in the work centers based on the required operations to be performed on them. These work centers hence comprise of general purpose machinery with the flexibility of making a variety of products. Control of work is managed through the individual work centers for each lot.

Flow Line / Repetitive / Continuous: In a flow line / repetitive / continuous manufacturing process, workstations are organized in the sequence needed to make the product. The product moves from one work station to the next along the defined sequence at an almost constant rate. If the products are discrete ex., automobiles, Refrigerators etc., the process is called repetitive manufacturing process. If the products are not discrete ex., gasoline, oils etc., the process is called continuous manufacturing process. The repetitive or continuous manufacturing process has the following characteristics:

- Setting up of a flow line is justified only if the demand of the product is large enough.
- Only a limited range of products can be produced in each flow line
- The work stations comprise of specialized machinery and tooling required for the product
- Since the flow of products between the work stations is balanced and is nearly constant; there is a minimal build up of work in process inventory.

Project: The Project manufacturing process choice is applicable to huge complex projects. In most cases, the product is developed at a particular location with all the necessary resources and equipment moving to the product development location. Large aircrafts, ship building and construction are examples.

9.8 Demand Management Concept

Organizations have to forecast demand accurately. This will result in:

- Synchronized flow of products and materials to customer demand
- Reduction of variability

Organizations should combine accurate demand forecasting with marketing plans, inventory management and sales projections to gain an advantage over the competitors. Better demand management process utilizes information resources to reduce costs, improve customer service and tap into hidden value throughout the supply chain. In this process customer demand is continuously gathered, complied and renewed in order to match the organization's supply capability with the requirements of the market.

The process has the following main objectives:

- Demand requirements and Supply capabilities are continuously modeled using point of sale and "key" customer demand data.
- Market requirements and production plans are coordinated on an enterprise-wide basis.
- Multiple sourcing and routing options are considered at the time of receipt of the order.
- Demand and production rates are synchronized and inventories need to be managed.

Customer Relationship Management Process:

Organizations should maximize customer service as a means of providing focused point of contact for all customer enquiries in order to insulate them from the complexity of a large, multi-divisional corporation. Main objectives of a CRM process are:

- Customer service provides a single source of customer information, a point of contact for administration of the product / service agreement.
- Instant promising / availability information is available for the customer
- On-line/real-time access to product and pricing information assists customers with quick order placement.
- On-line/real-time access to order status information is available to support customer order enquiries.

Procurement Process

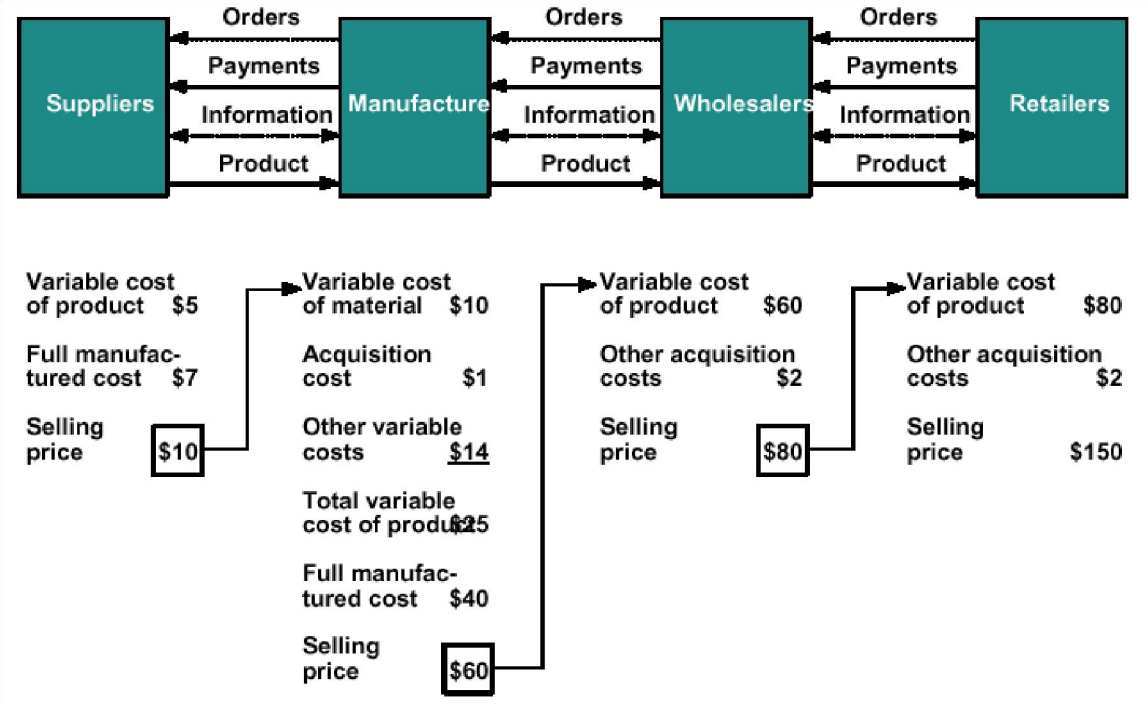
Organizations maintain relationships with major suppliers, which are corporately managed; in strategic alliances while purchase order transactions become simplified and integrated with supply process.

Main objectives of an efficient Purchase Process are:

- Strategic plans of suppliers and organization are aligned to focus on resources on holding down costs and developing new products.
- Supplier categorization and management is implemented on a corporate global basis, with purchasing in a strategic contracting role.
- Purchase Order transactions are integrated with supply process to improve productivity and all areas of supplier performance.

9.9 Financial Fundamentals

Practitioners of Supply chain management need to understand the cost structure of each organization in the supply chain. Following figure depicts how the cost structure of one entity in the supply chain impacts other entities:



An important activity in the management of a supply chain is to reduce the costs in the entire supply chain network. Therefore, one needs to be acquainted with the fundamental aspects of accounting.

Accounting Cycle:

Major steps of Accounting cycle are:

- Analyze Business Transactions
- Record entries in Journal
- Post entries to Ledger
- Prepare a Trial Balance
- Prepare Adjusting entries and Post to the Ledger Accounts
- Prepare Adjusted Trial Balance
- Prepare Financial Statements

  -Profit and Loss Statement

  -Balance Sheet Statement
- Closing entries are made

Balance Sheet :

It is a financial statement that summarizes organization's financial position at a specific point of time. It's a numeric illustration of the balance between a firm's assets on one hand and its liabilities and owner's equity on the other hand in a given point of time.

Assets:

The resources the business owns.

Assets are listed in the order of their liquidity – the speed which they can be converted into cash. Types of Assets are:

- Current Assets – Assets that can be quickly converted into Cash. Ex: Inventory
- Fixed Assets – Assets that are held or used for a period longer than a year. Ex:

Plant and Machinery :

- Intangible Assets – Assets that do not exist physically but have a value based on rights or privileges they confer on the firm. Ex: Brand Value.

Liabilities:

What a firm owes, its obligations liabilities are listed in the order that they are scheduled to be paid. Types of liabilities are:

- Current liability

  -Debts to be re-paid within a year or less.

  -Ex: Accounts payable, Income Tax payable, current portion of long term debt
- Long term liability

  -Debts that need not to be paid within a year

  -Ex: Mortgages, bonds and long-term loans.

Owner's Equity :

The owners investment after all obligations have been met.

Accounting Equation:

Assets = Liabilities + Owner's Equity

The Income Statement :

This summarizes the firm's revenues and expenses and shows total loss or profit during a specified accounting period. This is also called as Profit and Loss Statement or Earnings Statement.

Revenues:

The entire amount earned by a firm from all sources (e.g., selling goods, providing services, investing on stocks etc.).

- Gross sales – Total value of all goods and services sold during accounting period.
- Net Sales – The adjusted value after subtracting sales returns, sales allowances and sales discounts.

Expenses:

- Cost of Goods Sold

  -Beginning inventory plus net purchases less ending inventory
- Operating Expenses

  -All other business Costs

  -Selling Costs – Marketing related activities cost

  -General Expenses – Costs for managing the business

Net Profit or Loss:

The profit earned (cash surplus) or the loss (cash deficit) suffered by the organization during an accounting period, after all expenses have been deducted from revenues.

9.10 Financial Analysis

Financial Analysis enables SCM practitioner to analyze the cost structure of the supply network. Some of the financial ratios widely used are:

- Liquidity ratios
- Profitability ratios
- Activity ratios
- Leverage ratios
- Valuation ratios

Liquidity Ratios:

Liquidity Ratios are used to examine the firm's ability to meet short-term cash outflow needs.

- **Current Ratio**: indicator of company's ability to pay its short term liabilities

  Current Ratio = current assets/current liabilities

- **Quick (acid test) Ratio**: Measures ability to pay off short term obligations excluding Inventory

  Quick (acid test) Ratio = (current assets-inventory)/current liabilities

- **Inventory to net working capital**: Measure of inventory balance, shows if balance can be threatened by unfavorable changes in inventory.

  Inventory to net working capital = Inventory/ (current assets-current liabilities)

- **Cash Ratio**: Shows how much of the current obligations can be paid from cash or near-cash assets.

  Cash Ratio = (cash + cash equivalents)/current liabilities

Profitability Ratios :

Profitability Ratios are ratios used to measure the profitability of the firm.

- **Net Profit Margin**: shows how much after tax profits are generated by each rupee of Sales.

  Net Profit Margin = Net profit after taxes/net sales

- **Gross Profit Margin**: Indicates the total margin available to cover other expenses beyond cost of goods sold, and still yield a profit.

  Gross Profit Margin = (sales-cost of goods sold)/net sales

- **Return on Investment (ROI):** a measure of a company's efficiency, it shows the return on all assets under its control.

  Return on Investment (ROI) = Net profit after taxes/total assets

- **Return on Equity (ROE):** measures rate of return on the book value of shareholder's total investment in the company.

  Return on Equity (ROE) = Net profit after taxes/shareholder's equity

  Earnings per Share (EPS): Shows the after-tax earnings generated for each share of common stock. EPS = (Net profit after taxes-preferred stock dividends) / (Average Number of common shares)

Activity Ratios:

Activity Ratios are ratios used to measure the efficiency with which the firm conducts its business.

- **Inventory Turnover:** measures number of times that average inventory turned over during a period of time.

  Inventory Turnover Ratio = Cost of Goods Sold (COGS) / Average Inventory

  (inventory of finished goods)

- **Accounts Receivable Turnover:** the average length of time it takes to collect the sales made on credit.

  Accounts Receivable Turnover =Sales/Average Accounts Receivable (Sales/Accounts Receivable)

- **Days (Inventory/Receivable) Outstanding**: measures number of days each is outstanding.

  Days (Inventory/Receivable) Outstanding =365/Inventory Turnover; 365/Accounts receivable Turnover

- **Total Asset Turnover:** a measure of the utilization of all the firm's assets.

  Total Asset Turnover = Sales/total assets during period

Leverage Ratios :

Leverage Ratios are ratios used to measure firm's ability to meet its long-run debt service Obligation.

- **Debt-to-assets ratio**: measures extent to which borrowed funds have been used to finance the firm's operations. Includes long term, short-term debt.

  Debt-to-assets ratio = Total debt/total assets

- **Debt-to-equity ratio**: Provides another measure of the funds provided by creditors Vs. funds provided by owners.

  Debt-to-equity ratio = Total debt/total stockholder's equity

Valuation Ratios:

Valuation Rules are used to describe the way the market values the firm and the way that certain characteristics are related to the value of the firm.

- **Price per Earnings Ratio =** Current market price per share/after tax earnings per share.

9.11 Electronic Supply Chain Management

In an organization the SCM's core focus is to integrate its suppliers, the manufacturing process and its customers. As with most other aspects of business, Information technology has become a part of SCM. The internet has provided organizations the capability to integrate the entire supply chain, from raw material sourcing to delivery of the product to the customers. ESCM or electronic supply chain management is business to business integration through the internet.

ESCM – Implementation

In order to improve ESCM implementation the following activities should be undertaken:

- Understand and evaluate the level of integration within the organization.

- Determine the number of suppliers who have direct influence over the products or services that are delivered to the customers, across the entire supply chain.
- Divide suppliers into different categories: First tier, second tier, and so on.
- Define the customer base in terms of sales, profitability, size, etc...
- Improve the information infrastructure within the organization to accommodate ESCM requirements.
- Constitute a team with representative from various functions within the organization and representatives from suppliers and customers to plan and carry out the implementation.
- Identify leaders who are capable of guiding the implementations process competently.

Issues relating to ESCM :-

The purpose of ESCM is to allow effective sharing of information like forecasts and orders among the supply chain partners.

Utilization of data relating to customers and suppliers through internet technologies results in a virtual corporation that facilitates real time information flow between various supply chain partners. ESCM has many benefits, but together with the benefits, there are issues that must be addressed to improve the efficiency of ESCM. These issues include:

- **Security Issues** – Security is the most sensitive issue when information is shared or exchanged over the Internet. An organization has to ensure that the rightful recipient views the information. One way of doing this is to encrypt the data as this ensures that the data is secure and members of supply chain can view only that information which is relevant to them.
- **Changes to existing Business Processes** An Electronic Supply chain transforms a business process significantly. The changes arise in the way companies deal with each other. Al channel partners should be willing to exchange information such as inventory levels; production schedules forecasts, promotion plans, etc. Sometimes partners may be apprehensive of sharing too much information. In order to tide over such apprehensions, a culture of openness and trust should be developed between all the channel partners.

9.12 Just in Time Management

As a philosophy initially it is difficult to understand what is JIT. JIT is linked with the idea of high velocity manufacturing. Basically if factory is a pipe and raw material is water, which you want to flow from one end to the other, then our aim is to reduce the time gap of out flow on one end and inflow at the other. Hence we need to move materials and assemblies through the pipeline more and more quickly. Which basically means reducing the diameter of the pipe? With a narrower pipe we can have the same rate of shipments if we accelerate the velocity of "water" through the pipe. A faster throughput time also allows us to be more responsive to any change in customer demands.

Ideally we would like to have the "diameter of the pipe" as low as possible, in the ultimate situation a single piece flow made instantaneously. As we go on reducing we invariably come across constraints. First that constraint must be resolved before we proceed to do any further reduction. We must therefore employ methods that determine the location and cause of constraints. Once we remove that constraint we can safely move ahead on our journey. This "continuous improvement" is an important arm of JIT. Embedded in this endeavor is "elimination of waste". So basically JIT philosophy is nothing but making as much as possible with as little resources. To achieve that, various methods like pull systems, work cells, flexible manufacturing, etc are used in JIT.

Concepts of Waste : Waste can be defined as any activity that does not add value for the customer. It is the use of resources in excess of theoretical minimum, be it manpower, material, equipment, time, space etc. Waste can be excess inventory, setup times, inspection, and material

9.13 TQM

In today's world customer is king. You can ignore the king at your own peril. Gone are the monopolistic days where customer would take whatever the manufacturer dishes out. Today he wants goods on his own terms and that too if he sees value in it. Ultimately that means doing things that add value to the product, from customer's viewpoint. Which means "meeting or exceeding customer's expectation" (Juan's definition), or "conformance to requirement" (Crosby's definition). These are only some of the words that define quality. And why "Total"? Total means bringing quality into every aspect and not just in product or manufacturing, be it in sales or even a lowly operator punching challans. Every activity has to be viewed from customer's perspective and hence devoid of waste, and 'filled 'with quality. Quality does not mean "best" in any sense, but "best" for certain customer conditions. As a matter of fact JIT and TQM go hand in hand together. They are two sides of the same coin, one uncovers problem and the other solves it. It would be foolish to implement JIT without TQM. There is no sense to arouse a lion if you cannot make it disappear. TQM is the process that makes the lion of constraints disappears. You can implement TQM without JIT but experts agree that it is not as effective. Implementing JIT alone will give you paises whereas implemented it together with TQM will give you rupees. The sum of the parts of both these processes is greater than their individual parts.

9.14 Summary

In any manufacturing company, material flow can be basically classified into three phases :- Flow of raw material from suppliers into the manufacturing facility. Flow of material within the manufacturing facility as they are processed, and Flow of finished goods from the manufacturing facility to the end customers.

SCM is the integration of all the activities in the supply chain to achieve a sustainable competitive advantage. Supply Chain can be broadly classified of comprising of three networks – Supplier, Firm and Distribution. The supplier network consists of all organizations that provide inputs, either directly or indirectly, to the focal firm (i.e., the purchaser). Focal firm's network is involved in the conversion of input material to the output material. The distributive network consists of all downstream organizations from the focal firm that ensure that the right quantity of goods is delivered to the appropriate customer location in a timely manner.

Following are the key elements in Supply Chain Management: Customers Producers (includes Retailer, Distributor, and Manufacturer), and Suppliers.

Customers, Producers and Suppliers are interconnected in the Supply chain interrelationship of the elements there are three distinct phases in evolution of SCM:

9.15 Key Words

- **Activity:** An activity is a task, which must be completed in order to finish the project. Activities consume resources and time and have a definite end and starting point.
- **Customer:** The next process (where the work goes next) also, the end user or consumer.

- **Design Specifications:** The important, desired characteristics of a product or service specified in detail during the design phase.
- **Lot size:** Quantity of an item produced, serviced, or transported at one time.
- **Lot sizing:** Planning order quantities.
- **Just in time:** A manufacturing system whose goal it is to optimize processes and procedures by continuously pursuing waste reduction.

9.16 Self Assessment Test

1. What do you understand by Supply Change Management?
2. What are the Elements of SCM?
3. Explain the Evolution of SCM?
4. Discuss the Manufacturing process choices?
5. Elaborate the Demand Management Concept.
6. Describe the Financial Fundamentals?
7. Write an essay on Financial Analysis?
8. Expain the Electron Supply chain Management. State the issues in ESCM.

Unit – 10 Forecasting

Unit Structure

10.1 Objectives

After studying this unit you should be able to understand:

- Demand Management
- Key Demand Drivers
- Characteristics of Demand
- Forecasting
- Forecasting Objectives
- Principles of Forecasting
- Collection of Data
- Forecasting Methods
- Forecast Error, Measurment & Response
- Distribution Requirement Planning
- Distribution Requirement Planning – Inputs & Output

10.2 Introduction

Demand Management is a function of recognizing and managing the demands for all products to ensure that the master scheduler is aware of them. The two main components of Demand Management are: *Forecast (Uncertainty)* and *Order Service (Certainty)*. Demand Management

encompasses the activities of forecasting, handle order receipt and entry, order promising, branch warehouse requirements, interplant orders and service parts requirement and would cover demand from the following:

- Customers – domestic and foreign.
- Other plants in the same corporate family.
- Branch warehouse in other locations.
- Consigned stocks in customers' locations.

Demand planning is vital to every business & every significant management decision.. It also helps in long-term and short-term process selection, capacity planning and facility planning. Market place, customer expectations, and customer relationship drives planning.

10.3 Demand Management

Demand management is the function of coordinating and controlling of all the sources of demand in order to enhance efficiency and effectiveness of total business. Demand management could be short, medium or long term.

Sources of Demand - Following are the sources of demand :

- Consumers – the end user of a product.
- Refer – people who recommend the products.
- Dealers and Distributors – channels of distribution.
- Inter company – demand from sister or group company.
- Service needs – requirement from after sales service department.

Kinds of Demand :

(1) Dependent Demand : It is a demand for the product or service caused by demand for another product or services. Dependent demand is directly related to or derived from the bill of material structure for other items or end products. Such demands are therefore calculated and need not or should not be forecasted. This typically includes raw materials, purchased or manufactured parts or ingredients and manufactured subassemblies, attachments and accessories. For example, if an organization is making table tops with wooden top and 4 legs, then if firms sells100 table tops, then it requires 100 wooden tops and 400 legs. This demand of wooden tops and legs is dependent on demand of tabletop and hence termed as dependent demand.

(2) Independent Demand : If the demand does not depend upon or is unrelated to the demand of other items then it is called independent demand. Tabletop in above example is an independent demand. This typically includes demand for finished goods, parts required for destructive testing and service parts. Independent demand is forecasted. Sometime an inventory item can be subjected to both dependent demand and independent demand. For example, parts like automobile glass may represent both demands –dependent (as it depends on the manufacturing schedule of new automobiles) and independent (as it may be used as a replacement parts).

(3) Aggregate Vs Disaggregate Demand Aggregate demand : Demand estimates for a product group or family is called aggregate demand Disaggregate demand : Demand estimates for an

individual product is called disaggregate demand. For an example in a Home Appliance manufacturing company that makes air conditioner, refrigerator of different capacities, the demand estimates for total of air conditioners and refrigerators is aggregate demand. e.g. 20,000 air conditioners or 1,00,000 refrigerators. Similarly demand estimates of each product like 10,000 nos. of 165 ltr, refrigerators, 30,000 nos. of 200 ltr, refrigerators is disaggregate demand. Higher the level of aggregation is, the more accurate the demand estimate; the lower or more detailed or disaggregated the level, the less accurate the demand estimate. Though the increased demand forecast accuracy results from aggregation, the aggregated data may not be as useful. The most commonly used dimensions of aggregation and desegregations are time, geographic location and product group. The example cited above is at product group level.

10.4 Key Demand Drivers

Market place basically consists of customers, competitors and economic and regulatory policies as.

- **Customers Discussed Below :** Customers are considered as a king in today's fierce competition. The preferences of customer changes due to various factors beyond the control of the organization *viz* change in customer's need based in his experience with the product , general perception of a product, word of mouth etc., All these factors play an important role in future demand of the product.
- **Competitors :** Entry of new competition, competitor's differentiation in product and technological innovation/revolution by competitor causes major threats on firm's existing product line.
- **Economy and Regulatory Policy :** Economic policies declared by states and central government has major effect on demand. Increase in individual taxes and on product itself may discourages customer from spending. On the other hand, removal of taxes may boosts demand for the product.
- **Regulatory Policies** : These are the legal guidelines set by regulatory authority. The introduction and amendments in statutory requirement increases or lowers the demand, sometimes it may kill the demand completely.

10.5 Characteristics of Demand

Demand pattern for products and services could be as follows :

- **Trend** : It is an increasing or decreasing steady pattern of demand from year to year. A trend could be a) Linear trend b) S Curve c) Asymptotic Trend d) Exponential trend
- **Seasonality** : The demand in a particular period every year rises above or goes below the average yearly demand. This happens as a result of seasonal changes like festival, holiday's etc. .
- **Random Variations** : Random variations are caused by chance events. Statistically when all the known causes for demand (trend, seasonal, cyclical) are subtracted from the total demand, what remains is unexplained portion of demand. This unexplained portion is due to randomness.

- **Cyclical** : The world economy as well as country's economy influences overall demand pattern. Cyclical factors are more difficult to determine because the time span may be unknown. Cyclical influence on demand may also come from political election, war, and sociological pressure.

10.6 Forecasting

The forecast is an estimate of future demand. A forecast can be determined by mathematical means using historical data; it can be created subjectively by using estimate from informal sources; or it can represent a combination of both techniques. It looks into occurrences, timings or magnitudes of future events. Accurate forecast can reduce uncertainty and minor forecasting improvements have a remarkable and direct impact on inventory cost and responsiveness to customer requirements. Forecast management is a process of collection of data, selection of appropriate techniques, forecasting & then taking corrective action if actual demand varies significantly.

10.7 Forecasting Objectives

Planning of long lead time resources like; Plant expansion, Capital equipment, Planning of medium & short term resources like labor, Procurement of materials, and To shorten customer's delivery time Product Development Process needs forecasting of demand.

As customer demands are ever increasing with respect to quality, delivery and options, organizations are increasingly finding it difficult to meet the customer's expectations. It is often noted that customers want:

- Faster delivery
- Least price
- 0 % rejection rate

And as customer's preference keeps changing, organizations are forced to reduce the product development lead-time as well as costs. Organizations are increasingly employing the following strategies in the Product Development Process:

- Integrate customers and suppliers early in the development process
- Reduce time to market
- Incorporate supply chain considerations into product design
- Employ Concurrent Product Development Practices

10.8 Principles of Forecasting

Forecasts will be wrong- as forecasting is based on various considerations viz.,the source of data, the forecasting method, the time dimension of data, the level of aggregation of data, the unit of measure used, the frequency of reassessment, and the quality and accuracy of the data itself, it is bound to go wrong.

- Forecast shall include an estimate of error. This estimates of error can be mentioned either as percentage or plus / minus tolerances.
- Forecast is more accurate for shorter time periods. This is simply because nearest future is more predictable
- Forecasts are more accurate for a family or group of products. On the other hand, forecast of individual items is more erratic.

10.9 Collection of Data

The quality of forecast is as good as data used. Data collection shall be done in an accurate way leaving no way for errors and ambiguity. Following guidelines shall be considered.

- Data shall be recorded in proper units and location as needed for forecast. For example, if forecast of sales is to be made, data shall be of actual sales made in the past and shall not be of production or shipment.
- Capture the event or circumstances related to data. Certain events and circumstances influence the demand in that particular period like festivals, holidays etc., Capturing the data with relevance to such incidents would enable forecaster to account or discount such events in forecasting.
- Demand data of different customer group shall be recorded separately.

10.10 Forecasting Methods

Forecasting methods are broadly divided as :

- Qualitative Techniques
- Quantitative Techniques

Quantitative Techniques are further divided into :

- Intrinsic Techniques
- Extrinsic Techniques

10.10.1 Qualitative Techniques

It is a subjective, judgmental and is based on estimates and opinions. It is generally used by senior managers. Following are few examples of qualitative techniques :-

- **Grass Roots :** Derives forecast by compiling input from those at the end of the hierarchy who deal with what is being forecasted
- **Market Research :** This is used to forecast long range and new product sales and includes surveys, interviews. Generally market research connotes a more rigorous, often hypothesis-testing approach.
- **Panel Consensus :** Sales executives, middle managers, supplier, customer is invited in free meeting and future trends are discussed and summarized.
- **Historical Analogy :** Forecast is derived from actual sale of similar item in the past. Knowledge of past and mostly completed event may be closely related to a future event. Eg. Market development of colour TV may follow pattern Black and White TV. Historical analogies tend to be best for replacement products and where direct market substitutability relationship exist.
- **Delphi Method :** Group of experts respond to questionnaire. A group co-ordinator collects the feedback, compiles and prepares new questionnaire, which is re-submitted, to group.

10.10.2 Quantitative Techniques

This incorporates more extensive computational evaluation of data pattern or external relationships. There are two subsets of Quantitative methods :

- Extrinsic Techniques
- Intrinsic Techniques

- **Extrinsic Technique :** A certain set of external factors/ indicators outside the organization are used to forecast product demand. Examples are : rise in sales of automobiles & refrigerators will increase demand on steel industry. Some frequently used indicators are GDP growth, agricultural production, automobile production, steel production, hosing sector growth, census etc. Extrinsic demand is mostly used to forecast group or family of products.
- **Intrinsic Techniques :** These techniques use historical recorded data for future estimates.Past performance of product in the marketplace is studied/ analyzed with mathematical or statistical tools to arrive at future demand. Individual products are forecasted by these methods. Following are major techniques of intrinsic methods.

Average Demand : This is a simple average of last year's actual demand. It has limitation of not able to capture trend and seasonal variation.

Simple Moving Average : Simple moving average is used when demand for a product is neither growing nor declining rapidly and if there is no seasonality in it. It is very important to select the best period for the moving average. There are several conflicting effects of different period lengths. The longer the moving average period, the greater the random elements are smoothed out. But if there is a trend in the data either increasing or decreasing, the moving average has the adverse characteristics of lagging trend.

Weighted Moving Average : This allows any weights to be placed on each element, but ensuring that the sum of all weights equals to 1. Weights are chosen by experience & trial & error . As a logical rule, most recent data is given higher weight. But if data are seasonal, then weights shall be established accordingly. If different weights for each period are selected, the following three rules should be followed:

- Rule 1: The sum of the weights should be 1.0 (or factored to be 1.0)
- Rule 2: Weights should not be zero or negative
- Rule 3: More recent periods should receive heavier weights.

Exponential Smoothing : In both the above methods, an organization has to carry a large amount of historical data. It is well established that forecast based on recent data is more indicative of future than more distant past. Exponential smoothing is a technique that uses this kind of recent data in establishing future demand. In the exponential smoothing method, only 3 pieces of data are needed, the most recent forecast :

- The actual demand that occurred for that forecast period
- Smoothing constant alpha (á).

This smoothing constant alpha (á) determines the level of smoothing and the speed of reaction to difference between forecasts and actual occurrences. The value of alpha is determined by nature of product, forecasters' intuition. The another way is to use computer simulations and by trial and error arrive at the alpha value.

Seasonal Index : Demand of the product increases or decreases in a particular period every time, such demand is termed Seasonal. This could happen as a result of festival, recurring occurrences of certain event, holidays and so on. This seasonal variation in demand is captured through seasonal index. Seasonal index estimates by how much the demand in season will be below or above the average demand.

Seasonal Index = Period Average demand / Average Demand for all periods

The average demand for all periods is a value that averages out seasonality. This is called the desesonalized demand. Equation given above can be re-written like this; Seasonal Index = Period average demand / Deseasonalised demand

Regression Analysis : Quantitative models for finding the mathematical expression that best describe the relationship between two or more variables. Regression models often are used in forecasting.

Box-Jenkins Models : A quantitative forecasting approach based on regression and moving average models, where the model is based not on regression of independent variables but on past observations of the item to be forecast at varying time lags and on previous error values from forecasting

10.11 Forecast Error, Measurment and Response

The accuracy of a particular forecast method is measured in terms of the forecast error. The difference between the actual demand and the forecast demand is called forecast error.

The error can come in two ways : • Bias • Random

When actual demand is consistently above or below the forecast demand, the error is called bias. To improve upon bias, an organization needs to change forecast. Random errors in forecast are natural variation about the average demand. Bias & random variations are similar to assignable and inherent causes in SQC. Forecast error can be measured in any of following ways,

- Mean Absolute error
- Standard Error
- Tracking Signal

Mean Absolute Deviation (MAD) : MAD is simple method and very useful in obtaining tracking signal. MAD is the average error in the forecast, using absolute value. MAD is calculated using the difference between the actual demand and the forecast demand without regard to sign. It equals the sum of absolute deviations divided by the number of data points.

MAD = Sum of Absolute error / No of Observations

= 8400 / 12

= 700

MAD is the average amount by which the forecast errs. MAD does not consider the direction of the error, only the average amount of the error.

Standard Error : As shown in the example, MAD is a measurement of the differences between actual demand & forecast. If we plot histogram of frequency of actual demand of a particular value, it gives bell shaped curve also known as normal distribution. Normal distribution is based on; mean (average), and dispersion. This dispersion is measured by standard deviation. MAD though different can be interpreted the way standard deviation is interpreted in following manner,

The forecast error will be within,

+/-1 MAD of the average about 60 % of time

+/-2 MAD of the average about 90 % of time

+/-3 MAD of the average about 98 % of time

Tracking Signal : It is measurement that indicates whether the forecast average is keeping pace with any genuine upward or downward changes in demand. A tracking signal is the number of mean

absolute deviation that the forecast value is above or below the actual occurrences. Tracking signal is useful because it measures error over a specified range of data, for example 4 weeks in a month or 52 weeks in a year, Thus it can identify periodic areas where forecast has greater error. In addition to this, tracking signal can be used to indicate that the inherent pattern of the data is changing and the forecasting method needs to be adjusted.

Tracking Signal = Algebraic sum of forecast error / MAD

Referring to our example (MAD is already calculated as 700)

Tracking Signal = 1800 /700 = 2.57

Organizationa set limits for tracking signal called trigger, say +/- 4. If tracking signal calculated is beyond this limit, then forecasting model needs review otherwise not. Acceptance limits for tracking signal depend on the size of the demand being forecast and the amount of time available.

10.12 Distribution Requirement Planning

DRP provides a framework for implementation of centralized push systems of distribution inventory management. Distribution resource includes more than just the planning and control system for replenishment. It includes many of the physical aspects of distribution – warehousing and transportation facilities. It also implies the connection of replenishment system to financial systems and use of simulation as a means to improve system performance.

DRP is similar to MRP applied to MPS .The process of determining the need to replenish finished good inventory at branch warehouses. A Time-Phased Order Point (TPOP) approach is used where the planned orders at the branch warehouse level are “exploded” with the help of MRP logic to become gross requirements on the supplying source. This gross requirement then becomes input to MPS. The extension of distribution requirements planning into the planning of the key resources contained in a distribution system: warehouse space, workforce, money, truck, freight is known as distribution requirement planning 2 (DRPII)

10.13 DRP Inputs and Output

DRP Inputs : Requirement of each distribution system is calculated by Forecast. Hence, forecasting method shall be selected with utmost care so that trends & seasonality are captured properly. As in case of MRP actual customer order also becomes input to DRP system.

DRP Outputs : Planned order release are outputs of DRP which can be automatically generated from the system. This planned order release is input for Master Production Schedule. The point of connection between the production system and the distribution system is the master production schedule (MPS). DRP provides a framework for managing orders, shipments and inventories even in the face of dynamic market place. Unplanned events and changing conditions may often be accommodated through pegging of requirements, fair share allocations, and firm planned orders, while still maintaining overall lower safety stock levels.

