OPERATIONS MANAGEMENT

V SEMESTER

BBA

CORE COURSE: BBA5 B09

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UNIVERSITY OF CALICUT

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School of Distance Education

Study Material

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OPERATION MANAGEMENT

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Module I

Operations Management

Meaning

Operation is that part of as organization, which is concerned with the transformation of a range of inputs into the required output (services) having the requisite quality level. Management is the process, which combines and transforms various resources used in the operations subsystem of the organization into value added services in a controlled manner as per the policies of the organization.

The set of interrelated management activities, which are involved in manufacturing certain products, is called as production management. If the same concept is extended to services management, then the corresponding set of management activities is called as operations management.

Definition of Operation Management

According to S. Buffa ‘production or operation management deals with decision making related to production process so that the resulting goods and services are produced according to specifications, in the amount and by the schedule demanded and at a minimum cost’.

The Association of Operation Management defines operation management as ‘the field of study that focuses on the effective planning, scheduling, use and control of manufacturing or service organisations through the study of concepts from design engineering, industrial engineering, MIS, quality management,

production management, industrial management and other functions as they affect the organisation'.

Operation management is the business function that manages that part of a business that transforms raw materials and human inputs in to goods and services of higher value. Operation management is a business activity that deals with the production of goods and services. The term operation includes management of materials, machines, and inventory control and storage functions. Operations management includes a set of activities performed to manage the available resources in an efficient manner in order to convert inputs in to desired outputs.

The value addition to an input can be done in the following ways. They are mentioned below:

1. Alteration: It refers to the transformation of the state of input. This transformation can be a physical change in the input to produce goods.

2. Transportation: It refers to physical movement of goods from one location to another.

3. Storage: It refers to preserving goods in a protected environment.

4. Inspection: It refers to the verification of and confirmation towards the requirements of an entity.

All the above activities in one way or another are making a product more useful. The operations managers have the prime responsibility for processing inputs into outputs. They must bring together the materials, capacity and knowledge available for the purpose achieving its production objectives. The definition of the operations Management contains the concepts

such as Resources, Systems, transformation and Value addition Activities etc. A brief explanation about such words is given below:

Resources

Resources are in the forms of the human, material and capital inputs. Human resources are the key resources of an organisation. As the technology advances, a large proportion of human input is in planning and controlling activities. By using the intellectual capabilities of people, managers can multiply the value of their employees into by many times. Material resources are the physical facilities and materials such as plant equipment, inventories and supplies.

Systems

Systems are the arrangement of components designed to achieve objectives. The business systems are subsystem of large social systems. Business system contains subsystem such as personnel, engineering, finance and operations. The ability of any system to achieve its objective depends on its design and control mechanism. System design is a predetermined arrangement of components. It establishes the relationships between inputs, transformation activities and outputs in order to achieve the system objectives. System control consists of all actions necessary to ensure that activities conform to pre-conceived plans.

Transformation and Value Addition Activities

The objective of combining resources is to transform the inputs into goods and services having a higher value than the original inputs. The effectiveness of the production factors in the transformation process is known as productivity.

The productivity refers to the ratio between values of output per work hour to the cost of inputs. The firms overall ratio must be greater than 1, then we can say value is added to the product. Operations manager should concentrate improving the transformation efficiency and to increase the ratio.

Scope of Operations Management

As stated earlier, Operations Management is concerned with the conversion of inputs into outputs using physical resources so as to provide the desired utilities to the customers. It involves a number of well planned activities. Following are the activities that come under Production and Operations Management functions:

1. **Location of facilities.**
2. **Plant layouts and Material Handling.**
3. **Product Design.**
4. **Process Design.**
5. **Production and Planning Control.**
6. **Quality Control.**
7. **Materials Management.**
8. **Maintenance Management**

1. Location Facilities

Location of the proposed factory building is an important consideration in operation management. It is an important strategic level decision-making for an organisation. It deals with

the questions such as 'where our main operations should be based?' The selection of location is a key-decision because large amount of investment is required in building plant and machinery. An improper location of plant may lead to waste of all the investments made in plant and machinery. Hence, location of plant should be based on the company's future plan about expansion, diversification, nature of sources of raw materials and many other factors. The very purpose of the location study is to identify the optimal location facility that will results in the greatest advantage to the organization.

2. Plant Layout and Material Handling

Plant layout refers to the physical arrangement of facilities. It is the configuration of departments, work centres and equipment's in the inputs conversion process. The objective of the plant layout is to design a physical arrangement that meets the required output quality and quantity most economically. According to James More 'Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of best structure to contain all these facilities'.