10.14 Summary

Demand Management is a function of recognizing and managing the demands for all products to ensure that the master scheduler is aware of them. The two main components of Demand Management are: *Forecast (Uncertainty)* and *Order Service (Certainty)*. Demand Management encompasses the activities of Forecasting, handle order receipt & entry, order promising, branch

warehouse requirements, interplant orders and service parts requirement and would cover demand from the following:

- Customers – domestic & foreign
- Other plants in the same corporate family
- Branch warehouse in other locations
- Consigned stocks in customers' locations

Sources of Demand **-** Following are the sources of demand :

- Consumers – the end user of a product
- Referrers – people who recommend the products
- Dealers & Distributors – channel of distribution
- Inter company – demand from sister or group company
- Service needs – requirement from after sales service department

Forecasting methods are broadly divided as : (i) Qualitative Techniques, (ii) Quantitative techniques.

Quantitative Techniques are further divided into : (i)Intrinsic Techniques, (ii) Extrinsic Techniques

Qualitative Techniques are : Grass Roots, Market Research, Panel Consensus, Historical Analogy, Delphi Method

Quantitative Techniques : This incorporates more extensive computational evaluation of data pattern or external relationships. There are two subsets of Quantitative methods : (i) Extrinsic Technique, (ii) Intrinsic Technique.

Following are major techniques of intrinsic methods :-

- Average Demand
- Simple Moving Average
- Weighted Moving average
- Exponential Smoothing
- Seasonal Index
- Regression Analysis
- Box Jenkins Technique
- Regression Analysis
- Box-Jenkins Models

10.15 Key Words

- **Bias –** A forecast eror measure that is the average of forecast error with regard to direction and shows any tendency consistently to over or undr forecast; calculated as the sum of the actual forecast error for all periods divided by the total number of periods evaluated
- **Cyclical –** Cyclic refers to changes in the demand patterns which exist for more than one year.
- **Demand Management –** Recognizing and managing all demands for products and services in accordance with the master plan.

- **Dependent Demand –** Demand for an item that can be linked to the demand for another item.
- **Independent demand-** Demand for an item that occurs separately of demand for any other item.

10.16 Self Assessment Test

1. What do you understand by Demand Management?
2. What is Forecasting Management?
3. Explain the objectives of Forecasting
4. Discuss the Forecasting Techniques and methods?
5. Elaborate the Distribution Requirement Planning.
6. Describe the Principles of Forecasting?

Unit – 11 Operations Scheduling

Unit Structure

11.0 Objectives

After studying this unit, you should be able to understand:

- Concept of operations scheduling
- Objectives, reasons for operations scheduling
- Activities involved in scheduling
- Methods to schedule
- Scheduling in Services

11.1 Introduction

At the start of every semester a days plan is given to all students specifying when the classes will start, the time and sequence of classes, deadlines to submit internal assignments and the date for starting of semester end exam. While booking the tickets for railway we look at the timings of the trains. Big corporate players, heads of states register all their meetings well in advance. When Barak Obama came to India his plan was prepared well in advance so that all the things go as planned and space could be provided for contingencies.

In all these above instances a schedule was prepared so that all the things finish in specified deadline and everything happens on or before time. Scheduling not only covers timing rather it also pertains to the use of resources within an organization. In both manufacturing and services organizations scheduling covers use of equipment and facilities, the scheduling of human activities, and receipt of materials. It can be for short term or long term. In short term it may relate to finishing a project which can turn into expansion plans in long term. Scheduling indicates: what is to be done, when it is to be done, and with what equipment.

In operations management also scheduling plays a very important role. In today's highly competitive world it is very important to make your client happy, so orders have to be manufactured on or before time so as to beat competition. Operations scheduling makes sure that neither the

machinery waits for the raw material nor finished goods lie in the warehouse. All this has given rise to important operations concepts like Just in Time (JIT) and lean manufacturing.

Operations scheduling is a very important part of MES or Manufacturing Execution System. MES is an information system which schedules, dispatches, tracks, monitors and controls production in a manufacturing or a service concern. In service concern like a courier service this MES plays a very important role. By the use of MES a person sitting in Delhi can trace the mail which was sent form Bhopal to Kanyakumari and can find out whether it is in transit, or it has reached Kanyakumari head office, branch office etc. These days courier companies give their clients a unique number through which the client can himself find out whether the courier he had sent, has reached the destination or not, he can also get some other information like date of dispatch, delivery, current status etc.

11.2 Objectives of Operations Scheduling

1. **To maximize customer satisfaction –** Customers want that their order should be prepared according to the specifications given by them and this should happen on time. Operations scheduling helps to procure the raw material as soon as the order is received without any delay. With the help of techniques like backward scheduling managers schedule the start date so that it completes on the due date of delivery.
2. **Minimize Service delays –** On time delivery is very important for business like courier companies as they have very less time in hand from the time a mail is received and the time when it is to be delivered, so they have to schedule every movement from receiving the mail to its pickup and transportation through different mediums like truck, airplanes etc.
3. **To enable the firm to allocate the capacity to meet customers' demands on time -** In manufac turing a product, lot of machines are used. Firms should use their machines in such a way that idle time for every machine becomes zero or reduced to minimum. This becomes possible through effective scheduling of the orders that a firm has received.
4. **To reduce cost and maximize profit –** If all the facilities are used most efficiently so that rum time of machines is maximized and idle time minimized to zero, the cost will reduce because of less wastage. As a result profit of the firm is maximized.
5. **To create flexibility to accommodate variation in customer demand –** When operations manager plans and schedules the manufacturing process of the different orders received by a firm he comes to know about the changes that can be made if any new information is to be accommodated.

11.3 Work Centers

Work center – It is an area on the shop floor where resources of production are organized and work is completed. It can be a single machine, a group of machines or an area where a particular type of work is done. For example in a factory which makes hand-made paper work station can be the area where workers sit and work same is the case with BOP employees, their work station is the cubical where they sit and make calls.

Objectives of Work-Center Scheduling are to meet due dates, minimize lead time, minimize setup time or cost, minimize work-in-process inventory, maximize machine utilization.

1. **Forward Scheduling –** It is a scheduling method in which actual production starts when a job order is received. It is generally applicable to specific items which need to be manufactured on the basis of some other specification like big machines or limited edition cars like Limousine. These are prepared according to the needs of a customer, so until and unless a customer tells what he needs the product cannot be prepared.

   "In this method, operations manager schedules each operation forward in time starting from the date of production. Using forward scheduling, the operations manager determines start and finish times for jobs to be done by assigning them to the earliest available time slots at the work centers. As the jobs start at the earliest possible time, they are finished before they are required at next work centers. As a result work –in-progress inventory level tends to be higher in forward scheduling method.

2. **Backward Scheduling -** This method schedules orders according to their due dates. The operations manager obtains due dates for the job orders and develops the schedule backwards and thus calculates the latest starting date of the project to complete the order on time. Firms generally follow either backward or forward scheduling, depending upon the nature of the job. The forward scheduling method is used to estimate the earliest date by which a job can be completed. Operations manager uses backward scheduling if the estimated date is well before the actual date of its completion for example the due date for completing a consignment is on 31st day starting today, time required to complete the job is 20 days so operations manager will calculate the latest starting date so that the consignment gets finishes on the 31st day. So the latest day to start the manufacturing would be 11th day from today.

   On the contantary if the manager needs to give his clients an expected date of completion of a particular product then he would use forward scheduling method to forecast the date to completion of a product or project. "Retailers and wholesalers use forward scheduling for replenishing their stock."

3. **Infinite Loading -** jobs are assigned to work centers without considering work center's capacity, as if its capacity is infinite. Gantt load charts and visual load profiles and assignment algorithm are used to evaluate loading and assigning the jobs. So capacity is not regarded as a limitation.

4. **Finite Loading -** It is a scheduling procedure that assigns jobs into work centers and determines their starting and completion dates by considering the work center's capacity. Work center's capacity is allocated unit by unit by simulating job starting and completion time. This means that capacity of a work center is a limiting factor in the method.

5. **Machine Limited Process** – Basic production resources are men, material, machine and money. While actual manufacturing the products, two factors limit the volume which are machine and men (labor). In a machine limited process, equipment is the critical resource that is scheduled. It can become critical because of limited use it, or most important and expensive input.

6. **Labor Limited Process –** As discussed above if labor is in shortage or very exclusive kind of labor with high expertise is required which only a few people have then in that case labor becomes critical resource and all other things become dependent on this one input. Example can be of scientists, workers in jeweler industry, hand wearers etc.,

Scheduling Problem :

[Problem 1]

Two jobs are to be processed on two machines. Both jobs should be ready in 10 hours. The route sheet is given below. Develop schedule using forward scheduling.

Job A Route Sheet			Job B Route Sheet		
Routing sequence	Machine	Processing Time Hrs.	Routing sequence	Machine	Processing Time Hrs.
1	1	2	1	1	3
2	2	5	2	2	3
3	1	2			
Total		9			6

[Solution]

M1	A1	A1	B1	B1	B1	Idle	Idle	A3	A3	Idle
M2	Idle	Idle	A2	A2	A2	A2	A2	B2	B2	B2

0 1 2 3 4 5 6 7 8 9 10

Cumulative Hours

Explanation :

This qurstion means that there are 3 processes to be done to complete job A for which first it will be processed on machine 1(M1) for 2 hours, then it will go on mchine 2(M2) there it will be processed for 5 hours and only after this it can go on to M1 again on which it will be processed for 2 hours. Likewise job B has to go on M1 for 3 hours first then on M2 for 3 hours.

In the solution we have put job A on machine first because more processes are to be done for it and the process time is also long. The aim of this question is that both jobs should be completed within a span of 10 hours with minimum idle time.

On M1 first job A will be processed it will take a span of 2 hours there so 1 to 2 hours are occupied by it. During that time we cannot do anything for job B as it also has to be processed on M1 first and this span of 0 to 2 hours will be idle time on M2 as processing on M1 is not complete for any of the jobs. Once job A finishes at M1it will be transferred to M2 for 5 hours and job B will be done on M1. There is an idle time of 2 hours on M1 for 5 to 7 hours as job B has to go on M2 which is occupied by M1 and job A is already running on M2. At hour 7 job A will be again shifted to M1 for 2 hours then only job B can be processed on M2.

[Problem 2] Solve Problem by Backward Scheduling

Job A Route Sheet			Job B Route Sheet		
Routing sequence	Machine	Processing Time Hrs.	Routing sequence	Machine	Processing Time Hrs.
1	1	2	1	1	3
2	2	5	2	2	3
3	1	2			
Total		9			6

[Solution]

M1	ldle	A1	A1	ldle	ldle	B2	B2	B2	A3	A3
M2	B2	B2	A2	A2	A2	A2	A2	A2	ldle	ldle

0 1 2 3 4 5 6 7 8 9 10

Cumulative Hours

Explanation :

In Backward Scheduling we estimate the time backward i.e. if we want to complete both the jobs on 10th hour exact then when should we start doing the Job. Because of this reason only now we have Idle 1 hour at the starting of 0 to 1 hour. So in backward scheduling, we will start Job A form 10^{th} hour backward and calculate the time backward. Rest is same as above.

11.4 Scheduling Activities

1. **Routing** – Routing outlines the sequence of operations and processes to be followed for manufacturing a product. In short, routing lays down the flow of work through different workstations, machines and departments. It determines what is to be done, how and where it is to be done. Operations manager gives all the details like list of operation is to be performed, time of operation and the sequence in which it will take place. Routing Sheets can be in physical hard copy as well as computerized electronic copy. Routing can also be useful in service sector.
2. **Loading** – "Loading can be defined as "assigning specific jobs to each work centers for the planning period." There is one limitation to be considered while loading i.e. each work center has a limited capacity and work in excess of that capacity cannot be loaded at a time. In case there is no capacity restriction then operations manager tries to minimize the cost by reducing machine idle time, amount of inventory etc.
3. **Dispatching** – Next step in the process of scheduling is dispatching. It is the final act where job orders are released to worker to go ahead with the production process. Here job orders are released in the sequence as planned by the operations manager.

Job Sequencing –

It is the process of determining the job order on some machine or in some work center. These are also called as dispatching rules or priority rules which are used by the firms in light of the limitations that they have. These dispatching rule are simple which require jobs be sequenced according to one piece of data such as processing time, due date or order of arrival.

(i) Earliest Due Date (DDate) : Due date is the date promised for completion of product. So firms that follow this priority rule, first dispatch the one with earliest due date, next earliest job second and so on. For example if there are 5 assignments due on 23^{rd} Dec, 5^{th} Jan, 12th Dec, 30^{th} Dec and 10^{th} Jan. In this case first the one due on 12^{th} Dec will be dispatched, next would be 23^{rd} Dec, 30^{th} Dec, 5^{th}Jan and last would be the one due on 10^{th} Jan.

(ii) Longest Processing Time : According to this priority rule those jobs which take longest time to process are loaded first, then the next longest time and so on. These jobs are given priority as these are considered more valuable. So if there are 4 jobs A, B, C, & D are to be done for completing a product and they take 4, 10, 3 &12 hours respectively to finish. Then the order to be followed would be D, B, and A & C respectively in this order.

(iii) Shortest Processing Time (SPT) or Shortest Operating Time (SPT) : Some firms prioritize there jobs on the basis of shortest processing time. So jobs that take shortest time to process are loaded first. Here all jobs are treated equal and not prioritized according to there relative importance unlike in longest processing time priority rule. So in the above example the sequence to be followed would be C, A, B, D.

(iv) First Come, First Serve (FCFS) : Here jobs are processed as they come or in order of their arrival. In this method also all jobs are regarded equal so no importance is given to any job. This rule is followed to give fair treatment to customers. For example in all restaurants people who place their order first are served first.

(v) Slack Time Remaining (STR) : According to this priority rule operations manger calculates the slack time remaining of each job. Slack time is the difference between time remaining in due date and the processing time required. Jobs with the shortest slack time are dispatched first. If the due date for 2 jobs are on 20^{th} and 30^{th} day form today and these jobs take 10 and 8 days to process then job 1 would be done first as slack time for both these are 10(20-10) and 22(30-8) respectively.

(vi) Slack Time Remaining Per Operation (STR/OP) : In this method orders with shortest STR/OP are run first. STR is calculated as follows:

$$\text{STR / OP} = \frac{\text{Time remaining before due date - Remaining Processing Time}}{\text{Number of Remaining Operations}}$$

(vii) Critical Ratio (CR) : This is calculated as the difference between the due date and the current date by the work remaining. Order run in ascending order i.e. order with the smallest CR run first. The formula for calculating CR is as follows :

$$\text{CR} = \frac{\text{(Due Date) - (Current Date)}}{\text{Number of days remaining}}$$

(viii) Last Come, First Served (LCFS) : Suppose you have is jar, which is filled half with chocolates, now you got some more chocolates, your natural response will be to just put it in the jar. As a result now when you will take out the chocolates from it, first ones to come in your hand will be the once you have put last. This is exactly what happens frequently at the shop floor also. As orders arrive, they are placed on the top of the stock and operator picks up from top and uses it.

(ix) Random Order or Whim : This rule is no rule actually; supervisor or operator selects whichever he feels like running. So every order received by the firm has equal probability to be run by the operator. Now let's see a solved example of all these priority rules.

[Problem 3]

Scheduling n Jobs on one Machine : Rachit Iron Works ltd. manufactures bearings used in all the machines. It has received 4 orders from its customers P, Q, R, and S in the same order at the beginning of the month. The processing time and due dates of these orders are given on the next page:

Jobs (in order of arrival)	Processing Time (in days)	Due Date (days hence)
P	5	6
Q	8	11
R	4	7
S	2	5

Solve this by the following methods and calculate average delay of a job in each case :-

1. Earliest Due Date
2. Longest Processing Time

3. Shortest Processing Time
4. First Come First Serve (FCFS)
5. Slack Time Remaining
6. Last Come, First Served (LCFS)
7. Critical Ratio

[Solution]

Earliest Due Date

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
S	2	5	0 + 2 = 2	-3 (2 - 5)
P	4	6	2 + 5 = 7	1 (7 - 6)
R	5	7	6 + 5 = 11	3 (9 – 6)
Q	8	11	11 + 8 = 19	8 (19 –11)

Average delay is as follows -

(-3 + 1 + 4 + 8) / 4 = 2.5 days

So we can see that order S gets completed before time while all other orders get delayed by 2.5 days on an average.

Longest Processing Time

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
Q	8	11	0 + 8 = 8	-3 (8 - 11)
P	5	6	8 + 5 = 13	7 (13 - 6)
R	4	7	13 + 4 = 17	10 (17 – 7)
S	2	5	17 + 2 = 19	12 (19 – 5)

Average delay is as follows -

(-3 + 7 + 10 + 12) / 4 = 6.5 days

By this process job get delayed even more. Again order Q get finished before time and all the other jobs get delayed.

Shortest Processing Time

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
S	2	5	0 + 2 = 2	-3 (2-5)
R	4	7	2 + 4 = 6	-1 (6-7)
P	5	6	7 + 4 = 11	3 (9– 6)
Q	8	11	11 + 8 = 19	8 (19 –11)

Average delay is as follows –

(-3 -1 + 3 + 8) / 4 = 1.75 days

By this method order S and R get complete before time while P and Q get late by 3 and 8 days respectively.

First in First Serve

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
P	5	6	0 + 5 = 5	-1 (5 - 6)
Q	8	11	5 + 8 = 13	-2 (13 - 11)
R	4	7	13 + 4 = 17	10 (17 – 7)
S	2	5	17 + 2 = 19	12 (19 –5)

Average delay is as follows –

(-1 -2 + 10 + 14) / 4 = 5.25 days

Here though P and Q still get done before but average delay time gets increased to 5.25 days.

Last Come First Serve (LCFS)

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
Q	8	11	0 + 8 = 8	-3 (8 – 11)
R	4	7	8 + 4 = 12	5 (12 - 7)
S	2	5	12 + 2 = 14	9 (14 – 5)
P	5	6	14 + 5 = 19	13 (19 – 6)

Average delay is as follows –

(-3 + 5 + 9 + 13) / 4 = 6 days

According to this method one of the jobs get completed on time and the average delay is of 6 days.

Slack Time Remaining

Here first we have to calculate slack time for all the jobs which is the difference between due date and processing time. Then we will arrange the jobs in ascending order of there slack time. So according to that following is the slack time –

P (6 - 5) = 1 Q (11 - 8) = 3

R (7 - 4) = 3 S (5 – 2) = 3

Here as we can see that slack time for Job A is lowest, so it will come first. But for all other jobs slack time is same i.e. 3 so we will see their processing time and then arrange them in ascending order.

Job Sequence	Processing Time	Due Date	Flow Time	Delay (flow time – due date)
P	5	6	0 + 5 = 5	-1 (5 - 6)
S	2	5	5 + 2 = 7	-4 (7 - 11)
R	4	7	7 + 4 = 11	4 (11 – 7)
Q	8	11	11 + 8 = 19	8 (19 –11)

By this method job P and S get completed before time while the other jobs R and Q get delayed by 4 and 8 days.

Critical Ratio (CR)

$$CR = \frac{\text{(Due date - Current date)}}{\text{Number of days remaining}}$$

To solve this question by CR method first we need to calculate critical ratio for all jobs.So let today be Day 1 and allow a total of 15 days to do the work. The resulting CR's and order schedule are:

CR (P) = (6-5)/15 = .067

CR (Q) = (11-2)/15 = .6

CR (R) = (7-4)/15 = .2

CR (S) = (11-8)/15 = .2

So the order schedule would be P, S, R and Q respectively. As CR for R and S is same so we can have any sequence in them.

11.5 Techniques for Scheduling Activities

Scheduling becomes a very complicated task when it is to be done in big industries and it becomes impossible to do it manually so operations managers use different techniques some of then computer based techniques to make the schedule. Some of these techniques are Gantt chart, Job Sequencing Rule, Queuing Theory, and Critical Ratio.

1. Gantt Chart :

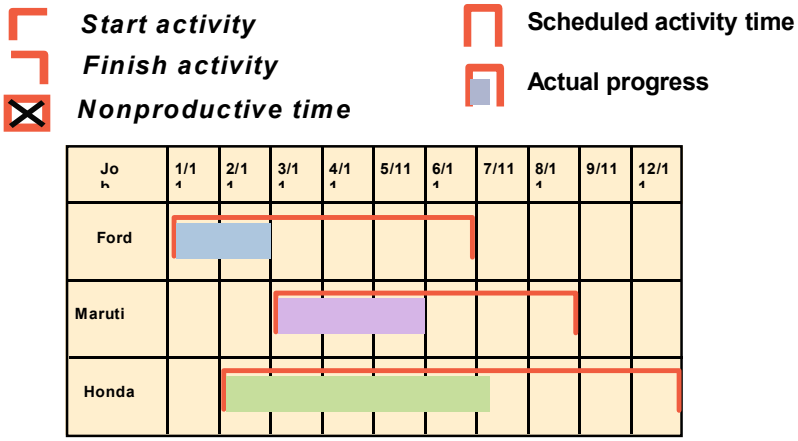
Gantt Chart was developed by Henry L. Gantt on whose name it is named. He won a presidential citation for his application of this type of chart for ship building during World War I. It is sometimes also referred to as *bar chart* showing both amount of time involved and the sequence of activities to be performed. Hence it is a graphical display of the duration of a set of activities. It is used by individual departments or job shops of large departments to plan and track jobs. It is a tool to monitor the progress of work and to view the load on workstations. The chart takes two basic forms:

(1) The job or activity progress chart, and

(2) The workstation chart.

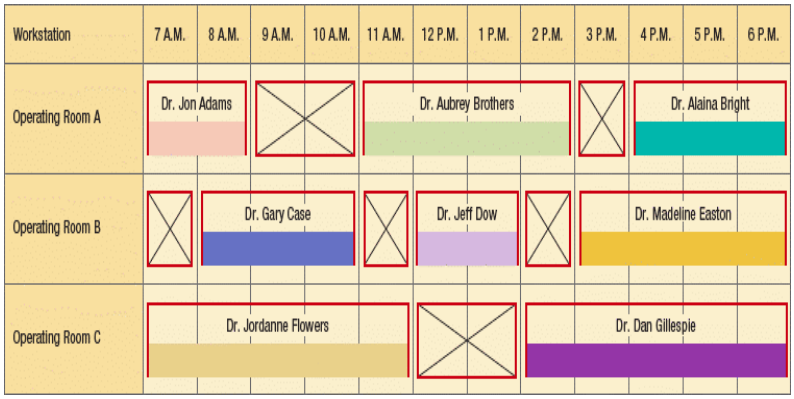
(i) The *Gantt progress chart* graphically displays the current status of each job or activity relative to its scheduled completion date.

Gantt Progress Chart for an Auto Parts Company



(ii) The *Gantt workstation chart* shows the load on the workstations and the nonproductive time.

Gantt Workstation Chart for Hospital Operating Rooms



2. Johnson's Job Sequencing Rules

Johnson's rule was developed by Johnson and Bellman, and it is utilized to minimize the total time span required for completing the given jobs. It is use to schedule n jobs on two machines. Sequencing of jobs is important for scheduling of jobs. It helps in minimizing the processing time and maximizing the operations efficiency. It also reduces the operations cost over a period of time. When products like ice-cream, tiles etc., are to be made, jobs are processed in multistage, it is necessary to sequence in such a way that idle time is reduced.

(i) Johnson's Rule for Two Stage Production : If a firm has to perform "n" jobs on two machines A and B in the order AB. Expected time for these jobs are A1, A2, A3….. An on machine A and B1, B2, B3….. Bn in machine B. Following steps are followed:

1. Identify least processing time in A1, A2,….An and B1, B2….Bn. If there is tie, select either of the processing time.
2. If the smallest processing time is Ar (rth job in machine A then place it at the beginning of the sequence. And if it is Bs (sth job on machine B), then place it at the end of the sequence.
3. If there is tie for the least processing time on machine A, any of the jobs can be placed at the beginning of the sequence. In case of tie at machine B, any of the jobs can be placed at the end of the sequence.
4. Identify the next least processing time and repeat the above step. The process is continued till all the jobs are assigned in a sequence. The sequence obtained is called as optimum sequence.
5. Once the time sequence is found, the total elapse time and idle time on machine A and B can be calculated by the following formula.

   Total Elapse time = time between start of the first job – end time of last job.

   Idle time on machine A = time of completion of last job on machine B in optimum sequence- time of completion of last job on machine A in optimum sequence

   Idle time on machine B = Time taken by Machine A in completing first job in sequence - " [(time when kth job starts on machine B) – (time when k-1 th Job finishes on B)

(ii) Johnson's Rule for Three Stage Production : If the expected processing time for n-jobs on 3 machines A, B and C are A1,A2,A3…..An; B1, B2, B3….Bn and C1,C2,C3…..Cn

Stage -1: check that Johnson rule can be used:

Any one of the following conditions should be satisfied

(i) The smallest processing time on machine A should be greater than or equal to the largest processing time on machine B.

(ii) The smallest processing time on machine C should be greater than or equal to the largest processing time of machine B.

Stage -2: Assume two fictitious machines G and H

Stage -3: Find out corresponding time for these machines by they following formula

$G_i = A_i + B_i$

$H_i = B_i + C_i$

Stage -4: solve the problem like 2 machines and n jobs with order of GH.

The resulting optimum sequence will also become the optimum sequence for the problem of 3 machines and n jobs.

11.6 Scheduling in Services

Till now we have discussed scheduling in manufacturing industries where machines are used for production of goods. Now lets see what kind of scheduling has to be performed in service industry like restaurants, courier services etc.,

In service industry the only critical resource which needs to be scheduled is human resource which is temperamental and comes with a lot of limitations. In BPO's and restaurants where work happens in a number of shifts and the staff is generally part time it becomes difficult to give time slots to the staff as you never know when the work inflow would be high. Another problem could be giving two consecutive days off to all the employees, when employer wants all seven days as working days. The problem gets even more complicated while going deep to set weekly, daily and hourly schedules. So all the issues in short can be summarized as follows:

1. Customer's direct interaction
2. High variability in demand

Two operations:

1. Front of the house
2. Back of the house

11.7 Methods to Meet Customer Service Facilities

- **Appointment System –** customer arrival time can be controlled. Like prestigious saloons, dress designers entertain clients only if they have to an appointment then only they are given entry into the establishment.
- **Reservation System –** At some places customers have to make a reservation first before they could enjoy the place like hotel rooms etc.
- **Strategic Product Pricing –** Strategic pricing is a method in which prices are adjusted according to demand of a product. When demand is high prices are higher and in off season prices are lower, same happens during different hours of the day like higher price at peak hours, electricity at high price in summer, advertisements also become expensive at prime time.

11.8 Summary

Organizations schedule their activities in order to meet customers' requirements on time and improve their operational efficiency. Scheduling activities are not only important for manufacturing firms but they are equally important for service organizations also. But the focus of both are different, while manufacturing concerns schedule production on machines, service organizations focus on employee scheduling using mathematical tools that can be used to set work schedule in light of expected customer demand.

11.9 Key Words

- **Backward Scheduling –** Starts from some date in future (generally the due date) and schedules the required operations in reverse order. It tells the latest date when an order can be started so that it is completed by a specific date.

- **Dispatching –** The activity of initiating scheduled work.
- **Finite Loading** – Each resource is scheduled in detail using the set up and run time required for each order. The system determines exactly what will be done by each resource at every moment during the working day.
- **Forward Scheduling –** Schedules from now into the future to tell the earliest date by which an order can be completed.
- **Johnson's Rule** – A sequencing rule used for scheduling any number of jobs on two machines. The rule is designed to minimize the time required to complete all the jobs.
- **Labor Limited Processes** – People are the key resource that is scheduled.
- **Machine Limited Processes** – Equipment is the critical resource that is scheduled.
- **Priority Rules** – The logic used to determine the sequence of jobs in a queue.
- **Work Center** – An area in a manufacturing plant where productive resources are organized and work is completed.

11.10 Self Assessment Test

(1) What is scheduling? Explain the different scheduling activities with an example.

(2) Is scheduling important only in manufacturing firms? If not, elaborate in which other industry it is used and write down the way to do it.

(3) Ayush Ceramics Ltd. manufactures tiles. It has received 4 orders from its customers P, Q, R, and S in the same order at the beginning of the month.

The processing time and due dates of these orders are given on the next page:

Jobs (in order of arrival)	Processing Time (in days)	Due Date (days hence)
P	2	5
Q	5	7
R	7	10
S	4	8

Solve this by the following methods and calculate average delay of a job in each case.

(i) Earliest Due Date

(ii) Longest Processing Time

(iii) Shortest Processing Time

4 Sanjeeva Jewels Emporium has received 5 orders from its customers for making necklaces. The processing time and due dates of these orders are given on the next page:

Jobs (in order of arrival)	Processing Time (in days)	Due Date (days hence)
P	3	8
Q	6	9
R	9	12
S	5	7

Solve this by the following methods and calculate average delay of a job in each case.

(i) First Come First Serve (FCFS)

(ii) Slack Time Remaining

(iii) Last come, first served (LCFS)

(iv) Critical Ratio

(v) What is a work center? Write down its importance.

(vi) Solve the following question by forward scheduling.

Can these jobs be completed in a span of 12 hours?

Job M Route Sheet			Job N Route Sheet		
Routing sequence	Machine	Processing Time Hrs.	Routing sequence	Machine	Processing Time Hrs.
1	1	1	1	1	3
2	2	2	2	2	4
3	1	3	3	1	1
			4	2	2
Total		6			10

(7) Following is a chart showing 3 jobs which are to be done on 3 machines. Make a schedule for it by Forward and Backward scheduling.

Job A Route Sheet			Job B Route Sheet			Job C Route Sheet		
Routing sequence	Machine	Processing Time Hrs.	Routing sequence	Machine	Processing Time Hrs.	Routing sequence	Machine	Processing Time Hrs.
1	1	2	1	3	1	1	1	1
2	2	3	2	2	2	2	2	4
3	1	1	3	1	3	3	3	1
4	3	2	4	3	1	4	2	2
Total		10			6			10

11.11 References

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Unit - 12 Total Quality Management

Structure of Unit:

12.0 Objectives

After completing this unit you would be able to:

- Understand the concept of quality and learn how to use quality as a competitive tool;
- Examine quality assurance, quality control, and quality planning;
- Understand the concept of TQM and its impact on the organisation;
- Know about the evolution of TQM;
- Enhance the understanding regarding various TQM concepts;
- Explain the systems approach to TQM and its implementation requirement;
- Point out various quality initiatives in Indian companies.

12.1 Introduction

In response to the question "What is quality?" Some people say that it is "getting what you pay for". Some says quality is "getting more than you paid for!" Quality is a term that is very common. In day-to-day conversation, if something needs to be classified as being 'superior', it is often said to be of 'good quality'. The Oxford American Dictionary defines quality as "a degree or level of excellence". It is obvious that quality can be defined in many ways, depending on who is defining it and to what product or service it is related. In this section of the unit we attempt to gain a perspective on just what quality means to consumers and different people within a business organisation.

- **Consumer's Perspective on Quality**

Quality is rapidly becoming a major factor in customer's choice of products and services. Customers now perceive that certain companies produce better-quality products than others, and they make decisions about which products to purchase accordingly. An important consideration, then, in producing quality products is how consumers make judgments as to what constitutes good

quality; that is, how does the consumer define quality? The consumer can be a manufacturer purchasing raw materials or parts, a store owner or retailer purchasing products to sell, or someone who purchases retail products. W. Edwards Deming, the internationally famous author and consultant on quality, has made the frequent observation that "The consumer is the most important part of the production line. Quality should be aimed at the needs of the consumer, present and future." From this perspective, product quality is determined by what the consumer wants and is willing to pay for. Since individual consumers have different product needs and requirements, they will have different quality expectations. This results in a commonly used definition of quality as a product's fitness for its intended use, or **fitness for use.** In other words, how well does the product do what the consumer or user thinks it is supposed to do and wants it to do?

David Garvin has identified eight dimensions of quality or product quality characteristics, for which the consumer looks in a product.

1. **Performance:** The basic operating characteristics of a product, for example, how well a car handles or its mileage.
2. **Features:** The "extra" items added to the basic features, such as a stereo CD or a leather interior in a car.
3. **Reliability:** The probability that a product will operate properly within an expected time frame.
4. **Conformance:** The degree to which a product meets pre established standards.
5. **Durability:** how long the product lasts; its life span before replacement.
6. **Serviceability:** The ease of getting repairs, the speed of repairs, and the courtesy and competence of the repair person.
7. **Aesthetics:** how a product looks, feels, sounds, smells, or tastes.
8. **Other Perceptions:** Subjective perceptions based on brand name, advertising, etc.

These quality characteristics are weighed by the customer relative to the cost of the product. In general, consumers will pay for the level of quality that they can afford. If consumers feel like they are getting what they paid for, then they tend to be satisfied with the quality of the product.

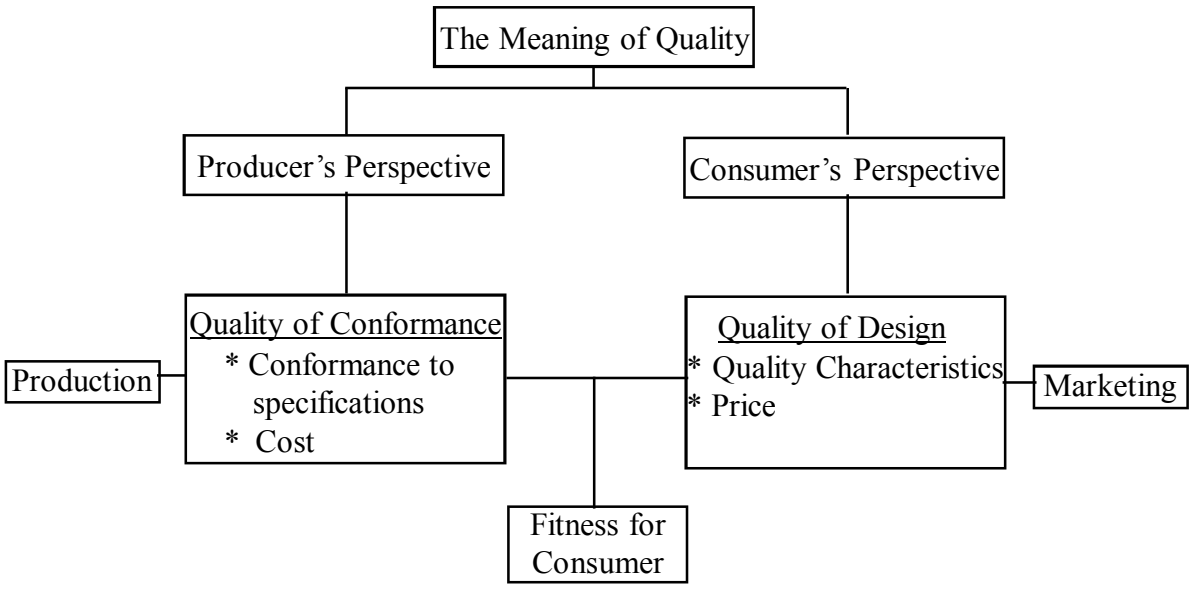

Figure 12.1 Meaning of Quality

- **Producer's Perspective on Quality**

A second point of view of quality derives from the producer's (or manufacturer's) point. We have already mentioned how product development is a function of the level of quality characteristics (i.e., the product's fitness for use) that the consumer wants, needs, and can afford. Product design results in design specifications that, it is to be hoped, will achieve the desired quality characteristics. How ever, once the product design has been determined, the producer perceives quality to be how effectively the production process is able to conform to the specifications required by the design. This concept is referred to as the **quality of conformance.**

The ability to achieve quality of conformance is a function of a number of factors in the production process like design of the production process itself, the performance level of machinery and equipment, the materials used, the training and supervision of operators, and the degree to which statistical quality control techniques are used.

In our previous discussion we noted that an important consideration from the consumer's perspective of product quality is the **product price**. Alternatively, from the producer's perspective an important consideration is achieving quality of conformance at an acceptable cost. Product cost is also an important design specification. Thus quality characteristics included in the product design must be **balanced against production costs.**

Competitive environments demand a better quality product or service at lower costs. Only those organizations which manage productivity and quality on a continuous basis are in a position to compete in increasingly global market place. The impact of poor quality on any organisation is presented in Figure. 12.2

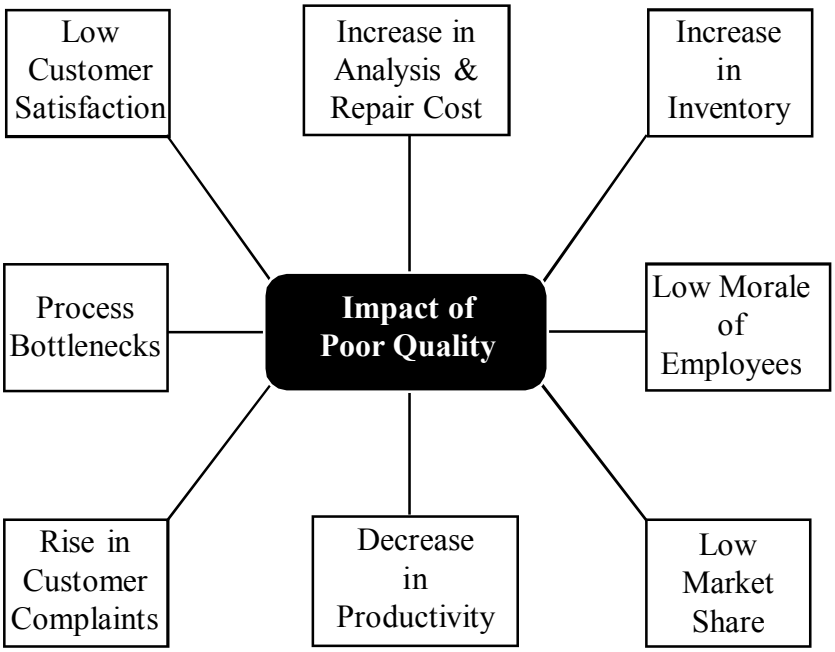

Figure 12.2 Impact of Poor Quality on an Organisation

Figure 12.1 summarizes our discussion of the meaning of quality from the consumer's and producer's perspectives. At the end of the figure, note that the final determination of quality is **"fitness for use",** which you will recall is the consumer's view of quality. This is a natural conclusion, since ultimately it is the consumer who makes the final judgement regarding quality, and so it is the consumer's view that must be dominant.

The modern view of quality is that products should totally satisfy the customer's needs and expectations in every respect on a continuous basis. This new concept of quality calls for:

- Well designed product with functional perfection at right time.
- Providing satisfaction beyond customer's expectation
- Excellence in service
- Absolute empathy with customer.

- **Definitions of Quality**

1. According to Juran, Quality is "Fitness for purpose or use"
2. As per the ISO 8402 Quality Vocabulary Quality is "The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs"
3. In the words of Feigenbaum "Total composite of product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product and service in use will meet the expectation by the customer"
4. According to Deming "Quality should be aimed at the needs of the consumer, present and future"
5. According to Crosby "Quality is conformance to requirements"
6. In the words of Broh "Quality is the degree of excellence at an acceptable price and control of variability at an acceptable cost"
7. The "official" definition of quality by the American National Standards Institute (ANSI) and the American Society for Quality Control (ASQC) is "the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs."

12.2 Quality Control and Quality Assurance

- **Quality Control** refers to the measures that ensure that all the equipment, processes, and personnel within an organisation adhere to rules that maintain the required level of quality from the first to the final stage of production. Quality planning constitutes all those processes connected with determining the needs of customers and optimizing the product features so as to meet the customer's needs.

- **Quality Assurance** refers to all the planned and systematic activities implemented within quality system that evoke confidence that a product or service will fulfill requirements for quality, in terms of fitness for use, and conformance to legal and environmental standards. It involves the activities of verification, audits and evaluation of quality factors. Quality assurance system is to provide guarantee which a customer requires that a supplier will deliver goods of desired quality. Responsibility of implementing Quality Assurance System lies with Quality Management which has also to carryout the following functions:

- To get support of top-management and ensure quality to customers and care to customer satisfaction.
- To make the programme of quality as programme of masses, i.e. to obtain participation and contribution of each employee.
- To develop awareness amongst all employees (quality attitude)

- To formulate quality policy, objectives, goals as per corporate policy.
- To develop quality plans.
- To ensure that quality control works:
  - Develop quality improvement group.
  - Training, education to all concerned people and continuous evaluation.
- To introduce rewards and incentives.

Quality assurance and quality control are often used interchangeably to refer to the actions performed for ensuring the quality of a product or service. However, both terms have multiple interpretations.

12.3 Total Quality Management (TQM)

Quality is regarded today as the most accurate arrow in a company's quiver, to hit the bull's eye of strategic competitive advantage in both domestic and international markets. The various attributes of quality such as performance, features, reliability, conformance, disability, aesthetics and perceived quality are being constantly evaluated and upgraded so to be in sync with current and future market demands.

In the previous section we approached quality from two perspectives, the consumer's and the producer's. In this section we explore how quality is managed in a business organization. Thus, our focus will be from the producer's perspective on the production process and achieving quality of conformance. The production process is used here in a broad context to mean the conversion of resources (of any type) into goods and services. In order to assure that the quality level designed into products are achieved, a commitment to quality through out the production system is required; that is, a systems approach to quality must be used. This approach to the management of quality throughout the entire production system and business organization has evolved into what is currently referred to as Total Quality Management, or TQM.

The TQM philosophy is then the guiding light that leads to superior product and process design, world class manufacturing, statistical process control, design of experiments and improved vendor as well as customer relations.

12.4 The Evolution of Total Quality Management (TQM)

The term quality assurance was first used at Bell Telephone Laboratories during the 1920s by a group of early pioneers in the field, including George Edwards, Hardold Dodge, and Walter Shewhart. Many of the technical methods for statistical quality control, such as control charts and sampling techniques, were developed by these individuals and in 1940 the emphasis was on process improvement.

It was as early as 1954 that Armand Feigenbaum came up with term total quality control. He defined TQC as an effective system for integrating the quality development, quality maintenance and quality improvement efforts of various function of business to enable production and service at the most economical levels to meet full customer satisfaction. Around the same time W. Edward Deming and Joseph M. Juran, Ishikawa were helping war-torn industries of Japan to recover and recoup with somewhat similar philosophy and techniques. Japanese termed this initiative as Company Wide Quality Control (CWQC).

Although the word total was replaced by company wide, the concept is the same - that all employees at all levels of the organization, led by top management, are responsible for quality. In 1960-70 there was zero defect movement in US to improve the quality of products & services and the initiator of this philosophy was Crosby.

In recent years the expression TQM has become popular. It embodies the same basic principles as quality assurance, total quality control, and companywide quality control. TQM emphasizes top management's predominant role in leading a total quality effort on which all employees at all levels must focus. All employees are responsible for continuous quality improvement, and that quality is the focal point of all organizational functions. TQM also emphasizes that quality is a strategic issue. The organization must determine what the customer wants in terms of quality and then use strategic planning encompassing all functional areas to achieve strategic goals related to quality.

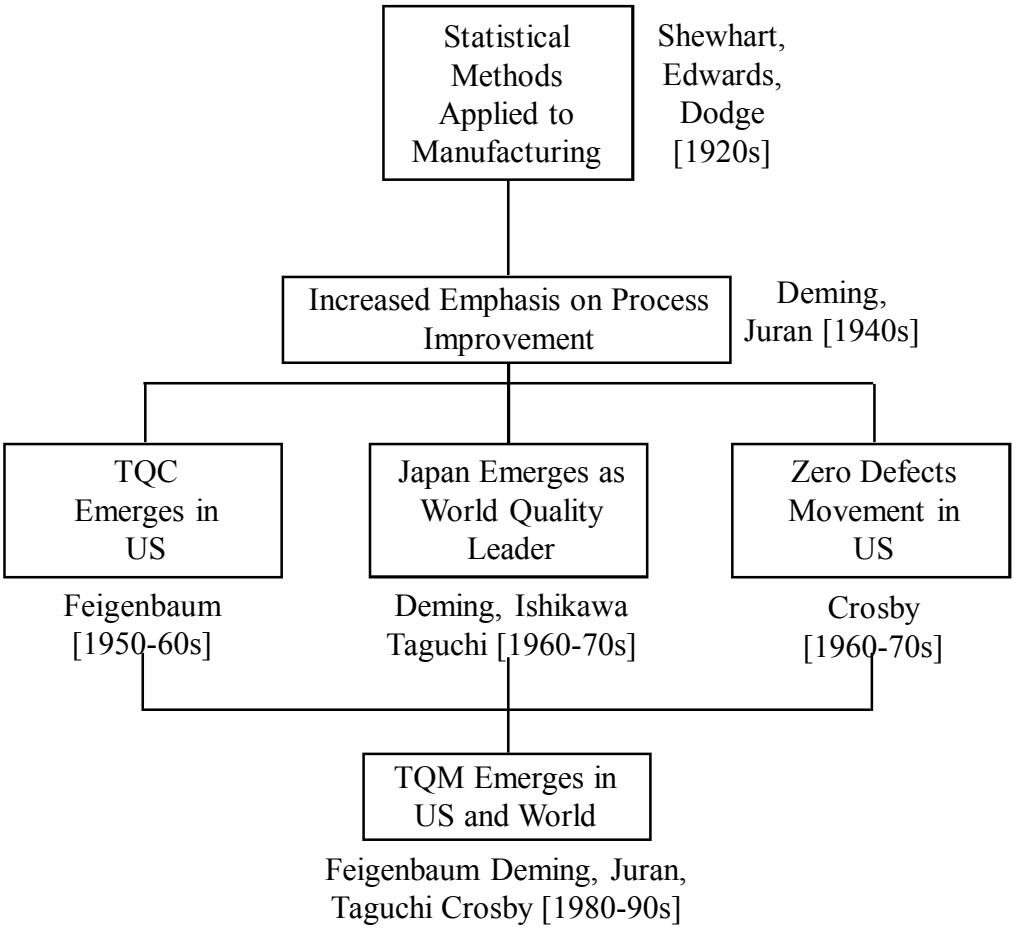

Figure 13.3 Evolution of Total Quality Management

In fact, to summarize, the three Americans Feigenbaum, Deming and Juran conceived and nurtured the idea, the Japanese Ishikawa and Taguchi refined the concepts in the test bed of Japanese industry and now TQM revolution is a rage in America (to regain America's Manufacturing Competitiveness) and it is fast spreading in the world.

12.5 What is TQM?

In our previous section, we came to know about the evolution of TQM, and now we will know that "what exactly TQM is"? Total quality management is a process with a strong philosophical base which incorporates many of the concepts upon which total quality control systems are based, but goes even further in emphasizing that quality should be managed into the system, and quality

management should always be oriented towards the achievement of complete customer satisfaction. Let's understand the different elements of TQM:

- **Total:** It refers to everything, including human resources and equipment, associated with the company that is involved in continuous improvement.
- **Quality:** It refers to the 'expressed and implied requirements' of the customers that are met fully, i.e., based on the customers' perceptions of a product's design and how well the design matches the original specifications as well as the stated or implied needs of the consumers. According to ISO 1994 quality is 'the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need'; 'fitness for use' (Juran); and 'conformance to requirement' (Crosby).
- **Management:** It means that top management and executives are fully committed to the philosophy of TQM. Satisfying the consumer's needs and expectations implies that a company needs to define accurately, early in its product / service development cycle, various attributes related to design, performance, price, safety, and delivery specifications from the consumer's perspective. The modern trend in total quality management is to exceed expectations of the consumers and delight them.

Total Quality Management (TQM) as defined by Richard J. Schonberger as, "the Total Quality Management is a set of concepts and tools for getting all employees focused on continuous improvement, in the eyes of the customer."

The quality concepts involved in TQM have worked so well in the manufacturing sector that these can well be applied to services such as banking, transportation, retailing, etc. Total quality management provides the overall concept that fosters continuous improvement in an organization. It emphasizes upon a systematic, integrated, consistent, and organization - wide perspective that involves everything and everyone. In other words, TQM is an important element of corporate culture that represents a vision as well as some behavioural patterns shared by all the members of the organization. TQM has three dimensions - excellence, universality and perpetuity. In TQM, it is not just products, process, customers and employees but it is entire gamut of organizational activities.

12.6 Key Concepts of Total Quality Management

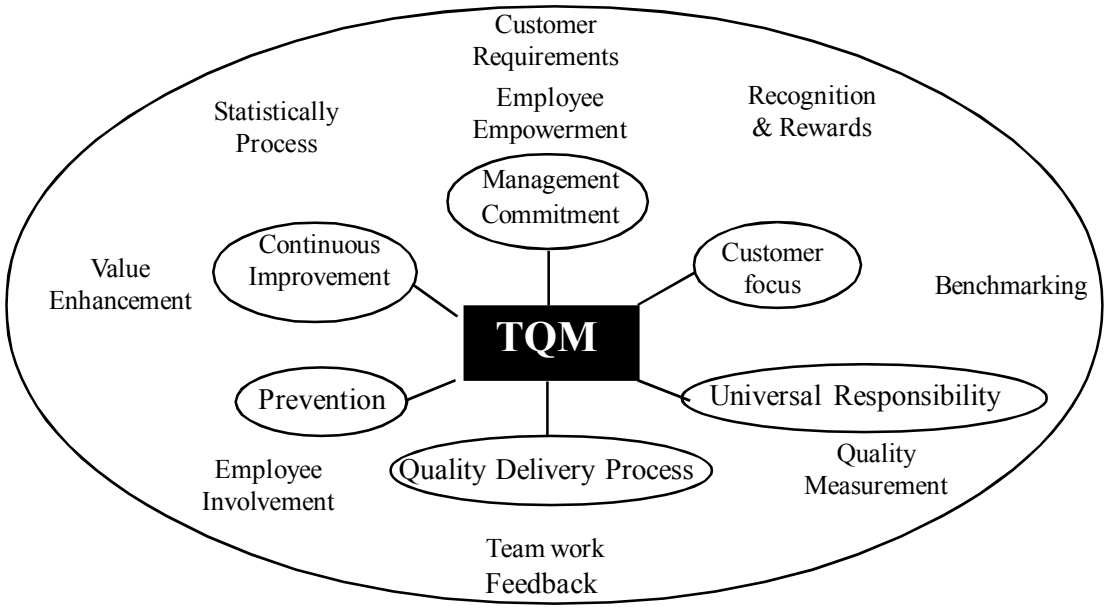

Figure 12.4 Key Concepts of Total Quality Management

1. **Management Commitment to Quality:** An organization's personality and culture will ultimately reflect its senior management's values. If an organization is serious about implementing TQM, the commitment to do so have to start at the top and the organization's senior management has to be unwavering in its commitment to quality. If management is willing to increase the sales only if quality levels are up to requirements, the rest of the organization will understand that the commitment to quality is real.
2. **Customer Focused:** TQM is focused on the requirements of the customer. On the personal front people only go back to restaurants that fully satisfy them and shop regularly at stores that meet their needs. An industrial customer has the same range of emotions as a person. Customer (personal or industrial) after being disappointed & cheated withdraw the business and start buying elsewhere.
3. **Customer Requirements:** In TQM the first question to answer is what does the customer require? The customer will have five questions, consciously or unconsciously. These are the five dimensions of quality. The traditional view of quality is simple 'conformance to specification'. However, this is only part of total quality. Quality involves all of the five dimensions for the customer to be satisfied. The measurement of quality will reflect each of the elements mentioned below:
   - The specification for the product or service.
   - The conformance to the specifications.
   - The reliability (or conformance through time)
   - The value for money aspect
   - The delivery (Quality and on time)
4. **Preventing rather than Detecting Defects:** TQM is a management philosophy that seeks to prevent poor quality in products and services, rather than simply to detect and sort out defects. If a single characteristic is most strongly attached to the TQM philosophy, it is prevention rather than detection. Like many of the philosophies tied to TQM, this is not a new concept. A popular saying from Halliburtion's Wise Saws, "An ounce of prevention is worth a pound of cure." That wisdom says it all, from a TQM perspective.
5. **Universal Quality Responsibility:** Another basic TQM precept is that the responsibility for quality is not restricted to an organization's quality assurance department, but is instead a guiding philosophy shared by everyone in an organization. In TQM everyone takes responsibility for quality. Does this type of thinking work? Absolutely. Most of us would intuitively suspect that in order to improve quality, the quality assurance department would have to grow. In companies that successfully implement TQM, just the opposite occurs. As quality improves, the quality assurance department gets smaller. If everyone is responsible for the quality of the output (and everyone accepts this responsibility), the need for a separate quality assurance function disappears.
6. **Quality Measurement:** Along with "An ounce of prevention is worth a pound of cure" is another saying particularly relevant to TQM, and it is: "If you don't know where you're going, you'll probably end up somewhere." The quality measurement aspect of TQM asks the question: Where are we and where are we going? A basic TQM concept is that quality is a measurable commodity, and in order to improve, we need to know where we are (or stated differently, what the current quality levels are), and we need to have some idea where we are going (or what quality levels we aspire to). This is an extremely important concept.

7. **Continuous Improvement:** TQM espouses a philosophy of continuous improvement in all areas of an organization. This philosophy ties in closely with the quality measurement and universal quality responsibility concepts mentioned above. Quality measurement is needed in order to focus improvement efforts appropriately, and continuous improvement should be pursued in all areas. This TQM concept focuses on finding shortfalls in administrative, manufacturing, and service processes that can detract from a quality output, and improving the process to eliminate undesirable outputs.
8. **Employee Involvement and Empowerment:** Another fundamental TQM concept is that employees must be involved and empowered. Employee involvement means every employee is involved in running the business and plays an active role in helping the organization to meet its goals. Employee empowerment means employees and management recognize that many obstacles to achieving organizational goals can be overcome by employees who are provided with the necessary tools and authority to do so.
9. **Team Work:** In addition to the TQM concepts of empowerment and involvement of employees, taking advantage of the synergy of teams is an effective way to address the problems and challenges of continuous improvement. Dr Kaoru Ishikawa first formalized the team's concept as part of the TQM philosophy by developing quality circles in Japan.
10. **Statistically Thinking:** Thinking Statistical is another basic TQM philosophy. Quality efforts often require reducing process or product - design variation, and statistical methods are ideally suited to support these objective.
11. **Benchmarking:** Comparing one company's performance with that of another is a reflex of TQM. Competitive benchmarking is a continuous management process that helps firms to assess their competitiveness and to use that knowledge in designing a practical plan to achieve superiority in the market place. The measurement takes place along the three components of a total quality programme :-

    Products: Products and services delivered to external and internal customers.

    Process: Business processes in all departments / functions.

    People: Organisation, business culture and calibre of people.

    Competitive benchmarking, then, is a vital component of any total quality programme. Five solid reasons for actively using the techniques are to:

    - Define customer requirements.
    - Establish effective goals and objectives.
    - Develop time measures of productivity.
    - Become more competitive.
    - Determine industry best practices.
12. **Value Enhancement:** The linkage between continuous improvement and value enhancement is simultaneously obvious and subtle. This linkage becomes apparent when one considers the definition of quality, which is the ability to meet or exceed customer requirements and expectations. The essence of value enhancement is the ability to meet or exceed customer expectations while removing unnecessary cost. Removing unnecessary costs and simultaneously satisfying customer expectations and requirements can only serve to increase customer satisfaction.

13. **Feed Back:** Performance feedback is vital to enable managers at all levels to improve their contribution to the business. Feedback provides information on where a manager is today and gives an indication of level of improvement compared with previous feed back.
14. **Recognition and Rewards:** An appropriate system of recognition and reward is critical to any company's TQM programme, particularly as the quality improvement process offers involvement to ordinary working people. Positive reinforcement through recognition and reward is essential to maintain achievement and continuous improvement through participative problem solving projects. People work for many reasons, for achievement, advancement, increased responsibility, recognition, job interest as well as finance.
15. **The Quality Delivery Process:** TQM is not just about awareness of Quality. TQM demands the implementation of new systems. 'The Quality Delivery Process' is a generic name for such a system. The purposes of the quality process are to:
    - Ensure that everyone works on those activities which are most important for the success of the business by fulfilling work group missions.
    - Improve the quality of work delivered (outputs) to the customers-internal customers, the next person down-the-line, who receives the work.
    - Eliminate work that is wasted because people do not do it right the first time.
    - Harness the combined skills, ideas and experience of the work group members to improve the business continuously through team work.
    - Satisfy the external customers.

12.7 Planning and Implementation of TQM

The strategic implementation of TQM involves continuous improvement of the quality, reduction of the costs, and delivery of goods in time as well as pushing for innovation thus strengthening the competitive edge in the process. It encompasses leadership, pre-operational, post operational organizational aspects and production processes. From choosing the right production equipment, to the right personnel and the right strategy of marketing and customer service.

To ensure effective implementation of TQM system the following paradigm shifts are needed shown in Table – 12.1

Table -12.1 Paradigms Shift Needed for Implementation of TQM

From	To
Control Management	Commitment Management
Tracing problems to workers	Tracing problem to systems & positive management
Focus on specific tasks and company standards	Focus on process & customer needs
Task assignment to individuals	Team work and synergy
Tall pyramidal Organization structure	Flat, flexible structure
Command oriented management	Consensus oriented management.
Unstated values	Standard and stated values
Drive people towards goal	Enable people to achieve goals through leadership
Resources consuming management	Resource creating management
Record keeping - close supervision to find faults	Score keeping - caching people doing the right and allowing them to score (trust)
Top-Down approach	Top-down, bottom-up approach

The following aspects are important in planning and implementing TQM:

1. **Quality Vision:** A statement regarding what your organization will become and how good your organisation intends to be in the business. Quality vision creates a common focus for the business organization, thus encourages strategic planning. The major areas covered under the head of quality vision:
   - The basis for strategic planning.
   - The basis for implementing quality initiatives.
   - The direction for heading with quality.
2. **Quality Policy:** To enunciate the basic principles which are to guide the action of the organization, to fulfill the quality vision, it is essential to document these and make it known to all employees. It is important that all further activities in the organization are not in conflict with the policy, aim and objectives conveyed.
3. **Quality Strategy Development:** The quality strategy should be based on the information that is important to customer i.e. how customer view quality. Quality strategy should be a part of overall strategic plan for the business. The major areas that it should cover include:
   - Customer needs
   - A documented strategy.
   - Data from wide spectrum of potential customer.
4. **Quality Goals:** A statement on specific goals related to the quality of goods/services to be offered by the organisation. The quality goals should be measurable. Quality goals can be set on the basis of following:
   - The needs and satisfaction of your customers.
   - Your performance compared to your competitor.
   - Specific performance defects.
   - Training needs.
5. **Deployed Objectives:** Quality goals (long term quality goals) must be divided into smaller objectives which can be easily implemented. Specific individuals must be assigned the responsibility to meet the objectives. The objectives can be set on the basis of resources and negotiation between the groups/individuals.
6. **Functional Responsibilities and Delegation:** All divisions, departments and sections have to spell out in clear terms their responsibilities. It is necessary to develop and well define as to what is required of each department and section. It should be stated in a way that serves as basis for action. It provides a yard stick for measuring progress and promoting target achievement. It is important to define the required quality in each section and to achieve the target without failure will eventually lead to improvement of the Total Quality Level.
7. **Information Sharing:** It is very important to create an overall awareness about the organization at all levels. The success of quality teams depends on resources used to perform the work. The most important resources include training, time for meeting, data collection and analysis, facilitator support, data analysis support, etc. Lack of this knowledge creates indifference in the employees of the organization. Information pertaining to organizational history, growth and development, routes and areas covered, public acceptability, future plans both short term and long term, achievements etc.; all policies, procedures, and rules affecting

employees must be made known to them and updated. The most important task is to organize the flow of information.

- From the top to the bottom.
- From the bottom to the top.
- Within various levels of the organization.

Total quality is directly dependent upon precise and timely communication.

8. **Customer Data:** Planning TQM requires adequate data of relevant areas:
   - Identification of customers, their needs expressed in terms of benefits.
   - The relative importance of each need.
   - Customer evaluation of your quality.
   - Customer evaluation of the competitor's quality.
   - Measure of performance of the self against the competitor's goods / services.

   Data on these areas should be adequate so that some statistical methods and scientific samples that include both current customers and potential customers can be applied.

9. **Quality Culture:** For effective implementation of TQM system, Quality Culture is very Crucial. It includes following:

(a) Personal Involvement: It includes:

- Meeting with people of all levels frequently
- Meeting and focusing attention on quality.
- Meet customers.
- Delivering talks in training.
- Lead quality based efforts.

(b) Consistency: Consistency in quality means not allowing the ordinary rush of business or even extraordinary events to slow or to suspend the process.

- Never allow other activities to interfere with scheduled quality responsibilities.
- Try to be consistent in quality / assigned activities.
- Consistent in quality initiatives.

(c) Changing Culture by Providing Time: People often require time to adjust to proposed changes. Time provided should be based on time needed for change psychologically, but if it is too long, it may paralyze the system. This time should be adequate to accommodate matters of dispute. Resistance to change may sometime create problem. So we should develop active plans dealing with resistance, but prove enough time to adaptation.

(d) Leadership is desired at the top level of management to lead the organization with impact. It may be based on focusing on the degree to which the top management or managers demonstrate faith in their subordinates through delegation. It can be assessed on the basis of:

- Sound decisions taken by subordinates.
- How much to concentrate on resources, methods, goals.
- Subordinates need careful review of their work/performance frequently and corrective actions are suggested to have better results.

(e) Changing Culture through Actions: Attitudes change as a result of activities in which

individuals participate. Efforts to change attitudes directly are rarely successful. The type of training that you provide is one indicator of the orientation of your efforts to create a quality culture. Training or other activities that focus directly on changing people's attitudes will create short term changes.

(f) Elimination of Blame: Blaming individuals does not solve the problems, it simply creates hostility. If we continue to blame people, we will create a situation in which we will be unable to solve problems because individuals will be fearful of identifying, describing or working on problems.

- Uncover the root causes of problems.
- Be consistent in assigning the faults.
- Less blame oriented approach.

10. **Quality Efforts:** Quality council or steering committee should be appointed to lead the quality efforts.
    - Top management to review periodically the status of quality and action taken.
    - Steering committee should also review the results of performance on periodic basis.
    - Steering committee should set the quality improvement groups.
    - Committee should set the priorities, top priority should be to satisfy customer.
    - Review the product deficiencies, cost of poor quality and quality culture.
11. **Purchase Quality Control:** An operating system and procedure for assuring quality of materials, equipment and spares, source selection, evaluation and development to meet all quality requirement consistently and includes proper packaging, handling, storage and issue. The same is applicable while sub contracting for any materials / work. Control of purchased inventory forms is an integral part to achieve the above. The relation between vendor and vendee has to make use of principles enunciated for assurance of quality.
12. **Process Quality Control:** It is necessary to introduce process quality control philosophy in organization. It means to check the process or product during production not after the production. The key points are:
    - To determine true quality characteristic for own process/outputs.
    - To determine the measurement methods,
    - To have proper, common understanding of errors, defects and deviations,
    - To expose latent deficiencies and observe quality statistically, and
    - To arrive at and maintain standards as well as review / revise and improve them.
13. **Monitoring Progress towards Goals and Quality Audit:** The results with respect to each goal must be measured regularly. Top-management must assign this responsibility for action so that goals/objectives can be met economically. It includes:
    - Progress measured against documented goals/objectives.
    - Results review and prompt corrective action to be taken.
    - Performance results highlighted.

    Quality Audit means to study the quality of a given product by taking samples from time to time either from within the company or from the market place. It checks the quality of the product to see if the requirements of the consumer are satisfied. If any defects, are

discovered, they are corrected which increase the product's attractive quality. The latest trend in quality auditing is to engage in a total quality audit which studies the entire management system. There are three ways for conducting quality audit in any organization:

- To be conducted by the corporate as well as by persons from other units.
- To be done internally by division/departments, and
- To be done by a consultant.

14. **Motivation through Non Monetary and Monetary Reward:** Recognition is a strong non-monetary incentive to adapt changes. Recognition must be in a form that is valued by the individuals being recognized. One of the most powerful forms of recognition is the active and personal participation of top-managers in the review, discussion, and implementation of results on which other individuals have worked. There shall be separate system for financial reward/incentives for contribution to quality.
15. **Quality Circle Activities:** Quality circle activities are to be carried out only as a part of TQM activities, to sustain the movement at work place. The outstanding features of the quality circles are:
    - Humanizes the work ie. Quality of work life is stressed and improved.
    - Brings out extraordinary qualities from ordinary people.
    - To display the human capabilities fully and eventually draw out infinite possibilities.

12.7.1 Operational Model of TQM:

Operational Model of TQM provides a very different view - point of management style. The corner stone of TQM are total participation and teamwork. Earlier such participation and team work was initiated through quality circles suggestion schemes and quality improvement teams. Currently the focus is more on self-motivated and self-empowered teams comprising multi-skilled workers.

Another dimension of the Operational Model of TQM as depicted in Figure 12.5 is the continuous quality improvement (through various quantitative tools), innovations as per customer wants and needs.

Figure 12.5 Operational Model of TQM

At the apex of the model is the support and commitment of top management towards the ultimate aim of customer satisfaction. Without the sustained support of management the TQM effort cannot be made operational.

At the centre of model is the total quality management system (QMS) which incorporate to issues such as quality assurance, quality planning, quality control, Quality policy, manual documentation and information on quality related matters.

12.8 Quality Initiatives and Benefits

The benefits of TQM include:

- The minimization of waste.
- Increased customer satisfaction and, therefore, additional sales.
- The ability to redeploy resources to add real value.
- The achievement of competitive advantage. Companies are increasingly competing on the basis of quality products and services, and
- Focusing attention on continuous improvement.

Overall, the process of developing a TQM culture can increase involvement, identification and commitment. The experiences of successful TQM oriented companies show that the integration of key business requirements is achieved by following a set of core values and concepts.