Material Handling refers to the moving of materials from the store room to the machine and from one machine to the next machine during the production process. It is the art and science of moving, packing and storing of products in any form. Material cost can be reduced by judicious selection of materials and its proper storage. Material handling devices increases the output, improves quality, speeds up the deliveries and decreases the cost of production. Hence, material handling should be a prime task in the designing of new projects.

3. Product Design

Product design deals with conversion of ideas into reality. Every business organisation has to design, develop and introduce new products as a commercial strategy. Developing the new products and launching them in the market are the biggest problems faced by the organizations. The entire process of need identification to physical manufactures of product involves three functions—Design, Product Development, and manufacturing. Operation management has the responsibility of selecting the processes by which the product can be produced.

4. Process Design

Designing of manufacturing process is another functional area of operation management. It deals with how the process required to produce a product is selected. These decisions encompass the selection of a process, choice of technology, process flow analysis and layout of the facilities. The major consideration in process design is to analyse the workflow for converting raw materials into final products.

5. Production Planning and Control

Production planning and control can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing dates for each item, to give production orders to shops and to follow-up the progress of products according to orders. The principle of production planning and control lies in the statement 'First Plan Your Work and then Work on Your Plan'. Main functions of production planning and control include Planning, Routing, Scheduling, Dispatching and Follow-up.

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

Routing is the process of selection of path, which each part of the product will follow. Routing determines the most advantageous path to be followed for department to department and machine to machine till raw material gets its final shape.

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

Dispatching is concerned with the starting the processes. It gives authority so as to start a particular work, which has been already been planned under Routing and Scheduling. Therefore, dispatching is the release of orders and instruction for the starting of production.

Follow-up is the process of reporting daily progress of work in each shop in a prescribed proforma and to investigate the causes of deviations from the planned performance and to take necessary actions.

6. Quality Control

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

activities, which ensures that the operation will produce the optimum quality products at minimum cost. The main objectives of Quality Control are:

1. To produce qualitative items

2. To reduce companies cost through reduction of losses due to defects.

3. To produce optimal quality at reduced price.

4. To ensure satisfaction of customers with productions or services or high quality level.

5. To build customer good will, confidence and reputation of manufacturer.

6. To make inspection prompt to ensure quality control.

7. To check the variation during manufacturing.

7. Materials Management

Materials Management is that aspect of operation management function, which is concerned with the acquisition, control, and use of materials needed and flow of goods and services connected with the production process. The main objectives of Material Management are given below:

1. To minimise material cost.

2. To purchase, receive, transport and store materials efficiently.

3. To reduce costs through simplification, standardisation, value analysis etc.

4. To identify new sources of supply and to develop better relations with the suppliers.

5. To reduce investment made in the inventories and to develop high inventory turnover ratios.

8. Maintenance Management

In modern industry, equipment and machinery are a very important part of the total productive effort. Therefore their idleness or downtime becomes are very expensive. Hence, it is very important that the plant machinery should be properly maintained. The main objectives of Maintenance Management are given below:

1. To reduce breakdown of machineries

2. To keep the machines and other facilities in a good condition.

3. To ensure the availability of the machines, buildings and services required by other sections of the factory also.

4. To keep the plant in good working condition.

Operations Management Decisions

A better insight to how production/operations managers manage can be had by examining the decisions in production and operations management, since all managerial functions such as planning, organising, staffing, directing and controlling involve decision making.

The decisions which production/operations managers make may be classified into three general categories:

(i) **Strategic Decisions:** Decisions about products, processes and facilities. These decisions are strategically important and have long-term significance for the organisation.

(ii) **Operating Decisions:** Decisions about planning production to meet demand.

(iii) **Control Decisions:** Decisions about controlling operations concerned with day-to-day activities of the workers, quality of products and services, production costs, overhead costs and maintenance of plant and equipment.

Production management decisions and their applications		
Type of Decisions	***Area of Involvement***	***Nature of Activities***
1. Strategic decisions (Planning products, processes and facilities)	*(i)* Manufacturing processes and technology *(ii)* design Plant location and plant layout *(iii)* Long range capacity planning (Equipment and labour capacity)	*(i)* Product design, process design *(ii)* Choice of production technology *(iii)* Choosing the best location *(iv)* Deciding about the type of plant layout and shop layout. *(v)* Deciding the installed capacity of the plant
2. Operating decisions (Matching	*(i)* Production planning Inventory	(i) Preparing the master production schedule (ii) Planning inventory

production with demand)	planning *(ii)*	levels for raw materials, work-in-process and finished goods
	(iii) Resource requirement planning	(iii) Planning for requirements of materials & capacities (Labour and equipment)
	(iv) Production scheduling	(iv) Detailed scheduling and machine loading charts
	(v) Procurement planning	(v) Vendor selection
3. Control decisions	Labour *(i)* productivity	(i) Controlling labour output through establishment of performance standards
	(ii) Quality	(ii) Controlling quality of incoming materials, semi-finished goods and finished goods.
	(iii) Projects	(iii) Controlling projects (Costs and completion dates) using PERT/CPM techniques.
	(iv) Maintenance	(iv) Controlling machine down-time and repair time by good maintenance practices.