- Focus on results;
- Employee participation and development;
- Build-in prevention and reliability;
- Customer - driven quality in products and services;
- Supply chain quality;
- Continuous individual and organizational learning;
- Management leadership in quality initiatives;
- Long - term vision, planning, and commitment; and
- Fast response to market and customers.

The boom in the Indian economy has seen a proliferation of goods. Whether it is automobile components, machines, or textiles, the costs are lower and quality is comparable to best worldwide. The examples are Infosys, Wipro, TCS, and Satyam in software; Sundaram Fasteners and Bharat Forge in Manufacturing; and a plethora of companies in textiles. According to Natrajan (1999) the quality evolution in post independent India followed the following stages:

- Inspection of products in factories and receiving departments.
- Statistical Quality Control and sampling plans.
- Process quality control in manufacturing industries.
- The ISI mark was recognized as a quality standard for products.
- ISO 9000 certification for manufacturing.
- ISI 9000 certification for service industries
- Kaizen for continuous quality improvement.
- Quality circles for management of quality.
- Juran and Crosby methods for TQM.

12.9 Summary

Quality offers organizations significant opportunities for improvement, including reduced costs, increased sales, better performance schedule, and more satisfied customers. A successful quality system does more than ensure the quality of products and services; it drives vigorous operations and leads to a healthy bottom line.

Total quality management provides the overall concept that fosters continuous improvement in an organization. It emphasizes upon a systematic, integrated, consistent, and organization - wide perspective that involves everything and everyone. In other words, TQM is an important element of corporate culture that represents a vision as well as some behavioural patterns shared by all the members of the organization. The total quality management process is not simply a new set of buzzwords on this week's quality slogan. TQM emerged is the result of pioneering work by Deming, Juran, Shewhart, Feigenbaum, and other. The TQM process gained acceptance in the United States during the 1980s, and the TQM quality revolution is continuing to develop in world. The terms quality assurance and quality control are used interchangeably. Quality assurance refers to all the planned and systematic activities implemented within the quality system. It evokes confidence that a product or service will fulfil requirements for quality. Quality control refers to all measures that ensure that all the equipment, processes, and personnel within an organization adhere to rules that maintain the required level of quality from the first to the final stage of production. Quality planning constitutes determining the needs of those customers and optimizing the product features so as to meet the customer's needs.

In TQM, it is not just products, process, customers and employees but it is entire gamut of organizational activities. Key concepts of total quality management are management commitment to quality, focus on customer requirements, preventing rather than detecting defects, universal quality responsibility, quality measurement, continuous improvement, employee involvement & empowerment, team work, statistically thinking, benchmarking, value enhancement, recognition and rewards, and the quality delivery process.

Quality vision, quality policy, quality strategy development, quality goals setting, functional responsibilities and delegation, information sharing, building Quality culture, purchase quality control, process quality control, monitoring progress towards goals, quality audit, quality circle activities, customer satisfaction, and employee motivation, are some elements to be considered while implementing TQM. Organizations such as the International Organization for Standardization (ISO) and Bureau of Indian Standards (BIS) set standards of quality for products and organizations.

12.10 Self Assessment Test

1. What do you understand by quality? Which definition of quality you like best and why?
2. How do you define TQM? Explain operational model of TQM.
3. "Quality should be aimed at the needs of the consumer, present and future" explain and also put light on the evolution of TQM.
4. What do you mean by the terms "Quality Assurance", "Quality Control" and "Quality Planning"? Is there any relationship between these? Explain
5. Describe the various key elements of TQM with suitable examples.

6. If you are required to implement the TQM in your organisation, write down the various point related to this.
7. What in your opinion should be done to change the mindset of Indian Industry regarding Total Quality Management?
8. What factors should be kept in mind while implementing TQM in an organisation?

12.11 References

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Unit - 13 ISO : 9000

Structure of Unit:

13.0 Objectives

After completing this unit you would be able to:

- Understand the concept of quality standards;
- Know in detail about ISO : 9000 standards;
- Explain the genesis of ISO : 9000 standard series;
- Differentiate between the usage of ISO : 9001, 9002, 9003 and ISO : 9004 codes;
- Enhance the understanding regarding elements applicable to ISO : 9001, 9002, 9003;
- Draw road map about national efforts done in India regarding IS standards;
- Examine the need of IS : 14000 in Indian business environment;
- Point out various quality standards like ISO : 9000, IS 14000, EN 29000 and BS 5750.

13.1 Introduction

Liberalization of economy, opening up the trade barriers, the gradual integration of local market into a global environment, the internationalization of engineering and IT activities and global access to knowledge and information have all contributed to a growing appreciation of Quality Requirements and Assurance in all Business Activities. To survive and remain competitive in global market, goods/services offered should not only be of high quality, but also be reliable, safe, energy-efficient, environment friendly and cost-effective. Ability to produce quality goods and services and to sustain them over a long period of time requires implementation of quality standards or systems approach (ISO 9000 Series of Quality Systems). Regional and International Standards in Quality Measures and Assurances like ISO 9000 series of Quality Systems monitor and ensure quality at all stages of manufacturing/production cycle (e.g. material selection-design-process selection-fabrication & assembly-testing-packaging–marketing)

Now Europe Corporations (EC) from world over (be it from the US, Japan or anywhere else)

will be expected to adhere to ISO 9000 registration. The U.K. has already taken an initiative in this direction and more than fifteen thousand British Companies have already been assessed and found conforming to ISO 9000 standards. It is clear that purchasing power of EC is huge and Indian exporters can ill afford to be silent spectators to the changing scenario in the EC market.

In the Indian market context, India has no product/service liability law that binds vendors to produce reliable and safe products/services therefore, perhaps ISO 9000 can prove to be a precursor to advent of product liability laws in India. Further, ISO 9000 also brings in economy is its wake. This is due to the fact that systems in the company adopting ISO 9000 will be controlled from start to finish resulting in economies in resources and time spent on preplanning or modifying processes and designs.

The idea of ISO 9000 certification is slowly gathering momentum in India also. Bureau of Indian Standards (BIS) has done considerable spade work and has got a number of personnel trained in ISO 9000 assessment and certification. The challenge to a developing nation like India is to motivate its manufacturers and service providers to adopt and implement these standards, and to establish a credible national quality registration system which will be recognized and be acceptable to its trading partners.

13.2 Genesis of ISO : 9000

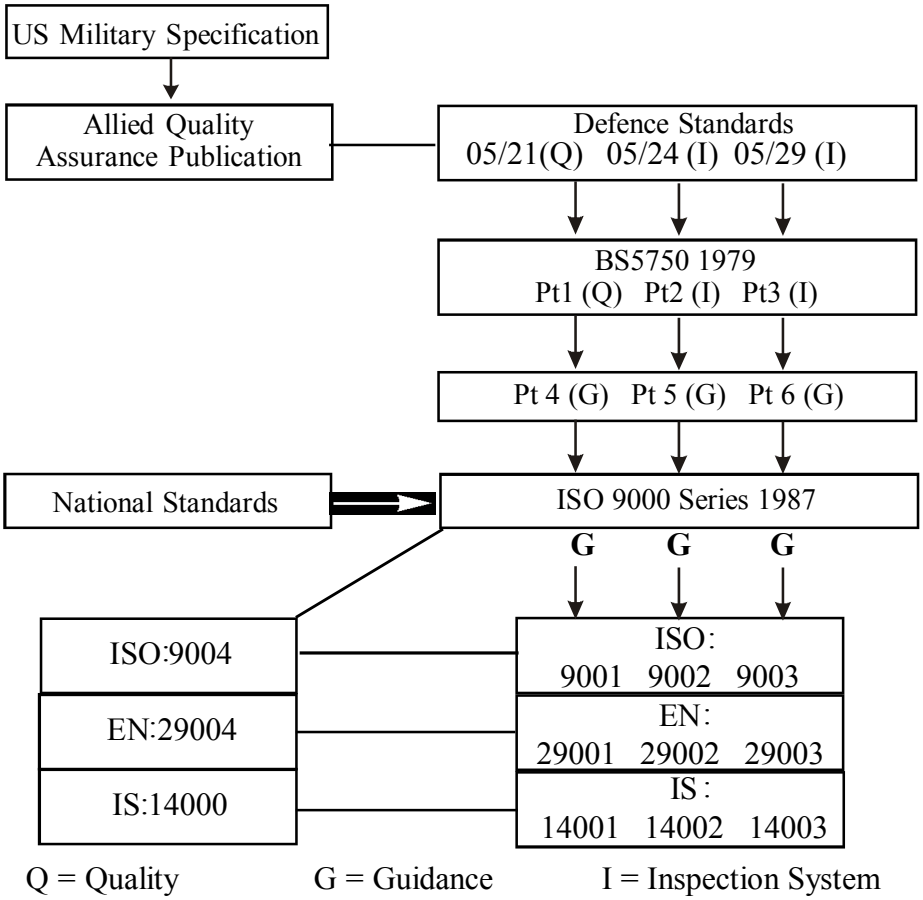

Figure: 13.1 Genesis of ISO : 9000

The roots of ISO : 9000 can be traced to the defence procurement philosophy prevalent in the North Atlantic Treaty Organization (NATO) in the 1950s and 1960s and which by 1970s spread to commercial establishments also. Beginning in the 1950s the defence procurement establishment of the North Atlantic Treaty Organization (NATO) stressed on the concept to make suppliers and

contractors more aware of their responsibilities in meeting the required quality and to achieve a cost-effective approach to large defence projects and requirements.

The supplies of NATO in the 1950s and 1960s were as per the U.S. Military specifications. These were then in consonance with Allied Quality Assurance Publications (AQAP) and were complying with Defence Standards of Ministry of Defence of the UK such as 05/21, 05/24 and 05/29. From these defence standards, BS5750 (1979) Part1, 2 and 3 were developed. These were much broader than the military specifications and hence were generally applicable. Later to BS5750 (1979) were added Parts 4, 5 and 6 which gave explanatory and non-mandatory notes.

The ISO 9000 series was developed by a technical committee working under ISO in Geneva. The series took several years in the making and was an outcome of previous work of military standards in World War II and the British Standards Institution's BS5750 series Part 1 to 6. In 1987, ISO published the ISO 9000 series. This series is a family of quality management and quality assurance standards. This family consists of 17 different standards out of which only ISO 9001, ISO 9002, and ISO 9003 are quotable standards (i.e., can be audited against) while the rest only guidelines.

13.3 Terminology

1. **Quality Policy:** 'The overall intentions and direction of an organisation as regards quality, as formally expressed by top management' (clause 3.1, ISO : 9000). It ultimately forms the key element of corporate policy.
2. **Quality Management:** 'That aspect of overall management function that determines and implements the Quality Policy' (clause 3.2 ISO : 9000). It is also experienced by Quality Consultants that 'Quality Management is not separate from general management. When used effectively, Quality Management should be an integral part of an organization's overall management approach'. That approach is designed to produce quality results for the customer.
3. **Quality System:** 'The organisational structure, responsibilities and authorities, procedures, processes and resources for implementing quality management' (clause 3.3 ISO : 9000). The quality should only be comprehensive as needed to meet quality objectives.
4. **Quality Control:** 'The operational techniques and activities that are used to fulfill requirements for quality' (clause 3.4 ISO : 9000). Quality Control is a very broad concept. When referring to a sub-set of Company-Wide Quality Control, company should use modifying terms such as 'Manufacturing Quality Control'.
5. **Quality Assurance:** 'Includes all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality' (clause 3.5 ISO : 9000).

   The purpose of quality assurance is to provide approximate confidence that a product or service will satisfy specific quality requirements. The purpose of quality-assurance system is to prevent problems form occurring, detect them when they do, identify the cause, remedy for the cause, and thus prevent re-occurrence. The basics (principles) of a quality system are to say what you do, do what you say, record what you did, check the results and act on the difference. But according to ISO : 8402 Quality Management and Quality Assurance vocabulary Quality is defined as 'the totality of characteristics of an activity that bear on its ability to satisfy stated or implied need'.

6. **Quality Objectives:** ISO : 9000 describes an organization's three basic quality objectives. Each organisation should:
   - Achieve and sustain the quality of the product or service produced so as to meet continually the purchaser's stated or implied needs.
   - Provide confidence to its own management that the intended quality is being achieved and sustained.
   - Provide confidence of the purchaser that the intended quality is being or will be achieved in the delivered product or service provided.
7. **Basic Definitions of Three Commonly Used Key Terms:**
   - The Supplier in the organisation is providing a product to the customer. In a contractual situation, the supplier is the producer, i.e. everybody can be a supplier.
   - The Purchaser is the recipient of product or services delivered by the supplier. According to revised version of the ISO : 9000 series standard plans to use the term Customer rather than Purchaser.
   - The Sub-contractor in the organisation provides products/services to the supplier. It is interesting to note that an organisation by itself can be a supplier, a purchaser and a sub-contractor at the same time.

13.4 ISO : 9000

The International Organisation for Standardization (ISO), headquartered in Geneva, Switzerland is a federation of national standards organizations for more than 91 countries. The ISO member for the India is the Bureau of Indian Standards known as BIS.

The objective of ISO is to promote the development of standardization and related activities in the world with a view to facilitating international exchange of goods and services and to develop cooperation in the spheres of intellectual, scientific, technological and economic activities.

The ISO : 9000 series of quality management and assurance standards, developed by the ISO/TC 176 Committee over a period of seven years and first published in 1987, consists of four subsections, ISO : 9001, 9002, 9003 and 9004.

Table 13.1 Quality System Standards

ISO	IS (Indian Standards)	EN (European Norms)	TITLE
9000	14000	29000	Quality Management & Quality Assurance Standards - Selection & Use
9001	14001	29001	Model for Quality Assurance in Design/Development, Production, Installation, Servicing - all elements.
9002	14002	29002	Model for Quality Assurance in Production & Installation
9003	14003	29003	Model for Quality Assurance in Final Inspection & Tests
9004	14004	29004	Guidelines and Development of Quality Management Systems to Minimize Cost & Maximize Benefits.

ISO : 9000 series sets out implementable methods in an organization that assure that the customer's requirements are fully met. It comprises of documented system, invokes total company

involvement, and also acts as a basis for effective management control. ISO 9000 is significantly different from normal engineering standards, such as units of measure, product specification, test methods, etc. set by agencies such as the Bureau of Indian Standards (BIS). ISO 9000 standards requirements are complementary and not an alternative to these engineering standards. Companies should, however, consider implementing ISO 9000 as the first milestone along the path of TQM and quality excellence. The five basic objectives of ISO 9000 are:

- To achieve, maintain and seek continuous improvement in product quality.
- To improve the quality of operation on continuous basis in order to meet customers needs.
- To provide confidence to internal management and employees that quality requirements are being fulfilled and that improvement is taking place.
- To provide confidence to customers and other stake holders that quality requirements are being achieved in the delivered product.
- To provide confidence that quality systems requirements are fulfilled.

13.5 ISO : 9000 Series Standards

ISO : 9000, the first standard in the series, titled Quality Management and Quality Assurance Standards for Selection and Use, is actually a guide for using the other four standards in the series, 9001, 9002, 9003 and 9004. One thing that has to be kept in mind about the ISO: 9000 series of standards that they don't prescribe any readymade answers to quality problems in organizations. What the standards do instead, is to prescribe the basic requirements that must be present if a system is to be considered superior, and capable in the first place, of consistently delivering to the customer what the organization has promised.

- **ISO : 9001,** Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing, is the standard with the widest scope of application. It applies to those instances where a supplier has responsibility for the design and development, production, installation, and servicing of a product. This standard includes a set of generic requirements for the quality management system of the supplier, beginning with top management responsibility and providing objective criteria to verify that key elements in the total quality management approach of the supplier are present. For example, ISO 9001 specifies minimum requirements for contract review procedures, design and process control, inspection, testing, etc. This standard also requires a documented system for the identification of tested products, the control of nonconforming products, and procedures for taking corrective action to avoid repeating nonconformance in processes. It further defines requirements for product handling, storage, packaging, delivery and includes requirements for conducting internal quality audits to verify the effectiveness of the quality management system.
- **ISO : 9002,** Quality Systems - Model for Quality Assurance in Production and Installation, is very similar to ISO 9001 except that it is limited to cases where the supplier is not responsible for design, development, or servicing of the product. For a supplier that only produces and installs a product, ISO 9002 assures the customer that the supplier's quality system for production and installation meets basic requirements.
- **ISO : 9003,** Quality Systems - Model for Quality Assurance in Final Inspection and Test, is limited to cases where product design and installation is less relevant because of the relative

simplicity of the product. As such, this standard is limited to providing guidelines for final inspection and testing. ISO 9003 gives a customer assurance that a supplier's final inspection and test area has quality system elements that guarantee the integrity of data about the quality of the product and actually reflect the quality of the product the customer is receiving. This standard shifts responsibility for quality to the supplier in that if the supplier's inspection and test process complies with ISO 9003, the customer is assured of that quality standard or level of quality when the product is received. Thus, it is not necessary for the customer to repeat the inspection and test process that the supplier has already done. The supplier simply provides the customer with the inspection and test data for the product.

13.6 Elements Applicable to ISO : 9001, 9002, and 9003

The scope of the requirements is presented in Table no. 13.2 and describtion below:

1. **Management Responsibility:** The standard suggests that management responsibility will only then be evident if the organization has enunciated a quality policy, which is documented, and is understood by all in the facility. Furthermore, the responsibility and authority of all those who manage, perform or verify work affecting quality, apart from being defined must also ensure that all such people have the requisite freedom to function in a manner that upholds quality.

Table 13.2 Elements Applicable to ISO : 9001, ISO : 9002 and ISO : 9003

S. No.	Elements	ISO 9001	ISO 9002	ISO 9003
1	Management Responsibility	*	*	*
2	Quality System	*	*	*
3	Control Review	*	*	NA
4	Design Control	*	NA	NA
5	Documents Control	*	*	*
6	Purchasing	*	*	NA
7	Purchase, Supplied Product	*	*	NA
8	Product Identification & Tracetability	*	*	*
9	Process Control	*	*	NA
10	Inspection & Testing	*	*	*
11	Inspection, Measuring & Test Equipment	*	*	*
12	Inspection & Test Status	*	*	*
13	Control of Non Conforming Product	*	*	*
14	Corrective Action	*	*	NA
15	Handling, Storage, Packing & Delivery	*	*	*
16	Quality Records	*	*	*
17	Internal Quality Audit	*	*	NA
18	Training	*	*	*
19	Servicing	*	NA	NA
20	Statistical Techniques	*	*	*

* = Applicable

NA = Not Applicable

The first requirement also encompasses the appointment of a management representative

who will ensure that the international standard is implemented and maintained. On the whole the organization's systems are to be regularly reviewed by senior management to ensure that it is being implemented as it should.

The involvement of senior management in the creation and the subsequent implementation and maintenance of the system is absolutely essential. The standard by making 'management responsibility' a mandatory requirement insists upon ensuring that the modicum of management involvement and support is discernible in the organization. It is obvious that what the standard insists upon is merely the 'bare minimum', and an enterprise wishing to touch a level of quality that is truly world class, has to go much beyond the minimum requirements of the standard. In total quality organizations, the support of management has to come in word and deed, and consistently.

2. **Quality System:** The standard requires that a documented quality system will be maintained in order to ensure that the output (product or service) of the firm conforms to specified requirements. The emphasis is on a documented system consisting of the following tiers of documents:

   - A quality manual, at the division/corporate level which provides a 'bird's eye view' of the quality system.
   - Procedures that are so written down that the questions: what for, When, by whom, where and what? about the system are unambiguously answered. The objective of having procedures is essentially to detail the appropriate methods of going about something, ensuring that the right personnel, who are trained and qualified for the tasks, do them. And in a manner that contributes to the production and delivery of consistent output.
   - Work instructions which are, as the name suggests instructions to people and which explain the 'how' of the system, and its functioning.

   Together the documentation is supposed to serve as a useful way of summarizing the organization's qualtiy programme, while at the same time indicates the linkages that people, processes, and procedures need to maintain for consistently delivering to the chosen customers the promised output.

3. **Contract Review:** This requirement of the standard mandates that any agreement on part of the customer and the supplying firm, based on the latter's promise to provide a certain output to the former, must be established carefully. The standard insists that the requirements of the customers be carefully scrutinized, assessed from the standpoint of being sufficiently detailed, unambiguous, and finally, within the ambit of the firm's process capability. Only when the system ensures that such a systematic review of the customer's requirements has taken place, is the supplier firm likely to be able to deliver what the customer wants right the first time. And that is what any total quality organization definitely must ensure.

4. **Design Control:** This clause pertains to the need for having a proper system whereby the voice of the customer is adequately translated into practical designs, capable of being produced by the operating units, and thereby guaranteeing the satisfaction of the user. This standard insists upon having documented systems in place that go through a sequential step by step approach covering the following:

   - Planning of design and development.

- Assigning the 'translation' to qualified staff, and ensuring that organizational and technical interfaces are clear to all for the free flow of pertinent information.
- Preparing a design brief relating to the requirements of the product or service (design input)
- Preparing comprehensive technical data that confirms that the product will function as it is meant to, while simultaneously also conforming to the safety and other regulatory requirements (design output).
- Verifying that the design outputs 'meet' the design inputs.
- Making sure that any changes in design are suitably made with the prior approval of competent agencies, so that the customers' interests in receiving an effectively designed product are not jeopardized.

5. **Document Control:** This standard emphasizes that the documentation pertaining to the maintenance of the quality system must be adequately controlled, so that at any given point in time, only the most up-to-date issues are in use and utilized by all those who are meant to rely on them in the course of their work. This necessitates having a suitable track of who gets which documents, and how amendments are made to them. Initially, the importance of this does not dawn upon many of us. However, it is fundamental to the process of effective shop-floor based communication. The success of any quality system can be adversely affected by the lack of proper document control.

   Computerization, and the advent of Information Technology has made it possible to have 'real-time' control on documents which are not hard copies, but 'screens' on Personal Computers (PCs). However irrespective of whether the documents are hard copies or on computer, the control that is required must exist.

6. **Purchasing:** From the point of view of the standard, what needs to be ascertained with respect to purchasing is that all purchased material that has a direct bearing on the quality of the product or service that is being rendered to the end-user, conforms to the requirements of the customer. The requirements of the customer, of course, are expected to have been duly and faithfully incorporated into the organization's very own criteria for evaluating purchased products.

   It is also expected that rather than merely relying on the inspection and testing of incoming material, the organization also assesses its suppliers in terms of their quality systems, and other relevant parameters, so that there is confidence in the suppliers' ability to produce what is expected of them, and that relevant records of material purchases are kept so that it is possible to actually determine whether the incoming material is as desired by the customer. Under many circumstances it is to be allowed to have the customer or his representative verify if the purchased material is as desired.

7. **Purchaser - Supplied Product:** In the language of the standard, the organization that supplies the product or service to the user, is the supplier, while the customer or the recipient of the output of the supplier is the purchaser. This usage is consistent in all the standards under ISO 9000.

   The standard makes a provision for the control of material that may be supplied by the customer for use in the final product that is ultimately to be used by the very same customer.

There are countless examples of this kind in industry. For instance, the manufacturer of boilers is asked to make a boiler for use by a steel tube making firm. The customers in this case also insist that they themselves will supply the boiler tubes of the appropriate sizes for fitment in their boiler. Under these circumstances it is mandatory from the standpoint of the standard to ensure that there is a system in place to ensure that the material supplied is suitably stored, verified and maintained in the right manner for incorporation in the product.

8. **Product Identification and Traceability:** This is not a mandatory requirement in the standard, but it is emphasized that wherever appropriate, the producing firm must have in place a suitable system whereby materials, right from the raw materials to final delivery stages (if possible) must be uniquely identifiable and traceable. This ensures that there are means within the organization where quality issues can be worked upon 'backwards' and the relevant causes identified and permanently rectified. Traceability and identification also come in very handy for Original Equipment Manufacturers (OEMs) who may use sub-assemblies made by another producer, and who can only get to the root causes of a customer complaint if they can go right back to the various streams of production - at their premises as well as in those of their suppliers. It is with this in focus that the standard expects that individual products or batches will be uniquely identified.

9. **Process Control:** The standard also emphasizes, by making it mandatory for the producing firm to ensure that only those processes be relied upon for producing the product, that have been brought under control, and which are also operated under controlled conditions. Ensuring controlled conditions would also need that documented work instructions exist, which are meticulously followed by the available staff because the absence of such discipline will adversely affect the quality of the output. Furthermore, it would be expected that there is also a reliable means of monitoring and controlling process and product characteristics, and workmanship standards for those levels of quality that rely on the skill of the operators.

   For certain special processes, which the standard defines as those where the results cannot be fully verified by subsequent inspection and testing, or where processing deficiencies may become apparent only when the product is in use, certain precautions need to be taken. The precautions include compliance with the conditions required for 'normal' processes, as well as continuous monitoring and assessment of adherence to the documented procedures. This would ensure control in the case of special processes. Typical examples of special processes include welding, heat-treatment, cooking food, plastic molding.

10. **Inspection and Testing:** Systems need to exist in order to effectively inspect and test materials used within the organization, at various stages in the process. The standard especially prescribes that Receiving Inspection and Testing (I & T), In-process I & T, and Final I & T, be conducted to verify that the material at each stage is conforming to specified requirements. As with all other requirements in the standards, it is expected that the inspection and testing routines will be conducted in accordance with written-down procedures, and a quality plan specifying the frequency and manner of inspection. It is emphasized that no material shall be shipped out until the activities specified in the quality plan and the documented procedures have been completed satisfactorily. Suitable records have got to be maintained to demonstrate that the product, prior to dispatch, passed the laid-down inspection and test criteria for acceptance.

11. **Inspection, Measuring and Test Equipment:** All equipment that is used for inspection,

measuring or testing any attributes of the product, need to be suitably controlled and maintained. This is irrespective of whether the devices used are owned by the organization itself, or whether they have been taken on loan or used at the premises of another agency (such as a subcontractor). This is to ensure that the measurement uncertainty is known and is consistent with the required measurement capability.

To achieve this organization will have to identify and monitor those measurements that have an impact on the quality of the final product, and accordingly choose the equipment that will be used for the purpose. The equipment chosen would then need to be calibrated at prescribed intervals, against certified equipment capable of measuring the same variables and having a known valid relationship to nationally recognized standards. The control of such equipment in the manner of handling, use and storage, would need to be assured to safeguard the accuracy and the fitness for use of the equipment. Records would also need to be maintained to ensure that regular verification of the status of equipment is possible.

12. **Inspection and Test Status:** There are only three conditions in which material that are subject to inspection and testing is likely to be classified, and these are:
    - Awaiting inspection or test
    - Passed requirements of inspection or test
    - Failed requirements of inspection or test

    The standard advocates that either condition or the status of the material be suitably identified using tags, labels, stamps or any other reliable means, so that there is complete clarity about the condition of the material. If the inspected and tested material is found acceptable for shipping out to the next process, or the subsequent user, the 'status indicators' must clearly show this.

13. **Control of Non-Conforming Product:** Care has to be taken to ensure that the system has a built-in check to prevent the inadvertent use of material that has been found to be non-conforming. This requires that the system ensures adequate control in the identification, documentation, segregation and disposal of the non-conforming product. The system also requires that all concerned be informed of the manner in which the disposal has been effected. The disposal of the non-conforming material may, however, is effected in either of the following ways:
    - Reworking it to meet the specified requirements.
    - Accepting with or without repair by concessions.
    - Re-grading for alternative applications.
    - Rejecting or scrapping

    Information to the customer is sometimes required to be given in the event of the non-conforming material being used after suitable changes, such as re-work and the like. This is especially so if it is also specified in the contract between the supplier and the purchaser.

14. **Corrective Action:** This clause in the system enables the organization responsible for the system to take the needed corrective action in the event it is found that somewhere the system is not functioning in a manner that contributes to customer satisfaction. The standard therefore recommends, as a mandatory requirement, to having in place of procedures whereby general

guidelines exist for improvement actions to be undertaken in all areas covered by the system. The objectives, of course, would be to eliminate the causes of non-conformance by initiating systematic investigations, analyses, diagnoses and the ultimate remedy of root causes. The procedures are essentially to ensure that once the corrective actions have been implemented the new work 'regimen' is documented to prevent a recurrence of the old problem.

15. **Handling, Storage, Packaging and Delivery:** It is often ignored, but a great deal of damage to products occurs outside the production premises, while the product is either in transit, or is waiting in a warehouse to be shipped further. This clause of the ISO: 9001 standard focuses on the need for having systems that assure the customer of receiving quality, extending to those locations where the material might otherwise be prone to deterioration or damage. For this it is mandatory for the supplier to develop a documented system that prevents the damage or deterioration of the material. The material is also expected to be stored in secure storage areas, prior to shipment to the customer, again to prevent damage. The packaging of the product is also done in such a way that, apart from protecting the product, it also conforms to national/international codes of practice.
16. **Quality Records:** It is important to have well-organized and easily retrievable records in order to provide objective evidence that the work in the organization is being done in accordance with documented procedures. The standard relies entirely on the presence of records to demonstrate that the system, as designed, is actually functioning in that manner. The records need to be compatible with the product to which they pertain, besides being kept neatly and well organized, either in manual or other storage systems, so that they are quick to retrieve. The records need to be retained for predetermined lengths of time, which again needs to be specified and then documented, in order to have uniform adherence to the system.
17. **Internal Quality Audits:** To ensure that the documented system is in place and being followed, it is mandated that comprehensive audits shall be periodically carried out by trained personnel, internal to the organization. This would be over and above the regular reviews that the supplier's management is expected to institute, in order to determine the effectiveness of the system. The reliance on frequent and systematic audit is the only way to ensure compliance with the written-down procedures. Non-compliance with the system is to be brought to the attention of the 'head' of the audited system, so that suitable corrective action may be taken, to restore the effectiveness of the system.
18. **Training:** For all those whose work affects the quality of the output, it is mandatory to spell out the qualifications clearly, in addition to ensuring that the following actions take place on a regular basis:
    - Identification of training need
    - Regular training, in the areas identified
    - Maintaining the relevant records of training

    The training also assures that the people involved in the system are capable of following the written-down work instructions, and have the requisite expertise to do what is expected of them right the very first time.
19. **Servicing:** Wherever servicing is a part of customer requirements, it is mandatory to have procedures that ensure that these are met. The servicing system is quite likely to include

some or all parts of the total quality system such as design, process control, training and although the focus will be on providing the appropriate resources to get the servicing done as desired by the customers.

20. **Statistical Techniques:** This is the last clause of the standard. It is relevant where the processes of production have to be in a state of statistical control, and where detailed knowledge of the process is needed to deliver the desired output. Where these conditions exist, written procedures need to be in place that will help in the analysis and the verification of process variables. Essentially, what is required is the use of the right tools that help in analyzing data and quantitative information, so that processes are always in a state of control.

A closer scrutiny of the clauses of the ISO: 9001 standard indicates that the focus is on ensuring that there is a documented system that exists for all those important aspects of the organization whereby consistency in the output is assured. The clauses together form the backbone of a set-up that assures consistency in operations and an overall control of the pertinent processes. If an organization conforms to the standards, it implies that it has a suitable documented system in place, which is also being meticulously followed.

ISO : 9004, Quality Management and Quality System Elements - Guidelines, provides general guidelines for developing and implementing the kinds of quality management systems required in ISO 9001, 9002, and 9003. It considers management responsibility, principles of quality system development, system structure, auditing, and system review. In general, these guidelines and suggestions are aimed at helping management develop an affective quality management system so that their companies can be qualified to meet ISO : 9001, 9002 and 9003 requirements. In 1991 the Technical Committee added a second part to ISO : 9004, providing special attention to quality management in the service sector, since, as already mentioned, the original ISO : 9000 series focused almost exclusively on the manufacturing sector. However, the ISO : 9000 standards can generally be applied to the service sector by making such simple modifications as substituting terms, such as process for production and service for product.

The ISO series standards do not tell management how to meet requirements; rather they simply indicate what is required. For this reason the ISO : 9000 documents are not very large. The standards are designed to be user friendly. They are generic in nature and follow a logical, easily understood format. For example, ISO : 9001 and 9002 contain only seven pages of text and 9003 has only two pages. As each company is unique and there may be different level of preparedness to implement the standards. In general, larger companies tend to use ISO : 9001, and smaller companies tend to use 9002, since smaller companies are not as frequently involved in the product design process. Also in some cases, smaller companies do not feel they can attain the type of pervasive total quality system required by ISO : 9001.

ISO : 9000 is both an opportunity and a challenge to developing nations. They now know with a good degree of certainty the level of quality that purchaser expect and can learn the prerequisites and characteristics of a good quality assurance and management system.

13.7 National Efforts in India

In July 1991, the Government of India made an important strategic and political commitment to move towards a market oriented economy with particular emphasis on the achievement of internationally accepted standards of quality in manufactured and exported products. The Central

Government announced the export policy in April 1992 introducing a scheme to recognize and suitably reward manufacturer who acquire the ISO 9000 series which are equivalent Indian IS 14000 standards. Presently, such manufacturer will be eligible to receive benefits related to the grant of import licenses.

In May 1992 Prime Minister launched a nation wide programme on quality awareness and a schedule compassing to reach out to 54 cities in all the states and union territories to spread the message. State Governments were to be encouraged to launch the movement in their respective states particularly in small scale and handicrafts sectors. To match the requirement of the industry which is expected to gain an impetus by such moves, a national scheme of certification is required to be a place. The objective of this scheme would be following:

- To provide criteria for certification bodies to certify quality management systems (ISO 9000/ IS 14000) and products.
- To provide criteria for training organizational personnel on quality management perspective
- To provide criteria for certification of test and calibration laboratories.
- To oversee the national quality campaign and the national information enquiry service. In most countries where such a scheme does operate, there is usually formed an apex umbrella organization of a national structure with the objective of promoting the establishment of a transparent, efficient and internationally recognized accreditation system for the regulated and voluntary area of certification. i.e. in the UK it is the National Accreditation Council for certification bodies and in Germany this the German Accreditation Council. A similar council with a support structure acceptable internationally has been setup in India.

Basic Requirements for ISO : 9000 Certification: The following are the basic requirements for ISO 9000 certifications:

(a) Documentation: Write down everything that has to be done and develop required documentation of procedures for carrying out any activity in the operation.

(b) Performance: Use the documentation as a working tool by doing everything that is written.

(c) Verification: Verify that in all cases, the accepted written procedures are respected by all parties concerned.

(d) Filling: A written trace of all procedures should be retained, kept updated and be available to all persons concerned to certification by an independent third party. It can take up to two years to obtain certification and the cost could be quite high. Re-certification is required every three years. Individual departments or divisions not entire organization must achieve regirstration individually and all costs are borne by the applicant. Bureau of Indian Standards (BIS) is also issuing the similar certificate as presented in (Table – 14.3).

ISO : 14000: In 1996, series of standards of ISO 14000 was established in order to achieve the environmental objectives of the organisation. This provides an 'environmental management system' to industries. ISO 14000 includes 20 separate standards covering from environmental labeling and assessing the life cycle of products. This is based on six principles:

- Organisation should define an environmental policy.
- Organisation must prepare a plan to achieve its policy.
- Organisation must provide all necessary support in order to achieve the environment policy.
- Organisation should monitor and evaluate its performance.

- Organisation must ensure commitment towards environmental management systems.
- Organisation must adopt new strategies for its improvement on continuous basis.

ISO 14000 does not require third party registration but the organisation will have to be certified ISO 14000 as a prerequisite for doing business. Its standards based on:

(a) Management Systems: Standards for system development and integration.

(b) Operations: Standards for consumption of natural resources and energy.

(c) Environmental Related Systems: Standards for measuring, assessing and managing emission, affluent and other waste streams.

Table 13.3 ISO : 9000 Standards and Indian Standards

S. No.	ISO : 9000	Bureau of Indian Standards
1	ISO 10011-1: 1990	IS 14011 Part I: 1991 Quality Systems Guidelines for Auditing Quality Systems: Part I, Auditing
2	ISO 10011-2: 1991	IS 14011 Part 2: 1991 Quality Systems - Guidelines for Auditing Quality Systems: Part 2, Qualification for Auditors
3	ISO 10011-3: 1991	IS 14011 Part 3 : 1991 Quality System -Guidelines for Auditing Quality Systems: Part 3, Managing Audit Programs
4	ISO 9004-2: 1991	IS 14004 Part 2: 1992 Quality Systems - Quality Management and Quality Septum Elements - Part 2, Service
5	ISO 9000-3: 1991	IS 14000 Part 3: 1991- Guidelines for Application to Software
6	ISO 10012-1: 1992	IS 14011 Part 1: 1993 - Quality System – QA Requirement for Measuring Equipment, Part I, Metrological confirmation
7	ISO 9000 - 2: 1993	IS 14000 Part 2: 1994 Generic Guidelines for Application
8	ISO 9004 - 3: 1993	IS 14004 Part 3: 1994 Quality Systems - Quality Management and Quality System Elements: Part 3, Processed Material
9	ISO 9000-4: 1993	IS 14000 Part 4: 1994 Quality Septum - Quality Management
10	ISO 9004-4: 1993	IS 14004 Part 4: 1994 Quality Systems - Quality Management and Quality Septum, Part 4, Quality Improvement
11	ISO 8402: 1994	IS 13999 Quality Management Vocabulary
12	ISO 9000-1: 1994	IS 14000 Part 1: 1999 Guidelines for Selection and use
13	ISO 9001: 1994	IS14001: 1994 Quality Systems - Model for QA in Design, Development, Production, Installation and Servicing
14	ISO 9002: 1994	IS 14001: 1994 Quality Systems - Model for QA in Production, Installation and Servicing
15	ISO 9003: 1994	IS 14003: 1994 Quality Systems - Model for QA in Final Inspection and Test
16	ISO 9004-1: 1994	IS 14004 Part 1: Quality Systems - Quality Management and Quality Systems Elements: Part 1, Guidelines
17	ISO 10013	IS 10013 Guidelines for Developing Quality Manual

13.8 Summary

Opening up the trade barriers, the gradual integration of local market into a global environment, global access to knowledge and information have all contributed to a growing appreciation of Quality Requirements and Assurance in all businesses. To survive and remain competitive in global market,

goods/services offered should not only be of high quality, but also be reliable, safe, energy-efficient, environment friendly and cost-effective. Ability to produce quality goods and services and to sustain them over a long period of time requires implementation of quality standards or systems approach (ISO 9000 Series of Quality Systems). The ISO 9000 series was developed by a technical committee working under ISO in Geneva. The series took several years in the making and was an outcome of previous work of military standards in World War II and the British Standards Institution's BS5750 series Part 1 to 6. In 1987, ISO published the ISO 9000 series. This series is a family of quality management and quality assurance standards which consists of 17 different standards out of which only ISO 9001, ISO 9002, and ISO 9003 are quotable standards while the rest only guidelines. The ISO member for the India is the Bureau of Indian Standards known as BIS.

The objective of ISO is to promote the development of standardization and related activities in the world with a view to facilitating international exchange of goods and services and to develop cooperation in the spheres of intellectual, scientific, technological and economic activities. Elements Applicable to ISO 9001 are management responsibility, quality system, control review, design control, documents control, purchasing, purchase & supplied product, product identification & traceability, process control, inspection & testing, inspection, measuring & test equipment, inspection & test status, control of non conforming product, corrective action, handling, storage, packing & delivery, quality records, internal quality audit, training, servicing, statistical techniques.

The challenge to a developing nation like India is to motivate its manufacturers and service providers to adopt and implement these standards, and to establish a credible national quality registration system which will be recognized and be acceptable to its trading partners.

13.9 Self Assessment Test

1. What is the basic difference between the following codes of ISO 9001, 9002, 9003 and 9004?
2. Briefly list the benefits of ISO 9000 certification to Indian companies.
3. What is ISO? Put a light on the genesis of ISO 9000.
4. Write the definition of following terminology as per ISO and interpret the same:
   (a) Quality Policy
   (b) Quality System
   (c) Quality Control
   (d) Quality Assurance
   (e) Quality Objectives
5. Explain the ISO 9000 series and also describe the objectives of ISO 9000.
6. Briefly explain the equivalent quality system standard in India and European Nations.
7. What are the key elements applicable and not applicable to ISO 9001, 9002, 9003? Briefly explain

   each.
8. What is the basic requirement for ISO 9000 certification? Also explain the national efforts done in India related to this.
9. Write an essay on "ISO 9000 Standards and Indian Standards"

13.10 References

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Unit – 14 Customer Relationship Management

Unit structure

14.0 Objectives

After studying this unit you should be able to understand

- The Concept of Customer Relationship Management
- The objectives , significance and types of CRM
- CRM to e-CRM
- Strategies of CRM
- Need for Customer Retention

14.1 Introduction

CRM stands for customer relationship management. It is a strategy used to learn more about customers need and behaviours in order to develop strategic relationship with them. Good customer relationship is the heart of business success. Customer relationship management is a strategic process that will help you better understand your customers need and how you can meet those needs and enhance your bottom line at the same time. This Strategy depends on bringing together lots of pieces of information about customers and market trends so you can sell and market your products and services more effectively.

The concept of managing relationships with customers is not new. Companies had been doing it since the beginning of trade, however, the focus was more on selling rather than customer orientation. Competition, driven by globalization has changed the whole gamut. Customers now have varied choices, are more knowledgeable and demanding too. Now they need to be handled with utmost care by the companies because the question is not only to acquire them but to satisfy and retain them for long. The companies now realize that they could boost up their profits by almost

100% by retaining just 5% of their existing customers. Time has come for customer-centric enter-prizes implementing CRM strategy to stay.

Customer relationship management is a strategy used to learn more about customers needs and behaviour in order to develop stronger relationship with them. From IT perspective, it provides an integrated view of a company's customer to everyone in the organisation so that the customer can be serviced effectively. There are many technological components to CRM but thinking about CRM in primarily technological terms is a mistake. The more useful way to think about CRM is as a "process" that will help bring together lot of pieces of information about customers, sales, management effectiveness, responsiveness and market trends.

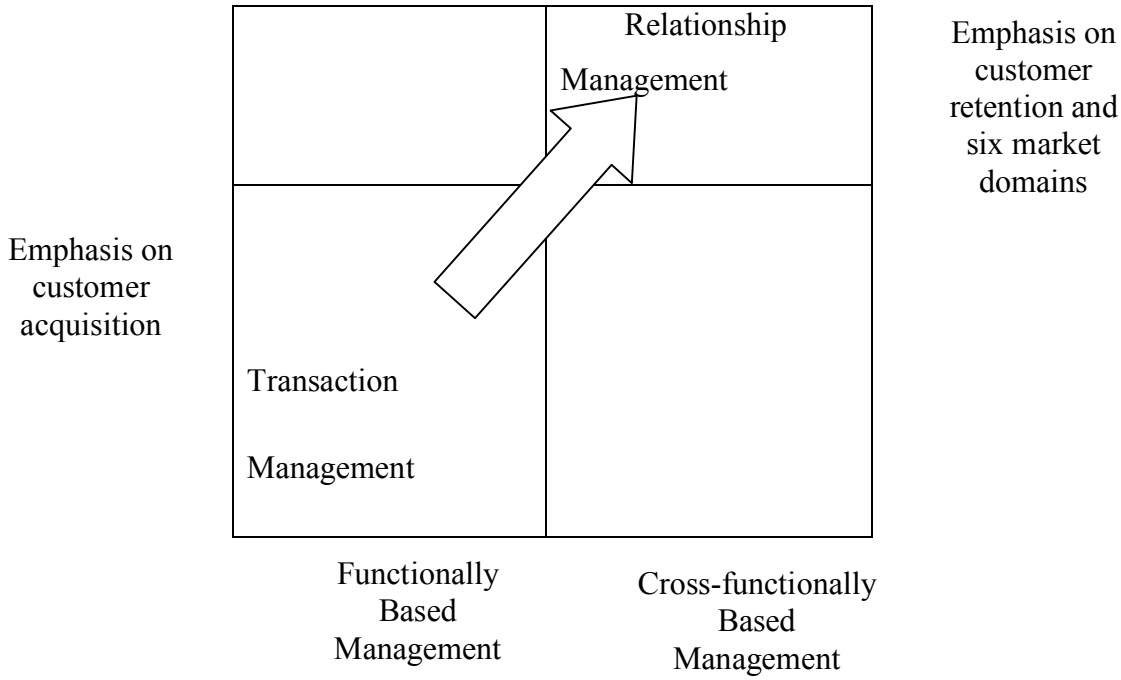
CRM focuses on automating customer value and satisfaction. CRM basically centers around the conglomeration of technology and human resource with an aim to gain insight into behaviour of customers and cater to their perceived value. Customer Relationship Management (CRM) is a buzzword today, it is based on this understanding that companies are able to customize their offer in such a way that the customer finds more value in dealing from them rather than any other companies.

The single most important thing to remember about any enterprise is that there are no results inside its walls. The result of a business is a satisfied customer. In present era of cut-throat competition, it is no longer enough to satisfy the customer but to delight them, As Philip Kotler puts it, "Today you have to run faster to stay in the same place". The most important tool available to the business firms these days to make the customer happy is "Relationship Management".

Relationship Management is one of the hottest trends in management today. It is gaining increasing popularity in the business world. Relationship Management is the process of attracting, maintaining and enhancing relationships with key parties-customers, suppliers and distributors-in order to earn and retain their business and honor their long term preferences.

In today's competitive business environment, customers are making their buying decisions not just on the basis of product comparisons, but on the basis of relationships they have with the company. In fact ensuring customer satisfaction is the key to success and companies are actively engaged in studying and exploring the conceptual foundations of managing relationships with customers. A brand derives strength from its experience with its customers and CRM is now recognized as a powerful tool, for brand management to have an edge over the competitors. Customer relationship management is the establishment, development, maintenance and optimization of long-term mutually beneficial relationship between customers and companies. Successful CRM stresses on understanding the needs and desires of customers in order to develop stronger relationships with them. It is all about creating a competitive advantage by being the best in understanding, commutating and developing existing customer relationships along with creating and keeping new customers. CRM is immensely beneficial to the brand marketers as it helps not only in retaining customers but also enables more effective management. It will also result in expansion of market share and profits of the brand. A good experience of business transaction with the brand will increase the customer loyalty and tendency to purchase again and again. A bad experience with the brand, on the other hand, will transfer the company's business to its competitors. Thus CRM is the commitment of the brand to put customer experience at the center of its priorities.

Figure 1 : Relationship Management Transition Model



The above model shows the Transaction Management to relationship which includes:-

A move from functionally based management to cross-functionally based management.

A shift from management activities which have emphasis on customer acquisition to management activities which emphasize customer retention.

14.1.1 Definition of Relationship Management

Philip Kotler – "Relationship management is the process of building long-term, trusting, win-win relationship with customers, distributors, dealers and suppliers."

Stanton – " By means of management function, marketer can direct the firm's response to an ever changing management environment and orient all activities of the business toward the creation of a satisfied customer".

Couldwell – "CRM is a combination of business process and technology that understands a company's customers from the perspective of who they are, what they do and what they like'.

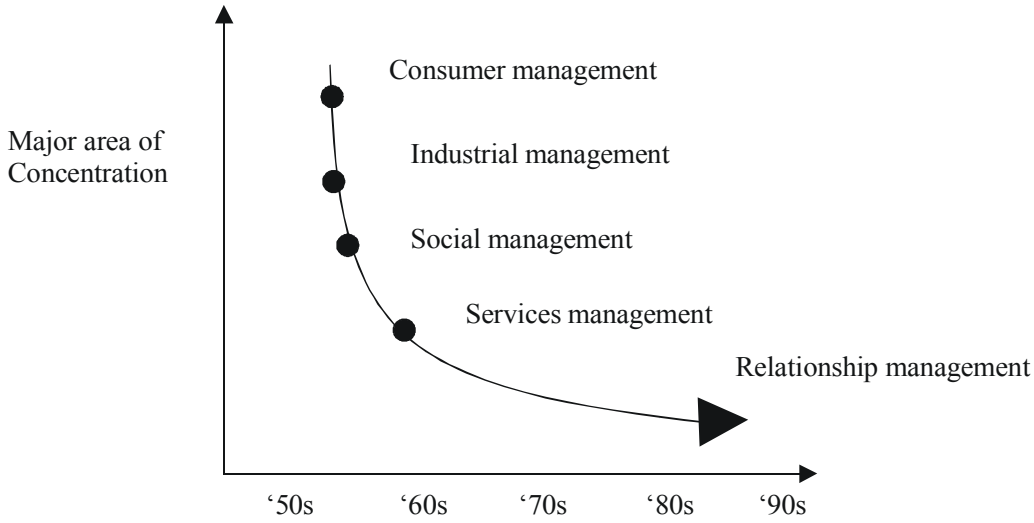
Anton - "CRM is an integrated approach to managing relationship with continuous improvement or re-engineering".

Berry – "CRM as a attracting, maintaining and enhancing customer relationship in multi service organization".

14.1.2 The Evolution of Relationship Management

The formal study of management has focused on an evolving range of management sectors over the past few decades as shown in figure-2.

Figure-2 : The Changing Focus of Management



In the 1950s, management interest was primarily focused on consumer goods. In the 1960s, increased attention also started to be directed towards industrial markets. In the 1970s, considerable academic efforts placed on the area of social management. In the 1980s, attention started to be directed at the services sector, an area of management that had received remarkable little attention in view of its importance in the overall economy. In the 1990s, we believe that relationship management is the area that will receive increasing attention. This involves two major considerations. First at the macro level the recognition that management impacts on a wide range of areas including customer markets, employee, markets, supply markets, internal markets, referral markets and influencer markets such as the governmental and financial markets; and second at the micro level the recognition focus to a relationship focus.

14.2 Benefits of CRM

In today's dynamic business world, if CRM is implemented effectively, it will result in immense benefits to the brand marketers as well as to the customers. Now days, it has become a vital element for success. Benefits of CRM can be divided into two categories i.e. (A) Benefits of CRM with reference to brand marketers (B) Benefits of CRM with reference to customers

(A) Benefits of CRM with reference to brand marketers :-

(1) **Improvement in Sales Revenue** - The sales revenue of the brand is improved through CRM. Keeping the customers satisfied and happy will *ensure that* they stay with the brand, thus maximizing their contribution to the business. By being customer centered the brand can increase its sales revenue.

(2) **Increase in Profits** -When CRM is applied; the profits of the brand will increase due to lower defection rates of the customers. When customers enter into a relationship with a brand, they are willingly foregoing other options and limiting their choice. By staying with the brand, the customers enhance profitability of the brand.

(3) **Reduction in cost of management** -If CRM strategy is adopted for management the products, the marketers will have a good relationship with the customers. The customers will be satisfied and readily accept the product. Thus less cost will be incurred in advertising and promotions.

(4) **Better Understanding of Customers** - CRM enables the brand marketers to have better understanding of the customers. They can easily anticipate what customers want in terms of the product and services provided by the brand.

(5) **Targeted Customer Contact**-Improved customer knowledge will enable the brand marketers to target their customers precisely. Management efforts can be optimized and fully exploited by targeting on right prospects and potential segments. CRM will help marketers to identify their target customers and not waste their time.

(6) **Improvement in Customer Satisfaction**-With the help of CRM, firstly the customers will choose the right product offered and also if they face any problems, they will be easily solved. Thus with CRM the level of customer satisfaction will be raised. Strong customer loyalty with the help of CRM good relationship is developed with the customers. This will result in increase in customer loyalty for a brand. Thus, CRM develops a strong customer loyalty and good brand image.

(7) **Increase in Customer Retention**-CRM helps in increasing retention of existing customers by improved after sales service and support. As the existing customer will be fully satisfied, they will buy the same brand, thus CRM helps to retain old customers.

(8) **Identifying, Attracting and Acquiring New Customers** -A fine tuned CRM would be able to add a large number of customers to the existing customer base. The brand marketers would be able to add more and more customers to the captive customers. CRM allows the brand marketers to focus their limited management resources on the most promising target markets with the highest potential value.

(9) **Proximity to customers-**The growing expectations of the customers have lead to the brand marketers to innovate, serve and satisfy the customers in a better way. The ability to successfully manage customer relationship is a decisive advantage in today's competitive world to increase proximity to customers.

(10) **Helps in identifying cross-selling and up-selling opportunities-**CRM helps in identifying opportunities for cross-selling and up-selling of higher value added services to existing customers based on their past purchasing behaviour.

(B) Benefits of CRM with reference to Customers *:-*

(1) **Decreased Cost for Customers-** CRM as management expenses of a brand will decrease in the long run; brand marketers can offer the same product at a little lower cost, which will be to the benefit of the customers.

(2) **Improvement in Customer Satisfaction**-CRM ensures that the customers experience positive interaction with the brand. Customers form long lasting impressions of how they are dealt with. Thus, a good experience with the brand will result in satisfied and happy customers.

(3) **Timely Delivery of Products**-The awareness level of customers has increased manifold. Now the customers are well informed about different types of products and brands available in the market. Therefore, companies are increasingly practicing CRM. This is resulting in effective and timely delivery of products to consumers.

(4) **Personalization and Closeness**-Customers in this competitive age expect constant access to a company. They demand immediate response. They want personalization and closeness

for meeting their needs, placing new demands on the company, which CRM alone can satisfy.

(5) **Availability of Wide Variety of Products**-CRM helps the brand to understand the customer's demands and manufacture new products according to their expectations. With heightened competition and easy to access information, customers have a wide variety of choice of products and services that are specifically tailored to meet customer's needs.

14.3 Traditional Management vs. Relationship Management

The traditional management, known as transactional management focused on mass production, mass management and standardized products and services. But with relationship management, the focus has now shifted to highly customized and personalized products and services.

Table-1 : Traditional/ Transaction Versus Relationship Management

	Traditional/Transaction management	Relationship Management
1.	Focus on single sale	Focus on customers retention
2.	Orientation on product features	Orientation on product benefits
3.	Short time-scale	Long time-scale
4.	Little emphasis on customer service	High customer service emphasis
5.	Limited customer commitment	High customer commitment
6.	Moderate customer contact	High customer contact
7.	Quality is primarily a concern of production	Quality is the concern of all

14.4 Types of Relationship Management

(A) Classic Market Relationship -

(1) **The Classic Dyad**: The relationship between the supplier and customer. This is the parent relationship of management, the ultimate exchange of value which constitutes the basis of business.

(2) **The Classic Trial**: The drama of the customer – supplier- competitor triangle Competition is a central ingredient of the market economy. In competition there are relationships between three parties: between the customer and the current supplier, between the customer and the supplier's competitors, and between competitors.

(3) **The Classic Network Distribution Channels:** The traditional physical distribution and the modern channel management including goods, services, people and information consists of a network of relationships.

(B) Special Market Relationship -

Relationships via full- time marketers (FTMs) and part-time marketers (PTMs) : Those who work in the management and sales departments- the FTMs- are professional relationship markers. All others, who perform other main functions but yet influence customer relationships directly ordirectly, are PTMs. There are also contributing FTMs and PTMs outside the organization.

(1) **The service encounter-** interaction between the customer and the service provider : Production and delivery of services involve the customer in an interactive relationship with the service provider, often referred to as the moment of truth.

(2) **The many-headed customer and the many headed supplier**: Marketing to other

organizations- industrial management or business management – often means contacts between many individuals from supplier's and the customer's organization.

(3) **The relationship of the customer's customer :** A condition for success is often the understanding of the customer's customer; and what suppliers can do to help their customers become successful.

(4) **The close versus the distant relationship :** In mass management, the closeness of the customer is lost and the relationship become distant, based on surveys, statistics and written reports.

(5) **The relationships to the dissatisfied customer** : The dissatisfied customer perceives a special type of relationship, more intense than the normal situation, and often badly managed by the provider. The way of handling a complaint, can determine the quality of the future relationship.

(C) Mega Relationship -

(1) **Personal and Social Networks :** Personal and social networks often determine business networks. In some cultures even, business is solely conducted between friends and friends-of-friends.

(2) **Mega management -** the real 'Customer' is not always found in the marketplace . In certain instances, relationships must be sought with governments, legislators, influential individuals and other in order to make *management* feasible on an operational level.

(3) **Alliances change the market mechanisms** : Alliances mean closer relationships and collaborations between companies. Thus competition is partly curbed, but collaboration is necessary to make the market economy work.

(4) **The knowledge relationships** : Knowledge can be the most strategic and critical resource and 'knowledge acquisition' is often the rationale for alliances.

(5) **The mass media relationship** : The media can be supportive or damaging to management and they are particularly influential in forming public opinion. The relationship to media is crucial for the way media will handle an issue.

(D) Nano Relationships -

(1) **Market mechanisms are brought inside the company :** By introducing profit centers in an organization, a market inside the company is created and internal as well as external relationships of a new kind emerge.

(2) **Internal customer relationship** :The dependency between the different tiers and departments in a company is seen as a process consisting of the relationships between internal customers and internal suppliers.

(3) **Quality providing a relationship between operations management** : The modern quality concept has built a bridge between design, manufacturing and other technology-based activites and management. It considers the company's internal relationships as well as its relationships to the customers.

(4) **Internal management** : Relationship with the 'Employee market' : Internal management can be seen as a part of relationship management as it gives indirect and necessary support to the relationship with external customers.

(5) **The relationship to external providers of management services** : External providers reinforce the management function by supplying a series of, such as those offered by advertising agencies and market research institutes, but also in the area of sales and distribution.

The Relationship Management Model

Relationship Management can be described with the help of the following Figure-3

Input	Process	Output
Value-added products and services	RELATIONSHIP MANAGEMENT	High customer satisfaction
One-on-one relationship		Increased customer share
Individual care and attention		Lower management costs
Special facilities and services		Positive word-of mouth
Structural ties		High brand equity
Information sharing		High customer loyalty

Figure-3

This model reveals the facts that certain inputs of relationship management will achieve the required output to build fair and long lasting relationship with the customer like individual care and attention is paid to the customer obviously it will create a positive word of mouth for the company and it will increase customer satisfaction. Thus we can say that relationship management is a two way process in which the inputs are required to generate the desired level of output in the present era of competitive world.

14.5 CRM to e-CRM

The 20th and 21st Century has seen an increase in the use of electronic transmission, mediums either as alternatives or as the sole means for the exchange of information, products, and services. Technology and the Internet in particular, has become as important a feature to business as the advent of the calculator photocopy machine and the telephone. As with other advances in technology and business system, inadequate or poorly planned inputs can only result in poor outcomes E-commerce has added benefit of allowing personalized services to occur over a far greater number of people and organization.

Now, customers have not only become more demanding about the level and quality of service but their tolerance for internal communications deficiencies are decreasing and the need for instant gratification is on the rises. If the company is unable to satisfy customers, they will lose their business to the competition. Using electronic means to buy and sell products and services over the internet will not in itself enhance customer service and support, it will increase sales opportunities, e-CRM had many advantages over traditional methods of CRM including mass communication, personalization around the clock availability, increased knowledge and awareness of customer needs and expectation, and the potential for increased customer satisfaction whilst increasing revenues. However, e-CRM has the potential to alienate customers, create problems within company culture and threaten the livelihood of the company if not implemented correctly.

In simple words, e-CRM is a means to conduct interactive personalized and relevant communication with customers across both electronic and traditional channels. It focuses on understanding how the economics of customers relationship affect the business. The e-CRM, i.e. CRM online implies an additional means of communication and level of interaction with the customer, e-CRM can be defined as “A comprehensive understanding of customer activities,

personalization, relevance, permission, timeliness and metrics as a means to an end optimizing the value of your most important customers.

It can be referred as "electronic" customer relationship management, or more simply CRM that is Web-based. The goal of e-CRM is to leverage technology, more specifically the power of the Internet to improve customer service, and enable a greater degree of customer interactions through personalized communication. The Internet has changed businesses around the world by offering simpler ways to send and receive information search, buy and sell products at the mere click of a mouse. This has made a lot of things easier for the customer. Features like products and services On-Demand, 24-house Access, up-to-the minute information on stock levels, prices and features, online customer support, self-service and personalized content are all easily available. This can save the customer time and energy scouting around for products for days. It can save the company executives from going back and forth to get the exact requirements from the customer and, it has also reduced errors.

Developing continuous relationships with customers and to make them feel delighted has become a necessity in the wake of globalization, where customer delight is the only key to success and to the very existence of the company. Company's perception is usually based on the customer's broad experiences with staff of the company. The status of relationship management in India elicits the various techniques employed by marketers to build and maintain relationship with the customers. It provides a rich insight into the role of IT in CRM. To become market driven CRM have to opt IT as e-CRM. This is the most potent weapon on the battleground of 21st century market place with digital markets, faster, smarter, adaptive management, and customized product/services for customers with the most potential long-term value.

e-CRM is not only simply electronic CRM, it is customer management for e-business that must confront the complexity of managing sophisticated customer and business partners in a variety of online and offline medias, personal contacts and other automated and electronic forms of communication. In simple words, e-CRM is technology driven CRM, where relationship is maintained with the help of technology. It is the skeleton of modern business and management is the core of all business activities, therefore the changes in information technology inevitably changes the management processes, systems, strategies and setups. Blossoming of the information age has made management efforts more information-oriented, service oriented and relationship-oriented.

The development of information superhighway and opening up of the digital market have enable the marketers to provide customized product or services offering and develop value laden long lasting relationships with the customers. Highly empowered and informed customers have made CRM a most important area to concentrate upon the marketers.

Success in the 21st century market place will depend on a company's ability to develop, retain, and expand profitable business relationships with its customer base. Getting the right technology and infrastructure is a major part of one's continuous relationship management strategy. Its no longer enough to understand who are your customers- you have to develop enduring and proactive relationships while buying a sustaining infrastructure that delivers to your company's customers' needs' expectations and wants at the time and place dictated by him/her. It's hard to enough fostering these personal relationships in the offline world.

Internet gives companies a greater opportunity to learn more about an individual customer's needs, preferences and buying pattern. Traditionally, customer services were reactionary, with a customer contacting the company and the company responding to the contact.

14.5.1 Basic Requirements for e-CRM :

Necessary technical and functional requirements for e-CRM solutions are listed out as follows:

(1) **Analytical capabilities** :In organisation, e-CRM applications contain a vast amount of information pertaining to its customers. Such information needs to be leveraged and analysed by decision makers to take more informed and timely business decisions. This is a major requirement, for management applications and possible only if e-CRM solutions have robust business intelligence and analytical capabilities.

(2) **Web based e-CRM**: Web is a critical channel for e-business, and is also important from an infrastructure perspective. Users of e-CRM applications require access to their applications, which is supported through standard web-browsers. Moreover, business logical and data are maintained centrally thus facilitating the deployment, maintenance and upgrading of applications.

(3) **Continuous Channels of Customer Interaction:** Continuous interaction with customers is a prime requirement for e-CRM. Integration of these components across multiple channels is required so that the customer interaction can be seen seamless, consistent and efficient.

(4) **Integrated Workflow with ERP applications**: Integration must include low-level data synchronization as well as business process integration so that the integrity of business rules can be maintained across systems and workflow tasks can pass between the systems.

(5) **Optimization of Interactive Continuous Relationships with Customers Problems:** e-CRM offerings might patch together sales force automation and customer support, producing only a fraction of an e-CRM solution. Still another CRM packages might provide customer analytical needed to observe customer relationship but lack the means to turn findings into initiatives in order to have a positive impact on continuous relationships with customers.

14.5.2 Six 'E's of E-crm Implementation

Implementation of e-CRM is the basic need for continuous relationship with customers, that requires following six 'E' outlined in brief as follows.

(1) **Electronic Messaging Channels-**For fast interactive and economic customer communications, companies have to adopt new electronic channels such as the Web and personalized e- Messaging. The purpose of the Web experience in the CRM is to identify a customer/derive the value of the customer and interact with him/her.

(2) **Enterprise-**Every enterprise gains the means to touch and shape a customer's experience through e-CRM. An e-CRM strategy relies heavily on the construction and maintenance of a data warehouse that provides a consolidated, detailed view of individual customer behaviour and communication history.

(3) **Empowerment**-At present consumer, have a power to decide when and how to communicate with the company and through which channel. Consumers also decide which firms earn the privilege to communicate with them. New e-CRM strategies must be structured to accommodate such type of consumers, and e-CRM solution must be structured to deliver valuable information timely and patiently information to its customers that he/she can accept it in exchange for his/her attention.

(4) **Economics**-Understanding customer economics relies on a company's ability to attribute customer behaviour to management programs. today, customer economics drives smart asset allocation decisions, directing resources and efforts at individuals likely to provide the greatest return on consumer communication initiatives. Many companies execute best communication strategies to understand the economics of continuous customer relationship.

(5) **Evaluation-**For meaningful evaluation, a company should evaluate customer interactions along with various customer touch point channels, and compare anticipated ROI against actual returns, through customer's analytical reporting. Results of evaluation allow companies to continuously refine and improve efforts to optimize continuous relationships between companies and its customers.

(6) **External Information-**External valuable information can be used to understand customer needs in a better way. External information can be gained from sources such a third-party information net works, and web page profiler applications, under the condition that companies adhere to strict consumer opt-in-rules and privacy concerns.

Company builds an e-CRM solution in order to optimize continuous relationships between companies; and its customers. Each company has different and multiple objectives such as increasing the number of customers, increasing customer profitability, growing revenue, driving customers through cost effective channels and cross-selling for continuous relationship with the customers.

14.5.3 e-CRM as a Component of CRM :-

CRM is essentially a right business strategy for acquiring and maintaining the loyal customers for continuous relationship for long-term period. A number of channels exist for interacting with current customers. One of it is called and known as e-commerce or e-business. In the simplest terms, e-CRM is electronic CRM on the web.

14.5.4 e-CRM as a Sales Tool :-

The application of e-CRM includes activities of sales executives internal as well as field. General application of e-CRM viz., time scheduling of sales persons; contact with accounting department; compensation of sales persons; sales forecasting; evaluation of demand; deciding pricing policy; allotment of sales territory; and reporting. Special rules should be programmed into configuration applications and need to be abstracted from customers. Sales configurations should suit the Web user customers they need not be expected to have a technical background to assemble products.

14.5.5 e–CRM as a Management Tools :-

e-CRM is a new business tool that all age companies are rushing to get. It is the agreement that was signed in the New Delhi between Microsoft and Infosys honchos Bill Gates and N R Narayana Murthy. It is a business strategy designed to optimize profitability, revenue and customers' satisfaction.

It is an integration of varying Communication Channels viz., Wireless application Protocol (WAP), electronic mail (e-mail), Telephony and Mobile Devices. Web, Wireless and Voice Technologies may make it possible to combine personalized touch and customized service with mass-market efficiencies. It expands on this technology by using next generation technologies that are integrated, comprehensive and interactive. It bring about a web-centric approach where the web and e-mail are a critical means of customer interaction that makes customer to access and make use of e-

CRM system from anywhere and anytime. General application of e-CRM consists of viz., management inventory management; forecasting and budgeting; management information system; pricing policies; channel and logistic management; and evaluation of management campaign.

It is primarily important to Indian customers because of increasingly available domestic and global brands in the market place. eCRM should cover majority of the customer touch bases such as face to face; Internet and phone. It should support employee and should customer-facing roles and allow all individuals viz., employees, and business partners, to innovate the entire value chain to come together and successfully create customer delight.

14.5.6 e-CRM a Management Strategy :-

e-CRM help companies to increase their dialogue bandwidth and engage in continuous dialogue with the customer, establish a learning relationship in order to deliver customized solutions. For Indian companies especially, global ambition and competition lie at the heart of e-CRM strategy, e-CRM especially makes it possible for varying departments to provide one uniform face to the customer whenever they interact with them. Therefore, their attitude, communication ability, knowledge base coupled with technical skill becomes important.

14.6 Successful Continuous Relationship

The dimensions of Successful continuous relationship are -

(1) **Trust** :It is an important factor in the development of management relationships and prevails where a customer has confidence in a seller's reliability and integrity. Trust in a person is acquired by assessing the previous interactions, such as conflicts; the partner has had with others in similar situations. Trust is strengthened if partners are responsive in ways that acknowledge an individual's particular needs and affirm their sense of worth.

(2) **Customer Satisfaction:** It plays an important role in developing long-term continuous relationships. Highly loyal customers remain loyal for longer period, which ultimately give strength to the relationship between the concerned parties. Customers' preference for a particular company or a company's product reflects his/her loyalty towards that brand, which in turn signifies positive attitude for building and retaining continuous long-term relationships.

(3) **Complaint Handling** :It results in efficient management of continuous relationships in service business. Complaint handling helps in developing and maintaining continuous relationship because of challenges in managing quality, profitability.

(4) **Commitment** :It focuses on long lasting desire of parties to maintain a relationship. The concept of commitment becomes relevant to services due to the need for customer participation in the delivery process. Like trust, satisfactory complaint handling is also related positively to customer commitment.

(5) **Customer orientation** :It suggests to be more customers focused instead of product-centric. Staffs have to understand the needs of customers as individuals, so that such information can be used to improve quality of service they offer. There has to be greater emphasis on training program to ensure staffs' use of the technology in ways appropriate to particular types of relationships.

(6) **Continuous Communication**: Continuous communication with the customers has been

determined as a key factor of relationship maintenance in service sector, such as insurance, wholesale banking. Parties cannot be expected to trust each other, if particular moments constitute their only opportunity to interact.

(7) **Continuous Periodic Assessment**: Continuous periodic assessment of customer's needs and assurance that they have made correct decision is necessary for strong relationship.

(8) **Continuous Personal Touch**: Continuous personal touch such as gifts on special occasion; cards; calendars; and diary etc. can maintain long way continuous relationships among parties. It is an interactive, face-to-face relationship between company and an individual on one-to-one base.

14.6.1 Satisfaction in Relationship :

Customers' satisfaction is a state of mind that occurs when the customer feels that his expected requirement is fulfilled by what is offered by the organization. Customer's satisfaction is related with various parts given as below :-

(1) **Product satisfaction**: Product satisfaction comes with the core benefit provided by the product. It is related to the minimum expectation of customer from the product. It is related with satisfying basic needs of customers.

(2) **Ambience Satisfaction** :It is a blend of tangible factors, which the customer experience, in the purchase and consumption process. The tangible aspect of ambience satisfaction include appearance of sales point, continuous services available and competitive pricing. Where intangible aspects include the courtesy extended by sales persons.

(3) **Peripheral Satisfaction** :When specific value added to the product in addition to the core benefit it resulted into peripheral satisfaction. It helps the customer to enhance their desire for personal attention.

(4) **Clarity satisfaction** :Clarity satisfaction is related with the satisfaction extended in tune with the individual of the customer concerned. It provides the customer an arena to reduce his anxieties and fear with respect to the purchase of product. A talkative customer would be much satisfied if the sales personnel engaged in lengthy dialogue. A suspicious customer would be fully satisfied if all his/her latent and expressed doubts are clarified.

14.6.2 Continuous Relationship Through Customer Loyalty:

In today's highly competitive and challenging business environment, it is really a blessing for organization if they are fortunate enough to have loyal customer in their directory. Building customer loyalty is the basic platform for continuous relationship. Loyalty in the *management* term has been defined as a willful, voluntary and repeated choice of a specific brand of a product or type of service. For the one-time purchase, Loyalty could be explained in terms of the extent of commitment to the brand selected; the positive attitude developed towards using the brand selected and positive image the customer projects about the brand he/she selected.

Loyalty for specific brand is the committed willful option for a particular brand. Loyalty toward brand is what customer normally develops with specific reference to a brand, irrespective of any one of the above categories such as organization, store, and sales person, etc.

Brand loyalty process starts with awareness of the fact that the brand is available. Creating such sense of awareness of brand is of the major responsibilities of the marketer. A customer who develops loyalty towards an organization might willfully offer to whatever product or service is

offered by the organization. He/she would be a strong supporter for the organization's products and services. Such a loyalty is a result of the organization's image, continuous relationship with organization, better performance of the organization and so on.

14.7 Customer Retention and Relationship Management

The major objective of 'relationship management' is to turn new customers into regularly purchasing clients, and then to progressively more them through being strong supporters of the company and its product, to finally being active and vocal advocates for the company.

The development of a closer, long-term relationship with customers is particularly important in certain types of service operation; namely when the service cannot be provided completely on one occasion, of instance, certain treatments at the dentist which require several visits, or a problem with a care which requires more than one visit to the mechanic. Similarly, if the service itself is highly intangible, the existence of a stronger relationship can be an important influence on a customer's decision to pay for the services of one provider in preference to another. If there is little tangible evidence available to assess the quality of the service on offer, customer frequently turn to the provider they have used before, whom they feel they can trust.

14.7.1 The Importance of Customer Retention

A relationship management approach draws attention to the importance of retaining as well as attracting customers with the emphasis being placed on the development of long-term relationships with existing customers. It involves changing the focus of management from a transactional to a relationship focus, with the emphasis on customer retention, high customer service and commitment, and quality being a concern for all. The focus of transaction management, with an emphasis on single transactions, limited customer service and commitment and with quality considered to be primarily a concern for production, is no longer appropriate.

One of the major reasons why relationship management has emerged as the new paradigm for management is because of advances in information technology and specifically the generation of customer databases. These clearly make it easier for service organizations to identify loyal customers. Both small and large service operators use databases in this way. A video retailer, for example, holds membership details of all customers on a database and sends regular users a birthday card with a complementary voucher for a free video despite a flurry of activities aimed at serving customers better, only a few companies have achieved meaningful, measurable improvements in customer loyalty. It would appear that although companies seem to agree that customer loyalty is a good thing, not so many are prepared to make loyalty retention measures an integral part of their strategy.

14.7.2 Need for Customer Retention

In order to maximize CLV, attention has to be paid to customer retention. Customers of today are becoming smarter, more price conscious, more demanding and are approached by various competitors with better offers. This had led the customers to churn. John Hutchinson – "Principal CRM consultant at Xansa has made an attempt to segment customers into three categories based on customer churn frequency". The first are the "**Habitual Churners**" who like to change suppliers frequently, view product as a commodity and are engaged in finding the best deal. The second segment is "**Possible Churners**" which might move if you given them the right offer at the right time. The third segment is "**Sluggish Churners**" which comprise of old and affluent customers who are clini-

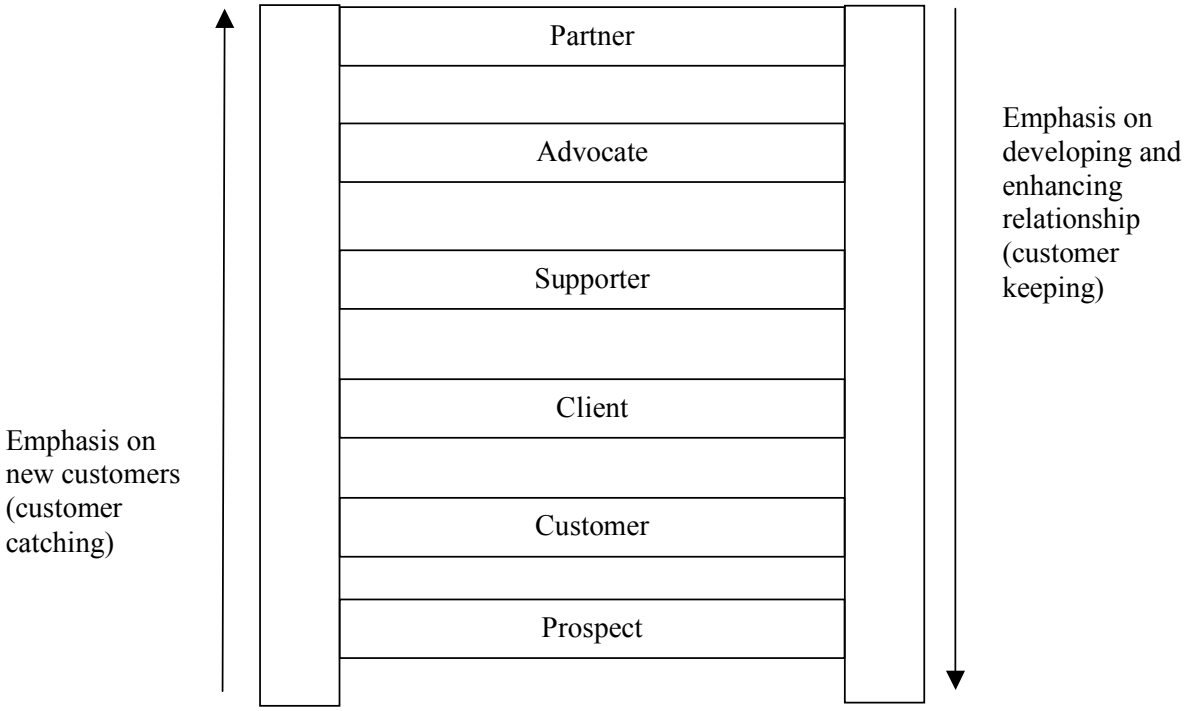
cal about benefits of change. Until and unless substantial cost benefit is offered they won't change their suppliers, therefore this is one of the most challenging group.

CRM strategy for habitual churners should be the lowest cost method of service and increased number of sales calls. For possible churners the strategy should comprise of high quality of information and product offering at the right time; and for sluggish churners hassle of switching supplier could be removed by subtle communication, encouragement and by developing shop window image.

All these CRM strategies center-around the basic idea of retention so as to get the most out of their existing or potential customers. According to Gartner Research firm, it cost five times as much to find a new customer as it does to keep an old one. "If you are losing high value customers, the cost go up substantially to acquire a customer and grow that relationship to the same level", says Kimberly Collins, a research director at Gartner. "Besides, once they leave it's too hard to win them back". Customer Life cycle for an enterprise begins with acquisition, is perpetuated with retention and is improved with cross-selling. Cross-selling is usually more profitable for customers.

Ultimately the heart of any retention strategy is a genuine commitment to customer service. The best thing a company can do is to make it easy for the customers to complain. Suggestion forms, toll free numbers and e-mail addresses serve the purpose. the 3M company claims that over two thirds of it's product improvement ideas came from listening customer complaints. At the same time changes in consumer behaviour be monitored, such as reduced buying frequency or purchase amount etc. which are the signs of dissatisfaction. This requires immediate action by building proper CRM system. Some companies maintain customer file for every customer and see if they have any unresolved issues. The key to retaining customers is relationship marketing According to Berry and Parasuraman, to keep customers happy, marketers can add financial or social benefits to products, or create structural ties between company and customers. For companies to reap profits, focus on retention will be the right direction.

Fig. The Relationship Marketing Ladder of Customers Loyalty



14.7.3 Retaining and Growing Customers :

Customers are becoming harder to please. They are smaller, more price conscious, more demanding, less forgiving, and they are approached by many more competitors with equal or better offers. The challenge, according to Leffrey Gitomer, is not necessarily to produce satisfied customers: several competitors can do this. The challenge is to produce delighted and loyal customers.

Companies seeking to expand their profits and sales have to spend considerable time and resources searching for new customers. To generate leads, the company develops ads and places them in media that will reach new prospects; it sends direct mail and makes phone calls to possible new prospects; its salespeople participate in trade shows where they might find new leads; it purchases names from list brokers; and so on. All this activity produces a list of suspects. Suspects are people or organizations who might conceivably have an interest in buying the company's product or service, but may not have the means or real intention to buy. The next task is to identify which suspects are really good prospects-customers with the motivation, ability, and opportunity to make a purchase by interviewing them, checking on their financial standing, and so on then it is time to send out the salespeople.

It is not enough, however, to attract new customers; the company must keep them and increase their business. Too many companies suffer from high customer churn-high customer defection. It is like adding water to a leaking bucket.

There are two main ways to strengthen customer retention. One is to erect high switching barriers. Customers are less inclined to switch to another supplier when this would involve high capital costs, high search costs, or the loss of loyal-customer satisfaction. This makes it harder far competitors to offer lower prices or inducements to switch.

14.8 Internal and External Relationship

Relationship management implies consideration of not just better relationships with customer markets, but also the development and enhancement of relationships with supplier, recruitment, internal, referral and influence markets.

(1) **Relationship with Suppliers:** In the relationship, the buyer recognizes that fact that suppliers are very much a part of his final products, and that working together with suppliers can increase the benefits to both parties. Benefits in this context have been found to include shorter delivery lead times, lower stock levels, fewer quality problems and faster implementation of design changes. Strategies aimed at improving relationships with suppliers also form part of what has been referred to in the service management literature as 'reverse management'.

(2) **Relationships with Recruitment Markets:** Relationship management also involves having a closer relationship with those who supply human resources to the organization, that is, recruitment markets. Service organizations need to cultivate long-term relationships with the suppliers of such employees to ensure that they receive both the right quantity and quality of employees.

(3) **Relationships with Internal Markets:** Employees need to feel that they have formed a long-term relationship with the service provider and have a shared understanding of the mission of the organization. Human resource strategies need to focus on internal markets and specifically an employee retention. The longer employees stay with the company, the more

familiar they become with the business, the more they learn, and the more valuable they can be.

(4) **Relationships with Referral Markets:** Specific strategies need to be devised to reward the referral sources that generate the most business. Although, traditionally, satisfied customers are the key referral source for service organizations, other sources might include suppliers, other agencies dealing with the company, for instance, banks, and in some cases even competitors.

(5) **Relationships with Influence Markets:** Influence markets can also affect the strength of the relationship the organization has with its customers like legislative bodies, political groups, and trade and consumer associations.

14.8.1 Building Relationship Through Blogs and Forums :-

The important job of ORM is to investigate about what is being said about the industry, competitors and about its own brand ORM system collects the conversation contents of customers and general public by visiting and analyzing various consumer blogs, pod casts and opinion forums. However, the size and complexity of blogosphere, coupled with speed news travelling in internet make difficult to monitor all that is being said about brand, industry and competition in internet media.

Building the relationship is nothing but building the reputation of the organization so that the duration and number of customer rotation must increase.

If a site includes complaints for the company it should immediately clarify its position. In cases of in accurate brand information on any site, the banking organization should send information to the site and should ask to remove the false information from the site.

Banking industry has witnessed a lot of changes since the era of liberalization. Retention and enlarging of the customer base bas gained utmost importance for all the banks since the last five to ten years due to the severe threat posed by competitors. This has forced banks to think the way they function and make use of the latest technologies available for the industry. The challenges faced by the banking industry have never been so complex. To operate in this tough environment banks need to be ready to change and redefine themselves in the way they conduct business. The transformed business should rapidly respond to meet any customer demands market opportunity or external threat. This business strategy requires the use of technology as an enabler for broader transformation within the organization.

With the changing environment, banks implemented tele banking, internet banking, mobile banking call centre services ATMs etc., for enhanced customer services. Internet banking is the latest in this series of technological wonders in the recent past involving use of internet for delivery of banking products and services. It uses today's computer technology to give a person the option of bypassing consuming paper used aspects of traditional banking in order to manage their finances quickly and efficiently. Banks view internet banking as a powerful value added' tool to attract and retain new customers. Internet banking also helps eliminate costly paper handling and teller interactions in an increasingly competitive banking environment.

14.9 Strategies for Relationship Marketing

Service organizations use a number of strategies to move their customers through the stages of relationship development.

(1) The possibility of relationships developing can occur only where the parties are aware of each other and of their mutual desire to enter into exchange transactions. At this stage, the parties may have diverging views about the possibility of forming a long-term relationship. The supplier must be able to offer potential customers reasons why they should show disloyalty to their existing supplier. In some case, low introductory prices are offered by service organizations which provide a sufficient incentive for disloyal customers of other companies to switch supplier.

(2) On entering into a relationship, buyers and sellers make a series of promises to each other. In the early stages of a relationship, suppliers' promises result in expectations being held by buyers as to the standard of service that will actually be delivered . Many studies on service quality have highlighted the way in which the gap between expected and actual service performance determine customers' perception of quality. Quality in perceived service delivery is a prerequisite for a quality relationship being developed.

(3) At a relatively simple level, incentives for frequent users can help to develop short to medium-term loyalty-many airlines, for example, reward frequent business passengers with free or reduced-price leisure tickets.

(4) The better approach is to deliver high a strategy used by some companies is to create relationships by turning discrete service delivery into continuous delivery. In this way, companies offer season tickets valid at all times which avoids customers having to make a choice-where it is available between competing but operators.

(5) Financial incentives are often given to customers as a reward for maintaining their relationship. These can range from a simple money off voucher valid for a reduction in the price of a future service to a club type scheme which allows a standard level of discount for club members. Incentives that are purely financially based have a problem in that they can defeat the service supplier's central objective of getting greater value out of a relationship.

(6) Rather than offer price discounts, companies can add to the value of relationship by giving other non-financial incentives. For example, many retailers offer special preview evenings for customers who have joined its membership club.

(7) Information about the preferences of individual customers can be retained so that future requests for service can be closely tailored to their needs.

(8) A more intensive relationship can develop where customers assign considerable responsibility to a service provider for identifying their needs.

14.10 Summary

With the advent of relationship marketing, companies are prepared to do anything and everything to keep their customers happy and satisfied. A satisfied customer is not going to shift his loyalty to the competition's grab for additional sales. Business firms are now willingly engaged in constant improvisation, personalization and customization marking a visible shift from "marketing myopia" to "marketing hypermetropia". The reason for all this is pretty simple. "If you would not take care of your customers, your competitors definitely would." So the firms should keep pleasing customers and they will keep coming back. Delivery what you promise-on time and in a visible fashion. A satisfied customer is the best advertising a firm can do. So, in present times, to be successful a company needs to be not just. High tech but high tough as well. Future of a business can be very

bright if it nurtures the key relationship well.

Today's economy is demanding. As margins get squeezed quality can deteriorate. Customer's don't want to spend hours on hold. Failure to quick access to information can turn "hot prospect" into ice cold. Speed of practical flow and speed of delivery has become the vital factors for survival. Not only this, the future web based integration is going to witness ERM i.e. Enterprise Relationship Management, a stage above CRM where entire enterprise operations align from CRM to ERP and data warehousing, to provide a single view to the customers.

14.11 Key Words

- **Customer:** Any person or firm who is making use of services or products and also the ones whom you can attract to build future relationship with your organization .
- **Management:** It is the ability of getting things done through others.
- **Customer Statisfaction:** Customers' satisfaction is a state of mind that occurs when the customer feels that his expected requirement is fulfilled by what is offered by the organization.
- **Relationship:** Mutual understanding and goodwill between the organization and customers.
- **Loyalty**: signifies commitment of the customer to a brand.

14.12 Self Assessnment Test

(1) What do you understand by customer relationship management?

(2) Explain the difference between traditional and relationship management.

(3) Explain the types of relationship management.

(4) How can you build continuous relationship through customer loyalty?

(5) What is customer retention and relationship management?

Unit – 15 Six Sigma

Unit Structure

15.0 Objectives

- After studying this unit you should be able to understand:
- The concept of six sigma.
- What is the statistics behind it and its origin ?
- Reasons of growing interest in six sigma.
- Implementing six sigma.
- The six sigma methodology.
- Implementation roles of six sigma methodology.
- Downsides of the six sigma.

15.1 Introduction

Six sigma is a philosophy of doing business with a focus on eliminating defects through fundamental process knowledge. Six sigma methods integrate principles of business, statistics and engineering to achieve tangible results. A business discipline that combines a structured process-improvement methodology with an array of tools that help manage the achievement of objectives. The objectives of most Six Sigma projects are specific and measurable, such as "improving the preferred customer order cycle time to 99.99% on-time performance level." Other objectives might be expressed in "mean time between failures (MTBF)" or other process-centric terms.

In statistical terms, the purpose of Six Sigma is to reduce process variation so that virtually all the products or services provided meet or exceed customer expectations. This is defined as being only 3.4 defects per million occurrences. Six Sigma was developed by Motorola in the 1980s but has its roots in Statistical Process Control (SPC), which first appeared in 1920s.

Why "Sigma"? The word is a statistical term that measures how far a given process deviates from

perfection. The central idea behind Six Sigma is that if you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible. To achieve Six Sigma Quality, a process must produce no more than 3.4 defects per million opportunities. An "opportunity" is defined as a chance for non-conformance, or not meeting the required specifications. This means we need to be nearly flawless in executing our key processes. The goal of Six Sigma is to increase profits by eliminating variability, defects and waste that undermine customer loyalty.

Six sigma tools are used to improve the processes and products of a company. They are applicable across every discipline including: Production, Sales, Marketing, Design, Administration and Service. Six Sigma is :

1. A statistical measure of the performance of a process or a product.
2. A goal that reaches near perfection for performance improvement.
3. A System of management to achieve lasting business leadership and world-class results.

The Greek symbol ó (sigma) is a statistical term denoting "standard deviation". Standard deviation denotes how far away the data points are from the mean, typically, and it may be computed with a formula. The phrase six sigma refers to several things: One, six sigma is a performance level for a six sigma process, 6 standard deviations each may be fitted between the mean and the upper and lower specification limits. Allowing for machine wear & tear and operator fatigue, this performance level equates to 3.45 dpmo (defects per million opportunities) for a process with a single-sided specification (or 6.9 dpmo for a process with a double-sided specification). Six sigma also is a disciplined and data-driven approach to insuring that repetitive work processes function in the best possible manner. The primary goal of six sigma is to minimize defect levels in the outcomes of work processes, a defect being anything that causes customer dissatisfaction. Maximizing customer satisfaction leads to improved bottom-line performance and globally competitive positions.

Six sigma offers a wealth of tangible benefits. When skilfully applied by your people:

- Six sigma reduces costs by 50% or more through a self-funded approach to improvement.
- Six sigma reduces the waste chain.
- Six sigma affords a better understanding of customer requirements.
- Six sigma improves delivery and quality performance.
- Six sigma provides critical process inputs needed to respond to. changing customer requirements.
- Six sigma develops robust products and processes.
- Six sigma drives improvements rapidly with internal resources.

Six Sigma as a fairly rigorous methodology for solving business process problems. Six Sigma tools are oriented to repetitive business processes, those that regularly produce outputs. It is data-based problem solving; it requires very specific measures of performance and that to quantify current performance with measurements—enough measurements to matter. Once quantitatively assessed current performance, rigorously determine what the root causes are for unacceptable behaviour, these are also confirmed with data, and then systematically attack those roots until system performs as desired as demonstrated by more data. There is nothing magic in this. It is the straightforward application of measurements, statistics, and scientific problem solving. A scientist might look at Six Sigma and say "What is all the fuss about? We've been doing this for a hundred years." And she would be

right!

However, businesses have not always been run with scientific methods. Businesses are created by entrepreneurs, people who have visions and leadership skills, people who have passion and endurance and sometimes great luck. As these businesses expand, the leader has less and less direct impact on the business and the processes that make it up so the company begins to rely more and more on the experience of their employees. Passion and vision are important but are not particularly useful at letting others know what to do in large groups. Also, passion and vision don't normally help create repeatable processes. Repeatable processes are necessary to have a reliable business operation. Six Sigma problem solving is oriented around the creation and improvement of repeatable processes. It is a methodology that allows businesses to solve problems in a scientific way rather than relying on hunches, "experience," or the way we've always done it. What is "experience" anyway? You know exactly what experience is: Experience is what is left after mistakes. Sometimes experience kills people but those who survive are considered valuable to many businesses. Why should that be? Does experience make a good problem solver? Does it make a good leader? A good trainer? Maybe, but maybe not. Relying on employees with experience is dangerous when one need reliability and predictability and high performance unless one is happy with their systems running just the way they have in the past, because experience tends to make people want to repeat what worked for them in the past.

Six Sigma gives us a way to use employees with normal experience and knowledge but harness what they know to solve problems and improve their business in ways that are predictable and better than normal. The Six Sigma system will make process improvement efforts successful, not whether they happened to pick the right person for the job. One never have enough right people anyway, right?

15.2 What Is a Standard Deviation?

We have been talking about things being predictable and repeatable. Why is that important and how do we measure it? These terms are closely connected. If something is repeatable, it means that it will tend to do the same thing over and over. If one is shooting a rifle at a target, and one was very repeatable, one could perhaps fire every round into the same hole. Even if the hole is nowhere near where one is aiming, if they all go to the same place, one has a repeatable process. If what one really wants is to hit the bull's-eye and his process is repeatable, it's easy to adjust what one is doing to hit it. Simply adjust the sights on the rifle so that the position of the round lands closer to where one wants. As long as one continue to fire the rifle the same as one did before, a successful adjustment will now has one hit the target every time. If one is familiar with guns, he will recognize this as a very simple adjustment to make. But what if when one look at their initial pattern, the rounds landed all over the place? What if there was no pattern to them at all? If sometimes they were high, sometimes were low, sometimes missed it completely, and sometimes hit the target next to him? Besides the fact that nobody would want to be anywhere near him, this would be a much more difficult process to fix. His process is not repeatable. Because of that, it isn't predictable. Repeatable processes are predictable. one can estimate reliably what they will do in the future. Unrepeatable or erratic processes are not predictable. One has no idea what will happen next. That's why the smart shooter will get far out of the way when the unrepeatable shooter comes to the range! Let's describe one other situation here. Let's say that after firing a group of rounds, one see that not all the bullets go into the same hole, but there is a grouping of them that has a discernable shape. It will probably be round.

Fi rn

If every time one fire a group of shots, one get a random but discernable shape, one also has a predictable process! His process is just as predictable as the person who puts them all into the same hole, but the two of them have different amounts of variation. If three shooters are all predictable (i.e., they all have circular patterns of holes in their targets), but each has a different size pattern, the one with the smallest pattern has the least amount of variation and the one with the largest pattern has the most variation.

How do one measure how much variation a process has? The most ubiquitous metric for this is the standard deviation. The standard deviation is a statistical measure of how much variation there is. In the case of the shooter, this would be how much the shots vary around the centre of the circle of shots. It does not measure how close to the centre of the target we are, just how big that circle of holes is. Figure 2 shows two shot patterns. The one with the smallest diameter (least variation) has the smallest standard deviation.

Figure 2: Two different random shot patterns

Part of the Six Sigma technique is simply for everyone to know the proper way to describe things and knowing what a standard deviation is and how to calculate it is the first step for a team to have a common language to describe variability. If one want to make data-based decisions, one cannot rely on statements like one might hear on the firing range such as “That’s really good,” or “One have really improved.” We have to be able to quantify variability and express it in the right terms and the standard deviation is what one use. Much better statements are “Last week the standard deviation of his shots was 2.3 and this week it’s 1.5. Good job!” The bigger the standard deviation, the more variation there is, so normally one is trying to make it smaller. A smaller stn dev would mean a tighter grouping of shots. Now one has a precise language that one can use to describe variability to each other. This is important because people do not have a natural way of distinguishing between two groups of things, one of which is slightly more or less variable than the other. Our minds and brains just don’t think that way. One needs to calculate the stn dev to really know. Table 1 is an example. The data represent how long a standard query from two different databases takes in milliseconds.

Table 1 Query Time Example

	Query Times (milliseconds)	
	Database A	Database B
	17.7	26.8
	20.2	22.8
	20.3	25.1
	18.9	16.4
	20.4	12.9
	17.4	29.1
	20.4	14.3
	20.9	17.2
	19.8	11.1
	22.0	16.4
	20.4	18.7
	18.6	26.4
	21.3	15.6
	18.7	13.6
	20.4	26.0
	20.1	18.2
	20.6	20.4
	21.4	19.9
	19.9	25.0
	17.9	22.5
Mean	**19.9**	**19.9**
Stn dev	**-1.3**	**-5.3**

Both databases have the same mean (average) query times but B has a much larger standard deviation than A, meaning it is a lot more variable and users of that database will see more variation in query time performance. One of the first things that Six Sigma practitioners learn is that although it is common business practice to compare two things by comparing their averages, it is a really bad idea to do that. Averages do not tell much about a process. When one add the standard deviation information, one know a lot more. In this case, the averages are the same but the two databases have widely different performance and users will notice it. If there is a specification on response time, Database B will fail it much more frequently than Database A.

15.3 Growing Interest in Six Sigma

Organizations like GE, Toyota, Hewlett Packard, FedEx, Motorola and American Express are just a few of the world's leading companies that in recent years have shared incredible improvements in increased earnings, reduced waste, improved leadership and more, as a result of Six Sigma implementations. Because Six Sigma principles focus on business and process improvement, their successful implementation leads to a significant savings in corporate resources, which can translate directly and rapidly into an increase in corporate profitability and business growth. Additionally, these process improvements result in increased company performance, quality and customer satisfaction. Today's competitive environment leaves no room for error. We must delight

our customers and relentlessly look for new ways to exceed their expectations. This is why Six Sigma Quality has become a part of our culture.

It should be obvious by now that I don't view Six Sigma either as a panacea or as a mere tool. The companies that have successfully implemented Six Sigma are well-known, including GE, Allied Signal, Intuit, Boeing Satellite Systems, American Express and many others. But the picture isn't entirely rosy, failures also exist, most notably Motorola, the company that invented Six Sigma. Running a successful business is an extremely complicated undertaking and it involves much more than Six Sigma. Any organization that obsesses on Six Sigma to the exclusion of such things as radical innovation, solid financial management, a keen eye for changing external factors, integrity in accounting, etc. can expect to find itself in trouble some day. Markets are akin to jungles, and much danger lurks. Six Sigma can help an organization do some things better, but there are places where Six Sigma doesn't apply. I seriously doubt that Six Sigma would've helped Albert Einstein discover relativity or Mozart compose a better opera. Recognizing the limits of Six Sigma while exploiting its strengths is the job of senior leadership.

If you are working in a traditional organization, deploying Six Sigma will rock your world. If you are a traditional manager, you will be knocked so far out of your comfort zone that you will literally lose sleep trying to figure out what's happening. Your most cherished assumptions will be challenged by your boss, the accepted way of doing things will no longer do. A new full-time, temporary position will be created which has a single mission: change the organization. People with the word "belt" in their job title will suddenly appear, speaking an odd new language of statistics and project management. What used to be your exclusive turf will be identified as parts of turf spanning processes; your budget authority may be usurped by new "Process Owners." The new change agents will prowl the hallowed halls of your department, continuously stirring things up as they poke here and peek there, uncovering inefficiency and waste in places where you never dreamed improvement was possible. Your data will be scrutinized and once indispensable reports will be discontinued, leaving you feeling as if you've lost the star you use to navigate. New reports, mostly graphical, will appear with peculiar lines on them labelled "control limits" and "process mean." You will need to learn the meaning of such terms to survive in the new organization; in some organizations you won't be eligible for advancement until you are a trained "belt." In others, you won't even be allowed to stay.

When done properly, the result of deploying Six Sigma is an organization that does a better job of serving owners and customers. Employees who adapt to the new culture are better paid and happier. The work environment is exciting and dynamic and change becomes a way of life. Decisions are based on reason and rationality, rather than on mysterious back-room politics. However, when done half-heartedly, Six Sigma (or any other improvement initiative) is a colossal waste of money and time. The message is clear: do it right, or don't do it at all.

It has been nearly two decades since Six Sigma began and the popularity of the approach continues to grow. As more and more firms adopt Six Sigma as their organizational philosophy, they also adapt it to their own unique circumstances. Thus, Six Sigma has evolved. This is especially true in the way Six Sigma is used to operationalize the organization's strategy. Inspired leaders, such as Jack Welch and Larry Bossidy, have incorporated Six Sigma into the fabric of their businesses and achieved results beyond the predictions of the most enthusiastic Six Sigma advocate. Six Sigma has also been expanded from merely improving existing processes to the design of new products and processes that start life at quality and performance levels near or above Six Sigma.

15.4 Origin of Six Sigma

The late Bill Smith, a reliability engineer at Motorola, is widely credited with originating Six Sigma and selling it to Motorola's legendary CEO, Robert Galvin. Smith noted that system failure rates were substantially higher than predicted by final product test. He suggested a number of possible causes for this phenomenon, including a dramatic increase in system complexity and the resulting opportunities for failure and a fundamental flaw in traditional quality thinking. He concluded that a much higher level of internal quality was required and convinced Galvin of the importance of setting Six Sigma as a quality goal. Smith's holistic view of reliability (as measured by mean time to failure) and quality (as measured by process variability and defect rates) was indeed new, as was the Six Sigma quality objective.

Prior to Smith's analysis, a number of gurus, including Joseph M. Juran, Dorian Shainin, Genichi Taguchi and Eliyahu Goldratt, had presented their programs for quality and productivity improvement at Motorola. Mikel Harry, president of the Six Sigma Academy and co-author of *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, attended some of these programs and developed a program for the Government Electronics Division of Motorola that included Juran's quality journey, statistical process control (SPC) and Shainin's advanced diagnostic tools (ADT) and planned experimentation (PE).

Harry later teamed with Smith on the Six Sigma initiative and created Motorola's Six Sigma Institute prior to forming his own firm. Smith and Harry's initial Six Sigma umbrella included SPC, ADT and PE. Later, they added design for manufacture (product capability and product complexity) and, as quality was linked to business performance, accomplishing quality through projects.

Motorola's design margin had been 25 percent (or 4s or Cp = 1.33). When Smith noted that escaping and latent defects under this strategy were far too high, he reasoned that the disparity between actual reliability and the reliability expected at final test could be accounted for by increased product complexity and deviations of the process mean from the target value, arriving at a value of 1.5 sigma. The complexity phenomena had been noted previously by Wernher von Braun in the U.S. space program: If a large number of components must function for a system to accomplish its objective, the probability of system success diminishes rapidly as the number of components increases unless the reliability of each is essentially perfect. The 1.5-sigma deviation remains controversial, but it's not a fundamental issue. What is important is that Smith recognized that a process mean could not be maintained exactly on target, and when it deviated from target, the traditional three-sigma process produced large numbers of parts that exceeded specifications. Thus, this breaking with the three-sigma quality tradition was a major contribution, as was the recognition of the role of complexity, which dramatically increases the number of opportunities for (and thus, probability of) defects and the likelihood of subsequent system failure.

But what about the existing theory of optimal quality levels? Motorola observed that Japanese products were of much higher quality than was predicted by the traditional optimal quality level curves. Independently, Robert Cole investigated this issue and noted several reasons for this change in the quality viewpoint. Japanese quality professionals, he asserted, realized that the costs of poor quality were far larger than had been supposed; recognized that focusing on quality improvement as a companywide effort improved a wide range of performance measures; established a system that moved toward quality improvement and low-cost solutions simultaneously; shifted the focus of quality improvement from product attributes to operational procedures; developed a dynamic model

in which customer demands for quality rise along with their willingness to pay for these improvements; and focused on preventing error at the source, thereby dramatically reducing appraisal costs.

As Motorola set out on its quality journey, Harry noted that the company ran into a five sigma wall. Motorola found that it could attain a three-sigma level by installing process improvement and control in its own installations, and improve this to the four- or five-sigma level through the education of its suppliers. However, Six Sigma only became possible once the company had attained a better understanding of the role of robust design—systems design, parameter design and tolerance design.

Not coincidentally, Motorola won the Malcolm Baldrige National Quality Award shortly after the rollout of Six Sigma. Receiving the Baldrige Award requires the winning company to present its concepts to the world. Thus, as Six Sigma was approaching adolescence, quality professionals at Motorola were describing their methods to their colleagues and learning how far Motorola had advanced in comparison to other companies. At this point Harry wrote a strategic vision for accelerating Six Sigma. This included a change in focus, anchoring quality by dollars and seeking a business transformation. It included a description of different competence levels in the Six Sigma methods, which, in the karate tradition, were designated by belts—Green Belt, Black Belt and Master Black Belt.

Elsewhere, GE's Jack Welch and AlliedSignal's Larry Bossidy (first at GE Financial) led their organizations' cultural change through Six Sigma initiatives. In 1998, *Business Week* reported that GE saved $330 million through Six Sigma, doubling its CEO's previous prediction. Welch has predicted a savings of $10 billion over five years. It's no wonder Six Sigma has gained industry's attention.

15.5 Implementing Six Sigma

After nearly two decades of experience with Six Sigma and TQM, there is now a solid body of scientific research regarding the experience of thousands of companies implementing major programs such as Six Sigma. Researchers have found that successful deployment of Six Sigma involves focusing on a small number of high-leverage items. The steps required to successfully implement Six Sigma are well documented.

(1) Successful performance improvement must begin with senior leadership. Start by providing senior leadership with training in the philosophy, principles, and tools they need to prepare their organization for success. Using their newly acquired knowledge, senior leaders direct the development of a management infrastructure to support Six Sigma. Simultaneously, steps are taken to "soft-wire" the organization and to cultivate an environment where innovation and creativity can flourish. This involves reducing levels of organizational hierarchy, removing procedural barriers to experimentation and change, and a variety of other changes designed to make it easier to try new things without fear of reprisal.

(2) Systems are developed for establishing close communication with customers, employees, and suppliers. This includes developing rigorous methods of obtaining and evaluating customer, owner, employee, and supplier input. Base line studies are conducted to determine the starting point and to identify cultural, policy, and procedural obstacles to success.

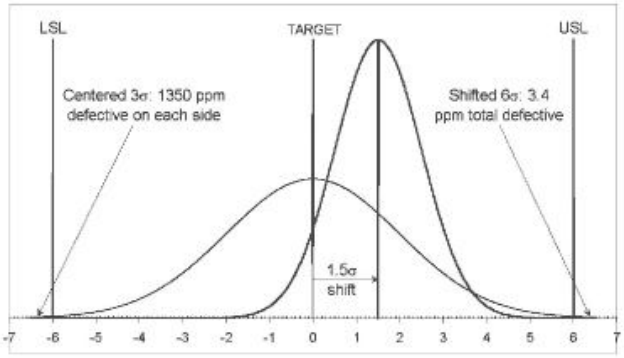
(3) Training needs are rigorously assessed. Remedial basic skills education is provided to assure that adequate levels of literacy and numeracy are possessed by all employees. Top-to-bottom training is conducted in systems improvement tools, techniques, and philosophies.

(4) A framework for continuous process improvement is developed, along with a system of indicators for monitoring progress and success. Six Sigma metrics focus on the organization's strategic goals, drivers, and key business processes.

(5) Business processes to be improved are chosen by management, and by people with intimate process knowledge at all levels of the organization. Six Sigma projects are conducted to improve business performance linked to measurable financial results. This requires knowledge of the organization's constraints.

(6) Six Sigma projects are conducted by individual employees and teams lead by Green Belts and assisted by Black Belts. Although the approach is simple, it is by no means easy. But the results justify the effort expended. Research has shown that firms that successfully implement Six Sigma perform better in virtually every business category, including return on sales, return on investment, employment growth, and share price increase.

Figure 3: Six-Sigma Process with +1.5s Shift vs. Centred Three-Sigma Process



15.6 How Does Six Sigma Work ?

Let's take a closer look at the difference between three-sigma and six-sigma processes under the assumption of normality, which is critical to the calculations that follow. (The assumption of stability is also critical. Without it, one cannot predict the operation of the process or state probabilities.) Figure 3 illustrates a three-sigma (centred) process and a six-sigma (+1.5 s shifted) process. Both process distributions appear to be entirely within the product specifications.

We define LSL as lower specification limit and USL as upper specification limit. The target, T, equals (USL + LSL)/2. For this example, we chose T = 0, USL = -6 and LSL = +6 for ease of explanation.

We have traditionally operated at the three-sigma level. Given the specifications, the process variation (s) must be small enough so that the base of the normal distribution fits within the specifications, when the mean equals the target. That is, the length from m - 3s to m + 3s, a length of 6s, must be less than USL & LSL. Hence s = (USL + LSL/6) is the largest variation allowable. The figure illustrates this situation with a normal distribution where the mean, m, equals 0, and the variation, s, equals 2. A process operating in this mode will produce 2,700 parts per million (PPM) defectives, with 1,350 PPM beyond each specification limit. And should the process mean shift to m = t - 1.5s (which would be - 3), then it would produce 66,807 PPM defectives.

Following the same reasoning as was given for the three-sigma process, a process variation of s = 1 or smaller is required to achieve the six sigma objective [s = (USL + LSL)/12]. If the six-sigma process mean were centred on the target value, the process would produce defectives at a rate

of two parts per billion (PPB), one PPB beyond each specification limit. Should the process mean shift by 1.5 sigma, the defective rate would increase to 3.4 PPM defectives. The figure illustrates the latter situation, with a normal distribution where the mean, m, equals 1.5, and the variation, s, equals1.

Note that every process has a variation that can be estimated through a process capability study. It isn't determined by the specifications of the product being produced. Here we are determining how precise a process must be to accomplish a three-or six-sigma objective for the product. P.R. Tadikamalla showed that the 3.4 PPM rate could be obtained in other ways depending upon the process spread and the process shift.

15.7 The Six Sigma Methodology

The Six Sigma includes two key methodologies; DMAIC and DMADV.

DMAIC is used for an existing process.

DMADV is used when creating a new product or process. Using DMADV for new projects can usually result in a more predictable process and ultimately higher quality product.

DMAIC :

DMAIC is an acronym for the most commonly used Six Sigma methodology. About 95 percent of all Six Sigma projects follow the DMAIC methodology. The acronym is the first letters of the stages of a Six Sigma performance improvement project: Define, Measure, Analyse, Improve, and Control. This methodology was developed to provide an organized way to solve problems. Using a standard structure for problem solving, all the process improvement teams go through the same steps and nothing is forgotten. The methodology also provides standard places for management review. In addition, the methodology provides a standard terminology for everybody to use. This helps both management and employees know where everybody is on each project. If I say that I'm in the Analyse phase, then you will know what I mean.

- **D** - Define goals to improve the overall process between company strategy and customer's demands (can also refer to group and the groups or individuals that one support) The Define stage is where one start each project. It's helpful to think of the outputs of each stage to know what the stage does. In this stage one establish the goal of the project. One should know who customer is, which process one will be working on, which part of the process one will work on, which of the process variables are important, what the goal is for those process variables, how much money one expect to save or other benefits one will get, when the project will be finished, who the project team is, and who the stakeholders are. It is in the defined stage where one first see evidence of Six Sigma thinking. The goal of a project always has to be stated as a measurement, the value of which will be improved. It might be stated as several measurements and goals for each of them. Each of these measurements is an important process output that matters to the customer. All six similar projects must identify who the customer is for each process. The customer sets the acceptable parameters for each of the key process outputs. These are usually expressed as specifications, but might take other forms. The key is that no project can proceed unless a quantifiable goal is stated. At the end of the define stage one will have a well-defined project with well-defined and quantifiable goals.
- **M** - Measure current processes. Collect relevant data on current processes and then use this data as a baseline for future comparisons. At the output of this stage one should has a thorough understanding of how the process is behaving right now. By understanding means a quantitative

description. This description will include current process variable averages, standard deviations, behaviour over time, and histograms. In addition, one will know whether the process is stable or not. Another thing one will know at the end of this stage is whether or not the process has a capability and what the value is. Capability is basically the measured ability of the process to meet customer demands. The sigma level, for which Six Sigma is named, is an example of a capability measure.

To do this entire one has to collect data, and to know what data to collect, one need to know which characteristics are critical. Sometimes this is determined in the Define stage, but sometimes what are given in the Define stage is not sufficient to collect data. The first thing one would then do is determine the precise measurements necessary to determine process capability. For example, let's assume that project is to improve the turnaround time for software support requests. How is one going to measure this turnaround time? Does it start when the initiators first think about it? When they create their request form? When they submit the form? When one receives the form? What if there are approvals necessary for the request to be submitted? Do all of those approvals those have to be finished before the request is considered start? In a similar vein, when is this request complete? Does it end when the programmer thinks he or she is finished? Does it end when the end user says that it is finished? Is it complete after the end user has tested it? Although this is a simple example, it illustrates the precise nature of the measurement definition that is necessary to collect data. This might seem a little picky, but it's not. Defining precisely when the start and finish points of the project are helps everybody to agree on a common definition of the critical variable, and it allows to actually collecting data unambiguously.

Let's talk about data for a moment. One runs the IT organization. One is swimming in data. Any database project should be a snap, right? Some bad news is that the chances that the data that one will need are the data that one has might be quite small. Of course, in some cases one will find he has just what he need in his databases. In other cases the agreed-on definition will result in the discovery that one doesn't quite have what is necessary. In addition, for certain aspects of data-based decision making, one need very specific kinds of data, frequently the kinds of data that are not collected by businesses. Businesses collect data for different reasons and problem solving. They collect data to assess financial results. They might collect data to determine which of their functions are performing best. The most common data collected are averages; everybody collects averages. However, as one has already seen, data averages do not tell the whole story. In fact, they tell only about a quarter of the story. We merely point this out to make one aware in advance that many Six Sigma process improvement projects will require that one collect new data. One might consider this bad news, but it is not necessarily bad at all. If one is not collecting data that will help him to determine process performance right now, he will be after each project. In addition, it frequently does not take very many data to make meaningful decisions about process performance. Very often only about one hundred data points are needed to make intelligent decisions. This is so few data that they can often be collected manually if necessary. In fact, one of the problems with IT organizations and process improvement is that more time is spent trying to find ways to collect data automatically when it would be cheaper and faster to do it manually.

- **A** - Analyse relationship within the process. It is important to understand the relationship to determine factors that can ensure to keep companies strategy in line with their customers

demands. The overall approach in Six Sigma problem solving is to carefully define a problem, find the root causes for the problem, and then attack the root causes. The purpose of the Analyse phase is to correctly identify what those root causes are and prove it with data. In this disciplined problem-solving method, opinions are not worth much. In fact, nobody's opinions are worth much. It is not that they are valueless, in fact use the opinions of the team to come up with ideas for what the root causes are and that is normally the very first thing one does via a brainstorming session. Then proceed to gather evidence to prove what matters and what doesn't. This could be a simple exercise or it could be most of the project, depending on how difficult the problem is and how complex the process is. This is where the similarity to the traditional scientific method comes in. Opinions as to what the root causes are constitute hypotheses. No scientist would act on a hypothesis because it's just a guess. They conduct experiments to prove whether the hypothesis is likely to be true or false. Do the same thing. One might be lucky and have historical data that can analyse using some basic statistics that will help to convince which of "guesses" are true and which are not, or one might has to conduct some experiments and collect some new data. Again, this could be a simple exercise or a very long and expensive one. How much one is willing to do depend on the value that one would gain to solve the problem. Nobody would spend two effort-months to prove or disprove a root cause hypothesis that would save the company $10,000. They sure would, however, if it had the potential to save $1 million. Sometimes the cost of implementing solutions is cheap and fast, so one could abandon scientific method and simply try various solutions. Although this approach might be repulsive to many rigorous Six Sigma people, one is realists, and sometimes trial and error is just plain effective. The difference between random trial and error, however, and a managed decision to do it for a few carefully selected potential root causes that were arrived at in an organized fashion, is huge. As long as one knows what one is doing and why and can defend decision, one see nothing wrong with avoiding experiments. More often than not, though, the analysis of historical data or the collection of new data because one had not been collecting the right data before to answer these questions, or constructing controlled experiments to determine cause and effects are necessary. Figure 3 shows a generalized process with inputs, process variables, environment variables, and outputs.

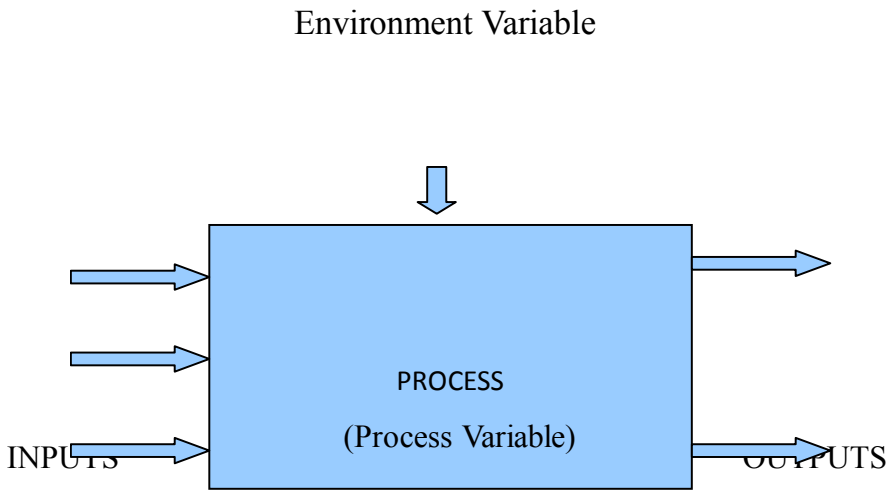


Figure 4: A simple process diagram.

Every output has multiple characteristics. Project is always defined as improving one or more characteristics of one or more outputs of a process. For example, reduce the number of times that incoming support calls take more than three minutes to complete. The output is the call.

The characteristic one care about is the call length. The process itself has many variables, of course. Some of them might be how many people one has, what their training level is, characteristics of phone system, and so on. The inputs in this case are also calls. Some characteristics are the topic of the call, the education or experience of the caller, and so on. The environment might include things like the time of day, the temperature of the call centre, whether it is a nice day outside, the level of noise in the room, the number of disruptions that are present, and so on.

One thing one's like to point out here is the folly of experience. People are good at a lot of things, but people are not very good at determining patterns within complexity. In other words, they are not very good at determining root causes in complex processes. In fact one will make the statements that the more experienced someone is, the less likely he or she is to come to the right answer of that true root causes are in complex situations. The only exceptions to this are physical processes that are very standardized, such as an oil refinery. The reason one say this is because people feel compelled to give their opinions. In fact, one as a business manager put them into this position every day. One demand that they make decisions, even when it's scientifically impossible for them to know they have made the right one, because one has no formal decision-making process in place, yet one still demand decisions so employees make them. They make hundreds of them every week, and many of them are, in the eyes of the formal problem solver, simply random decisions, half of which are right and half of which are wrong.

The objective of a formal process such as the DMAIC process is to ensure that important decisions are usually right and to not allow experience to make those 50-50 calls for us. Experience can kill a business. In summary, when one finish the analyse phase of a DMAIC problem-solving process, one knows what is causing problem and one has evidence to back that knowledge up.

- **I** - Improve the process. It is important to constantly improve and optimize the process, using analysis and other techniques. One technique that is often used is Design of Experiments. (This is a technique that can help to test a hypothesis, using acceptable experimental design) Perhaps it seems like a long time coming if one is the impatient sort, but in the Improve stage, come up with solutions. Finally! This stage also often starts with a brainstorming session. But now one knows what the root causes are. Let's reflect a minute on just what mean by a root cause. A root cause is something that is controllable and has a direct effect on the characteristic one is trying to improve. If one could has controlled the characteristic itself, if it had a big knob on it one could turn that made it bigger or smaller, one would have turned it, but it doesn't. So find root causes that do have knobs on them, things one can change that will improve the process characteristic one care about. This problem-solving session again can be short and simple or long and complex, depending on process. Frankly, at this point most teams have pretty good ideas of what to do, so solutions often flow easily. The hard part, after all, was finding out what the real root causes are. Now that one knows them for sure, one can attack them with gusto. In fact, one often has multiple solutions offered so one of the things one do in this phase is choose the best one. That might be a technology exercise, a financial one, an environmental one, or a combination of factors. Sometimes the solution is not obvious and one might have to conduct some other experiments and collect some new data to figure out what to change. Sometimes solution ideas are easy to come by, but analysing which are the best ones can be very expensive or complex. If problem is where to locate a new data centre to increase response time, some of the solutions might involve relocation of

data centres, combining them, or adding new ones in various places. How would one choose between them? This kind of problem doesn't lend itself to a calculation answer, but it can be easily simulated. In fact, dynamic computer simulation is often used to help choose from competing solution options when the effects cannot be calculated and trial and error is too expensive. Simulation concepts are taught in most Six Sigma Black Belt programs, but actually doing the simulation is a specialty and normally requires that one use a consultant who knows how because people would normally never do this or would do it so infrequently that it isn't cost effective to train them. One of the services that our firm provides is simulation for project teams.

Not only do figure out what the best solution is in the improve stage, but also implement it! At the end of this stage, the process improvement is installed and the process is now running per our goals. Some Six Sigma programs split this stage into two, where the improve stage involves figuring out what the solution is and the implement stage actually implements the solution. This is because there are different skills needed to problem solve (improve) and to build (implement) so it seems like a logical break. Although that is true, most programs only have one I in DMAIC and it's the team's job to get the solution done, even if they subcontract it to another group.

- **C** - Control. It is important ensure that you can control and correct any variances avoiding possibly costly defects and loss of quality. Many times pilot runs are set up to study process capability and production transition. These pilot runs can help fine tune or add additional control mechanisms. The final DMAIC stage is Control. This is unique to the Six Sigma approach. Most managers have heard of the Hawthorne effect. The Hawthorne effect is a temporary change of behaviour or performance in response to a change in the environmental conditions, with the response being typically an improvement. The term was coined in 1955 by Henry A. Landsberger when analysing older experiments from 1924 to 1932 at the Hawthorne Works (outside Chicago).

  Landsberger defined the Hawthorne effect as a short term improvement caused by observing worker performance. In other words, it's not what you did that improved performance, it's the fact that you paid attention to it that caused everyone around you to behave better than normal. As soon as you leave, things will go back to where they were. Even if the Hawthorne effect isn't operating on your project, because your problems are more technical and equipment oriented and less reliant on people's behaviour, there is still a tendency for systems that have undergone an improvement to degrade back to where they were. This happens for a lot of reasons, including the habits of people, but regardless of the reasons, if you want your improvement to stay there forever without you watching it, you need to build something into the process that will ensure it. That's what the Control stage is in Six Sigma. In this stage the team makes sure that appropriate things are done so that the process will continue to perform at its new level. This can include administrative things like making sure that training materials or written procedures are modified, making sure that new specifications are transmitted and understood by everyone who needs them, including suppliers, and making sure that critical control points are monitored and that procedures exist to react quickly when something goes out of balance. The Control phase isn't as exciting as the other phases because it tends to involve administrative and wrap-up activities, but the wise business owner will not let Six Sigma teams call their project finished until the Control phase is done. In Value-Train's Black Belt program, student project reports are not accepted unless they include a Control phase plan. So there you have it, Six Sigma in five letters—DMAIC.

  Six Sigma is called a tools-based methodology because the DMAIC framework itself is

fairly simple, and most of the work is done using a variety of tools such as flowcharts, various statistics, control charts, brainstorming exercises, and so on. Most of the specific tools and techniques used in all of these phases might already be familiar to you. In fact, very little was actually invented by the creators of Six Sigma. Their two most obvious inventions were the DMAIC process itself and the notion of a capability index called the Sigma Level, for which the methodology was named. It is for this reason that people with a background in quality, process improvement, or scientific approaches might already know many of the specific tools that they need to participate on a Six Sigma project team. Unfortunately, many business decisions, even very important ones, are made by the seat of our pants, so a formal methodology like this is very useful to make sure that some rigor is used in your process improvement decision making. As with anything, efforts like this depend heavily on management. If you train your people on how to do the Six Sigma approach and don't use it yourself or don't allow them the time to make good decisions, or demand fast answers that can't be justified, you will be your own worst enemy. From our experience, about half of all the corporations trained in Six Sigma approaches fail to use it effectively because senior management really doesn't believe in it. They don't enforce decision-making rigor and don't use it themselves. Your people will emulate your behaviours, regardless of what you send them to training for.

DMADV :

There are 5 important steps included in DMADV. They are:

- **D** - Define goals that are consistent between your business strategy and customer demands.
- **M** - Measure CTOs (critical to qualities) CTOs consist of production process, capabilities producing a product, the capability of a product and any risk assessments.
- **A** - Analyse and evaluate many different designs, choosing the best design for its overall qualities.
- **D** - Design details. It is important not only to design a product, but optimize the design features. In order to fully optimize a design feature, you may be required to create multiple designs or simulations.
- **V** - Verify the design. Important steps to verifying a design include setting up pilot runs and running a short production. This step also requires you to handover the design to process owners.

15.7.1 Implementation Roles in Six Sigma Methodology

There are many roles that are used in the Six Sigma Methodology. While most of the roles below are used in many organizations Six Sigma implementation, it should be noted that they are not universal. The roles include:

- **Executive Leadership** - Top level executives are responsible for vision and ultimately implementation of the Six Sigma Methodology. They also empower others to take initiative and ownership of the Six Sigma principles.
- **Champions** - Champions are usually upper management that is responsible for the implementation of Six Sigma throughout their organization.
- **Master Black Belts** - are usually hand picked by Champions to coach others within the organization on the Six Sigma methodologies. They allocate either all or most of their time to the Six Sigma methodologies. It should also be noted, that they usually have mentoring responsibilities to coach and train lower roles including Black Belts and Green Belts (see

below)

- **Experts** - while this role is not in every organization, it can play a huge role in major engineering or manufacturing sectors. They improve overall services, products, and processes for their end customers.
- **Black Belts** - Black Belts focus on six sigma execution. They are usually middle managers.
- **Green Belts** - These roles are usually taken on by employees who help Black belts execute specific projects, as well as other job responsibilities.

15.8 Downsides of the Six Sigma Methodology

For the vast majority of organizations, the Six Sigma methodology has helped them be competitive and reduce costs; however it should be noted that there are some downsides that do exist. In order to implement the Six Sigma methodology in an organization, it is extremely important to have buy- in from employees on all levels. If associates, middle managers or high level executives are not enthusiastic about using the Six Sigma Methodology, it can ultimately lead to failure.

Another downside of using Six Sigma is that in some instances, Six Sigma's effectiveness has never been measured or is unable to be measured. Due to the inability of measurements, it is unclear if Six Sigma is actually helpful.

Finally, many organizations use the Six Sigma methodology as a way of protecting themselves from liability. For instance, if a company produces a product that is low in quality or can harm its user, the organization can use the defence that quality is at the forefront in order to be viewed positively. In this respect, it is unclear if an organization has implemented Six Sigma for its methodology or to cover its liability.

15.9 Key Words

- **Critical to Quality:** Attributes most important to the customer.
- **Defect:** Failing to deliver what the customer wants.
- **Process Capability:** What your process can deliver.
- **Variation:** What the customer sees and feels.
- **Stable Operations:** Ensuring consistent, predictable processes to improve what the customer sees and feels.
- **Design for Six Sigma:** Designing to meet customer needs and process capability.

15.10 Summary

Ultimately, Six Sigma is a superb strategy that addresses leadership, tools and infrastructure issues, some of which were neglected by previous programs. CEOs of leading U.S. firms praise the accomplishments of their Six Sigma initiatives. Outstanding quality professionals and industrial statisticians concur and describe potential roles for their colleagues. Engineering programs have begun to incorporate elements of Six Sigma into their curricula. When have quality professionals ever had such a splendid opportunity to contribute? Constructive criticism of Six Sigma or any other quality program can be useful—but it should be informed and fair.

15.11 Self Assessment Test

1. What is six sigma?
2. Explain roles that are used in the Six Sigma Methodology?
3. Explain the six sigma methodology?
4. Discuss DMAIC & DMADV?
5. Explain how six sigma works?

Unit 16 Maintenance Management

Structure

16.0 Objectives

Upon completion of this unit you should be able to:

- Relate the objective and importance of maintenance management.
- Understand the failure analysis related to equipment and machines.
- Distinguish between various types of maintenance.
- Comprehend that the efforts involved in maintenance planning are worth it.
- Identify some of the key indicators for improving maintenance service.
- To have insight about recent trends in maintenance including computerized maintenance management and Total Productive Maintenance.

16.1 Introduction

Maintenance in general, has been practiced, since the days when man started activity such as hunting and making pots. Maintenance is very important to extend the useful life of an asset. It has been a challenging task since the beginning of industrial revolution. Maintenance directly affects quality, productivity, profits, safety and environment. Maintenance is basically a combination of actions carried out to retain an item in, or restore it to, an acceptance conditions. Main objective of maintenance is to have increased availability of production system with increased safety and optimized cost. In case of equipment we can say maintenance means keeping the equipment in operational condition or repair it to operational mode.

A formal definition of Maintenance can be stated as "That function of manufacturing management that is concerned with day to day problem of keeping the physical assets in satisfactory conditions". Maintenance ensures condition of the facility such that it permits uninterrupted implementation of plans requiring their use. It can also be termed as asset management system which keeps them in optimum operating condition. Maintenance is one function with has not been

rendered obsolete by advanced technology, has not faded away with passage of time & has not lost its stature in industry.

16.1.1 Objectives of Maintenance Management -

Maintenance management is concerned with planning and controlling routine, planned and preventive maintenance activity of an organization .

The management of maintenance activity has to concern itself with provision of un-interrupted production process at minimum cost and maximum reliability. The following are the objectives of a maintenance system.

i. To maximize the amount of time the assets will be available for the purpose for which these were procured.

ii. To preserve the value of assets by reducing the rate at which they deteriorate e.g. periodic removal of rust from the hull of a ship and repainting the areas involved preserves its value.

iii. To perform the maintenance activities in a most economical manner.

iv. To plan and schedule maintenance work so as to anticipate and prevent interruptions in operations.

v. To perform the activities of inspection, adjustment, repairs, replacements and operation of the shop performing the various jobs.

16.1.2 Importance of Maintenance Management

1. Good maintenance management is important for company's cost control. As companies try to become more competitive by adopting advanced technology they have to rely more on equipment and so these equipment should operate reliably with in specification and their maintenance become essential for the companies.
2. Quality assurance is another basis for a successful competitive edge. If the equipments are inconsistent & not maintained properly then they may produce defective parts that may fail to meetthe established specification.
3. Manufacturing organization specifically those who rely on JIT have very low inventory level and offer no protection in a situation of lengthy equipment failure which can lead to cost of idle equipment, cost of idle labour, loss of sale and even companies can permanently loose their market shares.
4. Proper maintenance management can help a company to remain productive and comptetive. If maintenance is overlooked, it can have its impact on idle labour costs, low quality products and overall loss to the company.

16.1.3 Functions of Maintenance Management

The basic function of maintenance activity is to keep the equipments and assets in a satisfactory condition or to restore them to these conditions. Maintenance function can be:-

1. Repair - When any item or a component breaks down then repairing or replacing it to keep it in working order.
2. Overhaul - In this function of maintenance the equipment or machine is stripped and the various parts are cleaned and oiled and critical components are replaced.

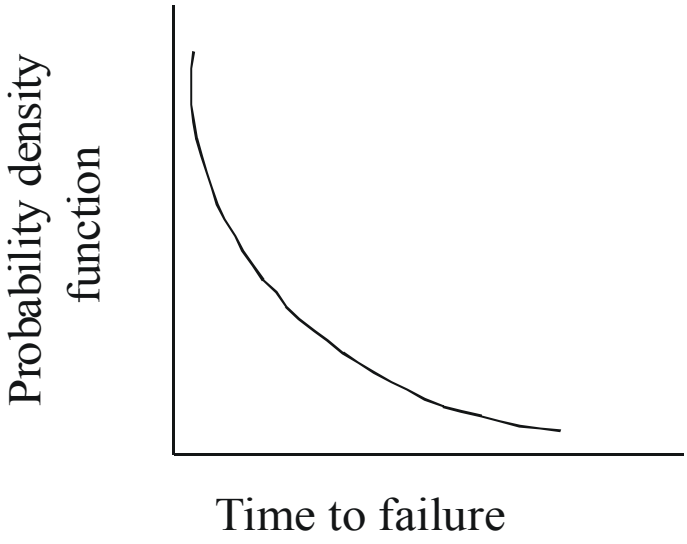
3. Lubrication - This function of maintenance reduce the gradual damage to the moving part by converting solid friction to liquid friction and thus prolonging the life of the equipment.
4. Inspection - Maintenance inspection involves detection of faults before they break down and ensure safe and efficient operation.

Besides, the basic functions, broadly, the major functions of a maintenance department are maintenance of installed equipment and facilities, installation of new equipments and facilities, inspection and lubrication of existing equipment and applying corrective maintenance technologies wherever required, to do modification of already installed equipments and facilities, management of inventory, supervision of man power & keeping records.

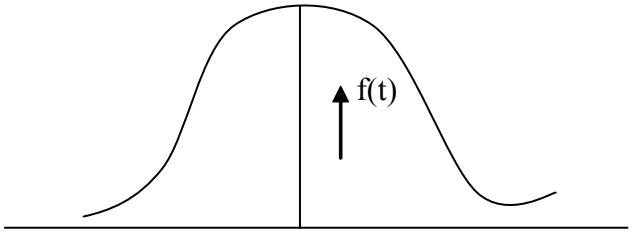
16.2 Failure Analysis of Equipments

The objective of maintenance is to facilitate the optimal use of capital equipment through action such as replacement, repair, service and modification of the components of the machinery. Failure analysis plays a vital role in taking decision pertaining to maintenance planning and control for effective management subject to budgetary constraints. It is important to identify the nature and occurrence of failures with respect to time so as to ensure adequate and reliable performance. Most situations in area of maintenance involve probabilities and on understanding of the statistics of failure, may provide useful information for making maintenance decision on a prior to the failure of an equipment. Answer related to question like how long was the machine component working before it failed i.e. the time to failure "t" and what percentage of instances did it fail at time "t" obviously the data collected will be in ranges like range of days it functioned before failure etc. These data can be approximated to a continuous probability distribution.

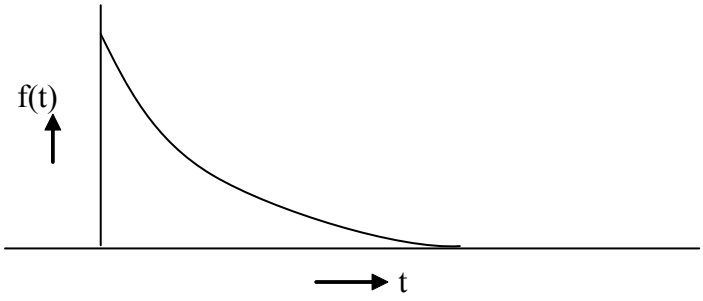
In maintenance we come across three types of probability distribution for the time of failure namely: Hyper Exponential distribution- It shows a steep fall in the probability density functions as the time to failure increases i.e. chances of a failure are high in initial period very much less in later, as in case of any built in design defect which is evident by the graph below;



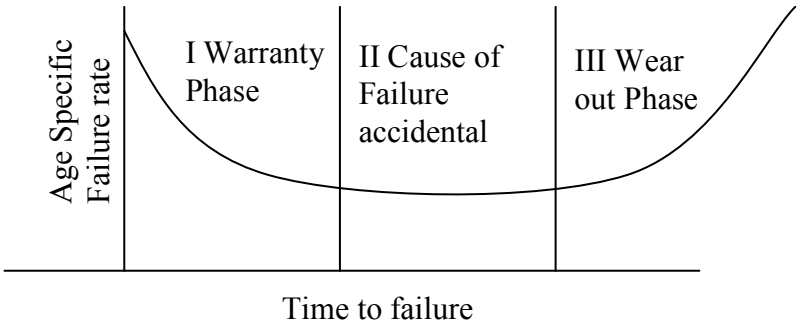
Normal distribution- A majority of failures occur around mean time to failures and failures show related frequencies around the mean. Such a behavior is observed in the wear out of components or machine. Some will wear out faster and some will do slower. The curve for such will be as shown below.



Negative exponential distribution - The phenomenon of failure where the probability of failure is constant and independent of running time i.e. cause of failure is external to the system, for example an electrical fuse blows up because of a sudden extra load elsewhere or a short circuit else where. The curve will be.



Combining the three figure of age specific failure rate to give a whole life figure & the result will be as shown in figure below which resembles a house hold bath tub in its contour.



The three distributions mentioned above can be combined into one distribution namely, Weibull distribution. The bath tub curve depending on the failure rate can be represented by a Weibull distribution and Weibull graphs can be used for determining mean time between failures which would provide good data for system reliabilities.

16.3 Types of Maintenance System

Different types of Maintenance System are as under :

1. **Preventive Maintenance -**

   Also termed as Diagnostic or Predictive Maintenance consists of routine actions taken in a planned manner to prevent breakdown and to ensure operational accuracy. It is undertaken before the need arises and aims to minimize the possibility of un- anticipated production interruptions or major breakdown. Preventive maintenance is a stitch in time procedure following the principle that "Prevention is better than Cure". Any preventive maintenance programme should contain features like proper identification of all items, adequate record

covering, volume of work inspection in definite schedule, an inspection frequency schedule, well qualified inspectors etc. Lubrication and inspection are also two major constituents of preventive maintenance. Lubrication ensure long and safe working of equipments without any risk and inspection tries to detect faults in equipments so that decisions related to timely repair or replacement can be done.

Benefits from preventive maintenance are :

-Reduction of total down time and consequent reduction in production losses.

-Reduction in number of accidents in the plant.

-Reduction in the unplanned or crisis management in maintenance.

-Reduction in the inventory of spare parts.

-Reduction in major repairs & consequently reduced maintenance expenses.

-Reduction in production of number of defective parts.

2. Break Down Maintenance

It occurs when there is a work stoppage because of machine breakdown. It is maintenance carried out to restore an item which has ceased to meet an acceptable condition. It is more economical for those equipments whose down time and repair costs are less.

3. Emergency Maintenance

An unplanned maintenance which is necessary to put in hand immediately to avoid serious consequences.

4. Planned Maintenance

In this type of system the maintenance work is planned in advance, is executed as per schedule and action taken are recorded on compeletion and historical data so produced and maintained are reviewed and analyzed for accomplishing better performance. It is a maintenance which is organized and carried out with forethought, control and record to a predetermined plan.

5. Running Maintenance

Maintenance which can be carried out when the item is in service.

6. Shutdown Maintenance

Maintenance which can be only carried out when the item is out of service,

7. Design out Maintenance

It aims at minimizing the effect of failure and aims at eliminating the cause of maintenance.It is a design oriented curative means aimed at rectifying a design defect originated from improper method of installation or poor choice of materials etc. It calls for strong design and maintenance interface. Design out maintenance aims to eliminate the cause of maintenance.It is suitable for items of high maintenance cost.

8. Corrective Maintenance

It is carried out to restore an item which has ceased to meet an acceptable condition and involves minor repairs.The emphasis is on obtaining full information of all breakdowns and their causes.

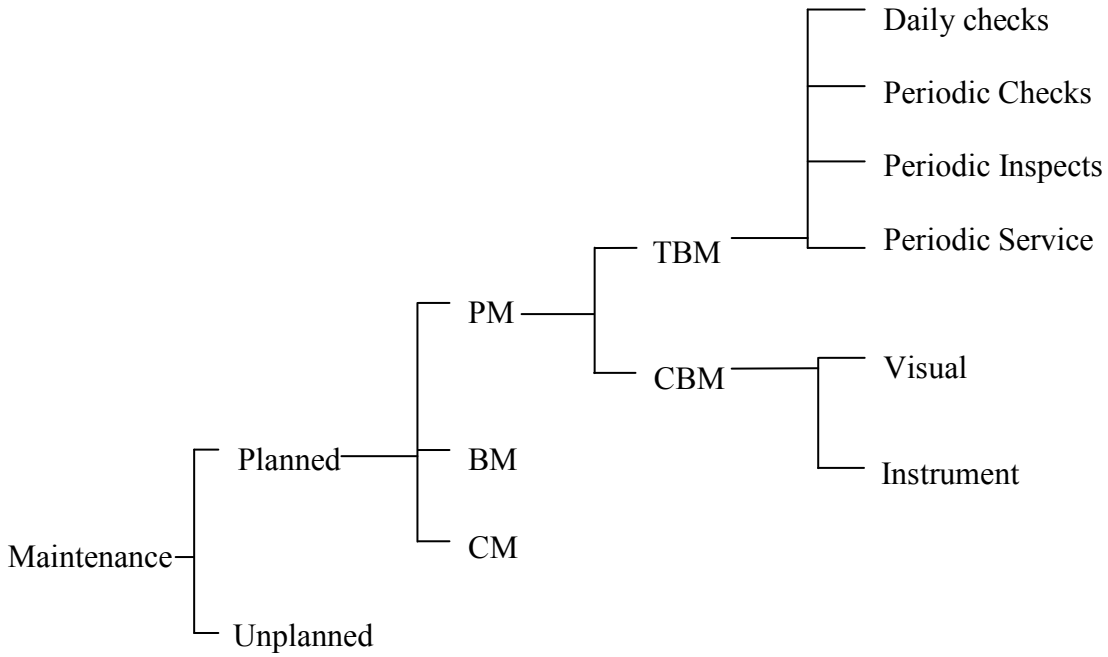
9. Condition Based Maintenance:

It is carried out in response to a significant deterioration in unit as indicated by a change in a monitored parameter of the unit condition or performance. Condition-based maintenance thus reduces injuries and fatal accidents caused by machinery as the conditions of machinery are indicated well before hand. It enables the plant to be stopped safely when instant shut-down is not permissible. Moreover, it permits advanced planning to reduce the effect of impending breakdowns and be in time to have necessary spare parts available. However, condition monitoring is not always used because it involves high manpower and monitoring costs and, furthermore, it is difficult to monitor some parameters.

10. Time Based Maintenance:

This Maintenance is carried out for equipments for which the failure of any item is time dependent and expected to wear out with in the life of equipment.

Various maintenance systems can be summarized as shown in Figure below:



Where,

PM: Preventive Maintenance

TBM: Time Based Maintenance

CBM: Condition Based Maintenance

BM: Break down Maintenance

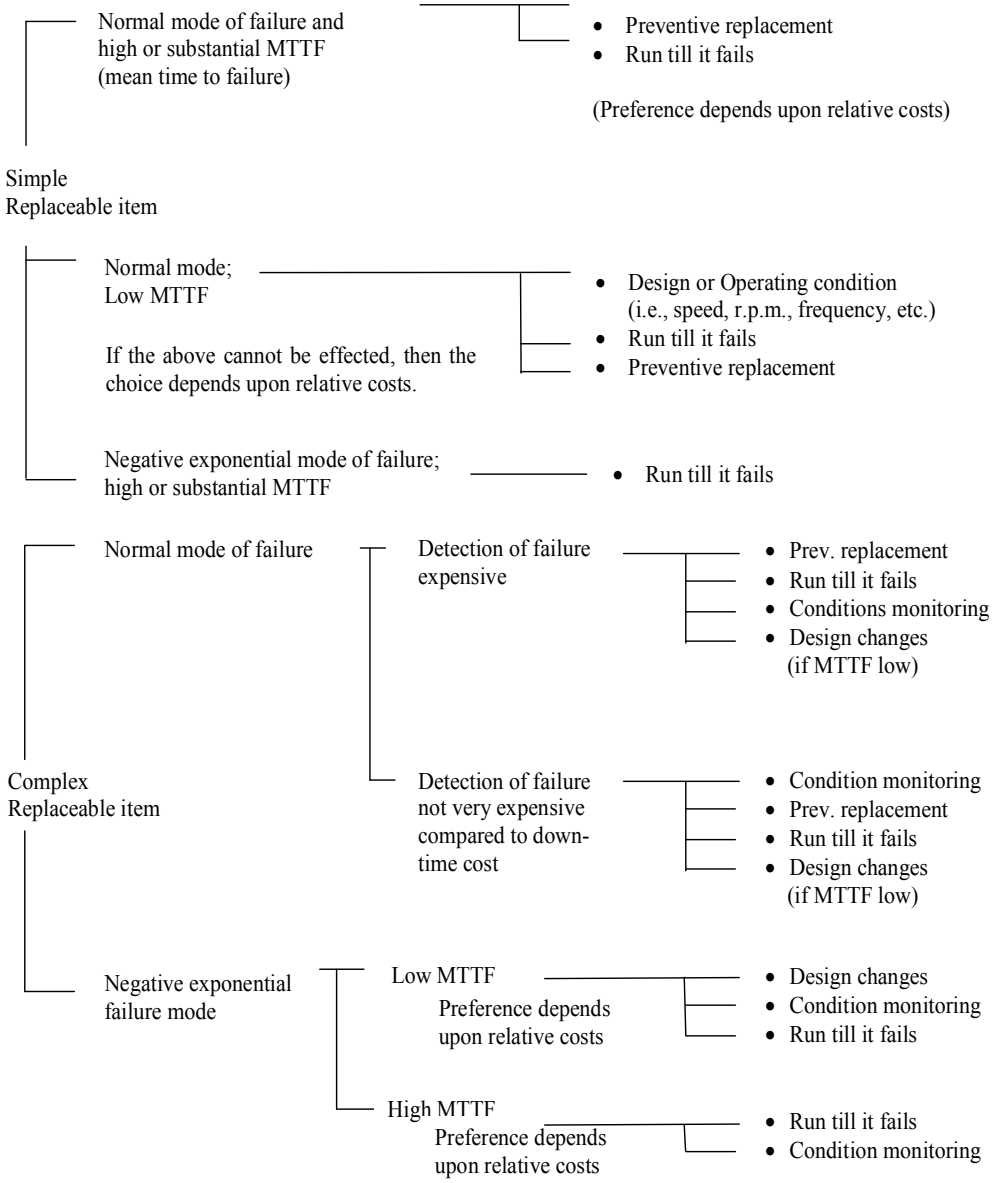
CM: Corrective Maintenance

16.4 Maintenance Policy

Maintenance polices of a company should primarily focus on issues concerned with work allocation ,work force , interplant relations and extent of activities etc. Maintenance policy depends on type of work involved, amount of work and expediency with which work must be accomplished. Different companies follow different policies and practices. For examples small plant may use maintenance department for simple repair & replacement and large non-production engineering job is

handled through outsides specialists. Large companies on the other hand, with more specialist staff may assign all major non-productions engineering jobs to their maintenances department where as, in some companies responsibility for planning and change is placed with maintenance department while the actual construction is led to outside contractors depending on which ever is cheaper which may depend on type of work involved. In case of policies related to equipment maintenance normally two practices are adopted. One is to have a well planned and organized maintenance programme designed to secure maximum life and utilization of machinery while the other one is to adopt a policy of minimum maintenance and maximum wear. Policies related to work force and size of maintenance department depends on factors like the cost of having a large maintenance crew, and prompt service, skeleton staff with lower cost and delayed maintenance services. Issues discussed above and related matter pertaining to maintenance department should be decided by top management and once the policy is formulated it should be circulated to every department so that limits of responsibility and authenticity may be defined properly for a proper and smooth working.

The diagram below provides a broad guideline for formulating an appropriate maintenance policy.



16.5 Maintenance Planning System:-

Planning and Scheduling is a disciplined approach for utilizing the existing maintenance resources to reduce down time and minimize overall production cost. This is accomplished through activities like prioritizing work, developing the physical steps to complete the job, procuring necessary tools and materials, scheduling the work of be done, completing the work, identify any additional work to be completed on the equipment, filing written documentation for equipment history etc. This can be achieved through having a proper maintenance organization. Maintenance planning system involves a systematic approach. The procedure commonly used is.:-

Maintenance Request:- It is document which serves as a prerequisite for planning maintenance function which includes the information regarding what exactly the labour force in doing and how long each task takes. The maintenance request by production staff details the defect or work believed to be required

Assets/Facility Register:- This register contains the name, code, description, reference numbers pertaining to manufacture, suppliers, user location with provision for changes if item is interchangeable or mobile & suppliers details of each & every asset & facility whose maintenance is to looked for.

Maintenance Scheduling:- After knowing what is to be decided i.e. about our assets next step is to determine how they are to be maintained. For this a maintenance schedule is prepared which includes grade of labour required, frequency and details of work to be done, and estimated time for execution of the work.

Work Specification:-After preparing maintenance schedules next is to prepare work specification which establishes a communication between the expert and the person who would be doing that particular job.

Programming time bound planned maintenance programmes:- After preparing maintenance schedules regarding what to maintain and how to maintain next step is to decide when to maintain. For this we prepare annual maintenance programme over a period of time, planned maintenance significantly reduces the demands of maintenance department. From annual planned programmes we can derive short interval programmes as well

Inspection Report:-This document contains all the data regarding maintenance and is used only for reporting the results of planned productive maintenance inspections.

History records:-The last step of a planned maintenance procedure is to build up a detailed historical record of results of maintenance of every asset. This record should be properly updated so that they can be referred to and made use of more meaningfully.

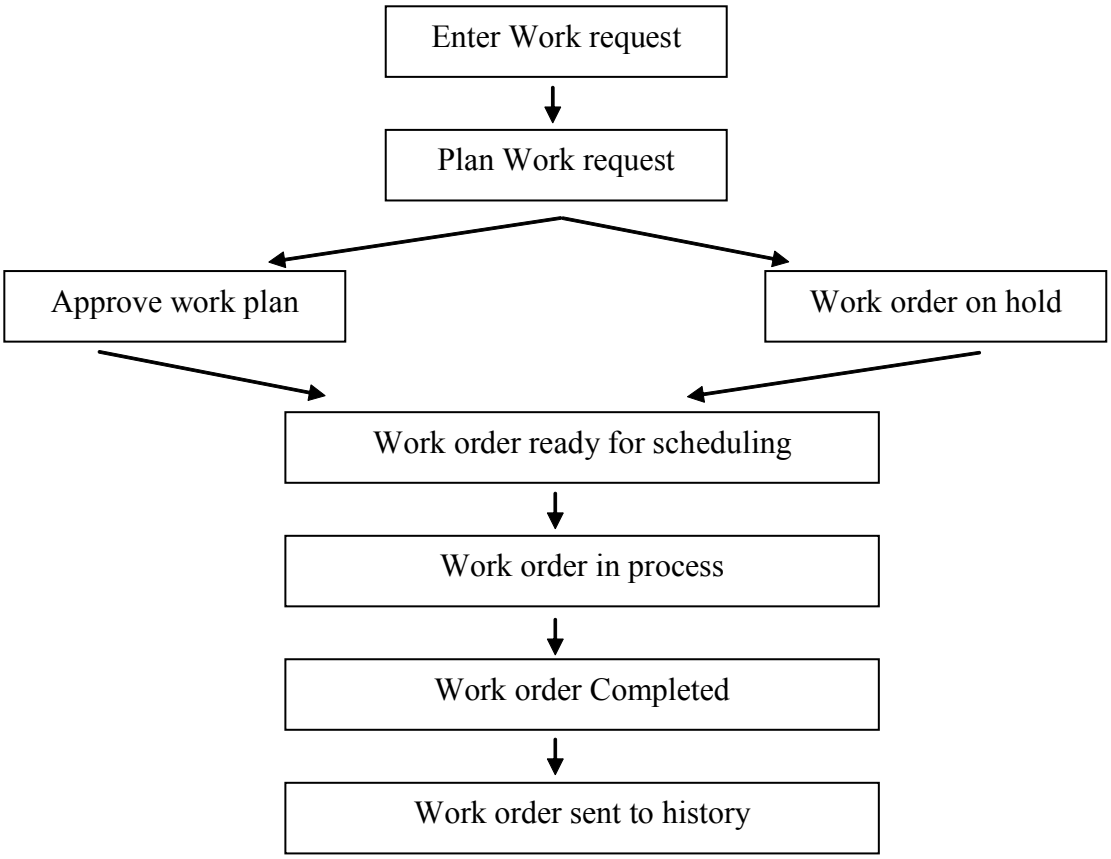
Maintenance record system should provide information like the percentage of planned work achieved ratio of planned to unplanned work, downtime for the period, equipment failure patterns, performance details for personnel, trends in spare part consumption & many more related information.

Beside the above discussed maintenance procedure related to the needs of engineering function decision making aspect is also essential. If management has to be truly effective & objective it must be provided with timely and appropriate information by maintenance organisation.

A maintenance organisation can be considered as being made up of three necessary and interdependent components mainly resources like men, spares and tools, administration which

includes a hierarchy of authority and responsibility for deciding what, when and how work should be carried our and work planning and control system which is a sort of mechanism for planning and scheduling the work and feeding back the information that is needed for correctly directing the maintenance effort towards defined objective. From above discussion we can have the following maintenance planning flow chart:

Maintenance Planning/Work order flow diagram



16.6 Maintenance Performance Indices

Although there is no such yardstick to rate maintance. Unlike direct production which can be rated in terms of output of any particular machine, no such analytical yardstick is available for rating maintenance but for maintenance one should essentially strive to maximize availability and reliability of the machines/ assets and minimize downtime. Maintenance though a support function, is certainly linked to increase in the productivity of the system in the long run. Chandra (Chandra D. 1976, Design out maintenance and Instrument Aids, University Book Corp., Bombay) has proposed some indices as below, which might help management achieve their objectives more effectively and efficiently.

1) Maintenance productivity index $= \dfrac{\text{The output of product}}{\text{The cos t of maintenance effort}}$

2) Maintenance cost index $= \dfrac{\text{Maitenance Cost x 100}}{\text{Capital Cost}}$

3) Downtime index $= \dfrac{\text{Downtime hours x 100}}{\text{Pr oduction hours}}$

4) Waste index $= \dfrac{\text{Quantity of Waste Pr oduced x 100}}{\text{Quantity of total output}}$

Also,

(1) $$\text{Breakdown Maintenance index} = \frac{\text{The hours spent on breakdown} \times 100}{\text{Total man hours available}}$$

(2) $$\text{Level of Maintenance} = \frac{\text{The hours spent on scheduled maintenance} \times 100}{\text{Total man hours available}}$$

(3) $$\text{Inspection of effectiveness} = \frac{\text{Standard mintes of work saved on improved inspection}}{\text{Total standard minutes of inspection carried out}}$$

(4) Technial Competence Ratio =

$$\frac{\text{Annual saving in labour and material costs resulting from additions or modifications made during the year}}{\text{Total maintenace man hours}}$$

16.7 Total Productive Maintenance

The basic concept of maintenance management relates to the fact the breakdown are inevitable. There is always a comprising attitude between preventive maintenance and the breakdown maintenance. On this score the Japanese have shown a new path to the world of management by ceaselessly working towards the ideal goals of zero breakdown and zero defect or zero defectives but for the west it is a new way of looking at maintenance. Less the breakdown of machinery, the less would be the proportion of defective quality. Breakdown of equipment can occur in the following different ways.

1. Equipment stops performing its function
2. Equipment deteriorates
3. Equipment has hidden defects

All these type of breakdowns have to be eliminated. There is no room for trade-offs. This is the rationale behind the Total Productive Maintenance (TPM). The objective of TPM is much wider than just minimizing equipment downtime; the objective is to minimize the life cycle costs i.e. the costs for the entire life span of the equipment.

It is basically a maintenance progrmame which involves a newly, defined concept for maintaining plant & equipment. The goal of TPM is to markedly increase production while at the same time, increasing employer motivation & job satisfaction TPM bring maintenance into focus. Down time for maintenance is scheduled as a part of the manufacturing day. The goal is to hold emergency and unscheduled maintenance to a minimum.

Earlier, equipment maintenance was not practiced to be preventive and predominantly involved just the act of repairing a piece of equipment after it breaks down (break down maintenance) Factory managers eventually realized the importance of preventing equipment breakdown in order to boost productivity. Thus, system for subjecting equipment to scheduled maintenance activities in order to prevent unforeseen breakdowns (preventive maintenance) became popular. Under the scheme, equipment maintenance is the sole responsibility of technical personnel.

TPM includes

1. Optimizing equipment effectiveness by elimination of all types of breakdown or failures, speed losses defects and other wastes in operations.

2. Autonomous Maintenance by operators, which means the people who operate the machines will look after their machines by themselves. This would mean training and involvement of the operators. The idea is that the operating people would get to know their equipment even better so that they will be able to contribute not only in maintenance of the preventive and breakdown kind but also in the prevention of maintenance itself through their suggestions for improved design of machines, processes, systems, materials and products.
3. Company-wide involvement of all employees through small group activities which would support the above. Such participative management would enhance creative thinking and cross-flow of information. Continuous improvement comes through such participative processes.

We say that, TPM refers to a management system for optimizing the productivity of manufacturing equipment through systematic equipment maintenance involving employees at all levels. Under TPM, everyone is involved in keeping the equipment in good working order to minimize production losses from equipment repairs assists, set-ups, and the like.

Under TPM, operators no longer limits themselves to simply using the machine and calling the technician when a breakdown occurs. Operators can inspect, clean, lubricate, adjust, and even perform simple calibrations on their respective equipment. This frees the technical workforce for higher-level preventive maintenance activities that require more of their technical expertise. Management should also show interest in data concerning equipment uptime, utilization, and efficiency. In short, everyone understand that zero breakdowns, maximum productivity, and zero defect are goals to be shared by everyone under TPM.

In a nutshell we can say, aside from eliminating equipment downtimes, improving equipment productivity, and zeroing out defects TPM has the following goals; improvement of personnel effectiveness and sense of ownership, reduction of operational costs, reduction of throughout times, and customer satisfaction down the road.

TPM has eight Key Strategies :

(1) Focused improvement (Kaizen);
(2) Autonomous Maintenance
(3) Planned Maintenance
(4) Technical Training
(5) Early Equipment Maintenance
(6) Quality Maintenance
(7) Administrative and Support Functions Management
(8) Safety and Environment Management

At the same time, TPM eliminates six big losses:

(1) Breakdown, which can result in long, expensive repairs;
(2) Set-ups, conversions, and changeovers;
(3) Idling and minor stoppages
(4) Reduced equipment speed
(5) Defect and Rework
(6) Start-up Losses

Also, TPM requires the mastery of four equipment maintenance techniques:

(1) Preventive Maintenance to prevent breakdowns;

(2) Corrective Maintenance to modify or improve an equipment for increased reliability and easier maintenance;

(3) Maintenance Prevention to design and install equipment that are maintenance-free; and

(4) Breakdown Maintenance to repair equipment quickly after they break down.

16.7.1 Steps in Introduction of TPM Programme

STEP A - Preparatory Stage-

STEP 1-Announcement by Management to all about TPM introduction in the organization:

Proper understanding, commitment and active involvement of the top management in needed for this step. Senior management should have awareness programmes, after which announcement is made to all. Publish it in the house magazine and put it in the notice board. Send a letter to all concerned individuals if required.

STEP 2- Initial education and propaganda for TPM:

Training is to be down based on the need. Some need intensive training and some just an awareness. Take people who matters to places where TPM is already successfully implemented.

STEP 3- Setting up TPM and departmental committees :

TPM includes improvement, autonomous maintenance, quality maintenance etc., as part of it. When committees are set up it should take care of all these needs.

STEP 4- Establishing the TPM working and target:

Now each area is benchmarked and fix up a target for achievement.

STEP 5- A master plan for institutionalizing wherein TPM becomes an organizational culture.

STEP B- Introduction Stage -

All concerned are invited suppliers as they should know the quality supply is essantial requirement from them and related companies and affiliated companies who can be the customers, sister concerns etc. Some may learn and some can help and thus creating awareness that the organization cares for quality output.

STEP C- Implementation -

In this stage all the 8 activities or strategies which are essantial for development of TPM are carried out.

The first four activities are for establishing the system production efficiency, others for initial control system of new products and equipment, for improving the efficiency of administration and for control for safety, sanitation and working environment.

STEP D- Institutionalizing Stage

This is the maturnty stage where TPM now becomes an oranizational curlture.

16.8 Computerized Maintenance Management System "CMMS"

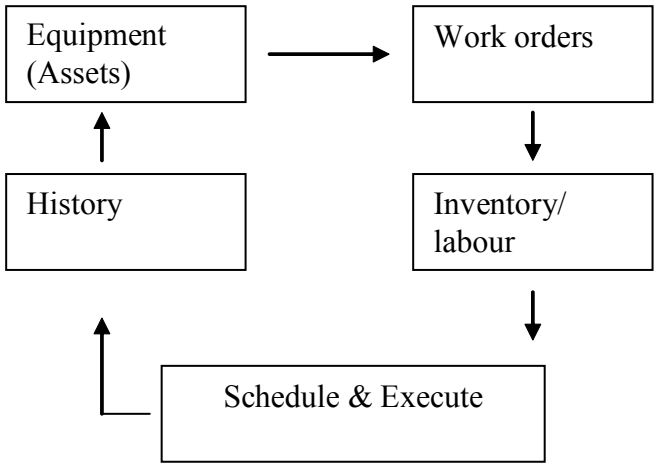
Historically, most system for managing activities were manual. Every thing from index card to memo files, to wall mounted log charts. These outdated method were cumbersome, incomplete and inefficient and were generally used inconsistently

Also, The potential costs of doing nothing are high. Industry statistic show that billions of our currency are spent annually to maintain physical plants, commercial buildings, educational & healthcare facilities. A large amount of currency spent on maintenance are wasted due to poor or inadequate maintenance management. When scheduled maintenance is not followed, premature break-down is a certain come out. The associated cost of breakdown do not stop with equipment repair and replacement, there are also the realties of unproductive down time, loss of business, displacement of building, uneven workload overtime and emergency inventory purchasing and so maintenance function is a very important aspect.

With the dawn of computer age it was recognized that computer software could be used to record works requirment, track the status of work and analysis recording data. Computer aided maintenance management is a much more reliable & better overall maintenance tracking system.

Computer Maintenance Management Systems is a computerized system to assist with the effective and efficient management of maintenance activities through the application of computer technology.

The Maintenance Process



It has been developed to organize, expatiate and monitor all maintenance activities. CMMS are usually fragmented into inventory, preventive maintenance and work order tracking.

CMMS maintains a complete database of information about an organization maintenance operation which is intended to help maintenance worker or crafts man do their jobs more effectively like which machine requires maintenance and which store rooms contain the spare part. They need and help management make informed decision like calculating the cost of machine breakdown repair versus preventive maintenance. CMMS data may also be used to verify regulatory compliance.

As CMMS program have to be integrated, allowing control of all the major areas of maintenance in one system, the system vary in size allowing organization with 5 to 5000 workers to be cost effective in using them. The need for and use of CMMS is not specific to any one industry or type of application. Any facility or corporation that has a maintenance workforce is potential user of a CMM system. However, each organization will have some differences in their requirements to be cost effective in using them.

The impact of CMMS :-

Reduce equipment downtime through the benefits of regular scheduled preventive maintenance.

Increased equipment life

Increased craft productivity

Reduction in stores inventory

Reduction in emergency and critical maintenance.

The Need of a CMMS Today

1. **The Safety Factor -** Many facilities have to review their maintenance system if they are to bring creditability to their maintenance departments.For Example :- Fires in the airport have been attributed to bad maintenance,
2. **The Cost Factor -** An effective maintenance management program results in savings in maintenance time and costs, improve productivity.
3. **The ISO Factor -** Many manufacturing companies are implementing ISO. A maintenance system is now a requirement under ISO 9002.
4. **The Productivity Factor -** In an effort to have an edge over their competitors, many companies are turning toward TQM (Total Quality Management) of which TPM (Total Productive Maintenance) is a major program. One of the key element in TPM is a Maintenance System.

16.9 Summary

Maintenance means keeping any equipment or asset in operational condition so that it can give desired output and this has always been a challenging task. Now a days maintenance does not mean reducing stoppage time of an equipment but also to avoid unscheduled stoppage and breakdowns by frequent performance checking, testing and providing inspection and skillful repair whenever required. This can be achieved by adopting various maintenance strategies. The strategy adopted should be such that emergency maintenance remains an exception. Maintenance is expected to play even much bigger role in years to follow, as industries world wide are going through an increasing & stiff competition and increased automation of plants. The down time cost for such system is expected to be very high. To meet these challenges maintenance have to use latest technology and management skills in all spheres of activities to perform its effective role.

16.10 Key Words

- **Maintenance:** A combination of actions carried out to retain an item in, or restore it to, an acceptable condition.
- **Maintenance Management:** it is concerned with planning and controlling routine, planned and preventive maintenance activity of an organization.
- **Maintenance Planning:** Deciding in advance the job, methods, materials tools, machines, labour, timing and time required.
- **Planned Maintenance:** maintenance organized and carried out with forethought, control and records to a predetermined plan.
- **Running Maintenance:** maintenance which can only be carried out while the item is in service.
- **Computerized Maintenance System:** It maintenance a complet database of information about an organization maintenance operation which is intended to help maintenance workers to do their jobs more effectively.

- **Total Productive Maintenance:** TPM refers to a management system for optimizing the productivity of manufacturing equipment through systematic equipment maintenance involving employees at all levels. Under TPM, everyone is involved in keeping the equipment in good working order to minimize production losses from equipment repairs, set-ups, and the like.

16.11 Self Assessment Test

Q1. Explain the failure analysis of equipment?

Q2. What are the objective of maintenance management?

Q3. Discuss the various type of maintenance system? Giving Example in each case.

Q4. Discuss the various maintenance performance indices discuss a few of them?

Q5. What are the different function of maintenance management?

Q6. What do you understand by computerized maintenance management system?

Q7. Discuss the need and importance of TPM.

Q8. Write a short note on maintenance policy.