Historical Evolution of Operation Management

The traditional view of manufacturing management began in eighteenth century when Adam Smith recognised the economic benefits of specialization of labour. He recommended breaking of jobs down into subtasks and recognises workers to specialized tasks in which they would become highly skilled and efficient. In the early twentieth century, F.W. Taylor implemented Smith's theories and developed scientific management. From then till 1930, many techniques were developed prevailing the traditional view.

Production Management became the acceptable term from 1930s to 1950s. As F.W. Taylor's works become more widely known, managers developed techniques that focused on economic efficiency in manufacturing. Workers were studied in great detail to eliminate wasteful efforts and achieve greater efficiency. At the same time, psychologists, socialists and other social scientists began to study people and human behaviour in the working environment. In addition, economists, mathematicians, and computer socialists contributed newer approaches.

With the 1970s emerged other two distinct changes. The most obvious of these, reflected in the new name Operations Management was a shift in the service and manufacturing sectors of the economy. As service sector became more prominent, the change from 'production' to 'operations' emphasized the broadening of field to service organizations. The second, more suitable change was the beginning of an emphasis on synthesis, rather than just analysis, in management practices.

A brief account of development of operations and production management is given below:

Year	**Contribution**	**Contributors**
1776	Specialization of labour in manufacturing	Adam Smith
1799	Interchangeable parts, cost accounting	Eli Whitney & others
1832	Division of labour by skill; assignment of jobs by Skill; basics of time study	Charles Babbage
1900	Scientific management time study and work study Developed; dividing planning and doing of work	Frederick W.Taylor
1900	Motion of study of jobs	Frank B. Gilbreth
1901	Scheduling techniques for employees, machines Jobs in manufacturing	Henry L. Gantt
1915	Economic lot sizes for inventory control	F.W. Harris
1927	Human relations; the Hawthorne studies	Elton Mayo
1931	Statistical inference applied to product quality: quality control charts	W.A. Shewart
1935	Statistical Sampling applied to quality control: inspection sampling plans	H.F. Dodge &

		H.G. Roming
1940	Operations research applications in world war II	P.M. Blacker & others
1946	Digital Computer	John Mauchlly and J.P. Eckert
1950	Mathematical programming, on-linear and stochastic processes	A. Charnes, W.W. Cooper& others
1960	Organisational behaviour: continued study of people at work	L. Cummings, L. Porter
1970	Integrating operations into overall strategy and policy Computer applications to manufacturing, scheduling, and control, Material Requirement Planning (MRP)	W. Skinner J. Orlicky & G. Wright
1980	Quality and productivity applications from Japan: robotics, CAD-CAM	W.E. Deming & J. Juran

Recent Trends in Production/Operations Management

Many recent trends in production/operations management relate to global competition and the impact it has on manufacturing firms. Some of the recent trends are:

1. Global Market Place: Globalisation of business has compelled many manufacturing firms to have operations in many countries where they have certain economic advantage. This has resulted in a steep increase in the level of competition among manufacturing firms throughout the world.

2. Production/Operations Strategy: More and more firms are recognising the importance of production/ operations strategy for the overall success of their business and the necessity for relating it to their overall business strategy.

3. Total Quality Management (TQM): TQM approach has been adopted by many firms to achieve customer satisfaction by a never-ending quest for improving the quality of goods and services.

4. Flexibility: The ability to adapt quickly to changes in volume of demand, in the product mix demanded, and in product design or in delivery schedules, has become a major competitive strategy and a competitive advantage to the firms. This is sometimes called as agile manufacturing.

5. Time Reduction: Reduction of manufacturing cycle time and speed to market for a new product provide competitive edge to a firm over other firms. When companies can provide products at the same price and quality, quicker delivery (short lead times) provides one firm with competitive edge over the other.

6. Technology: Advances in technology have led to a vast array of new products, new processes and new materials and components. Automation, computerisation, information and communication technologies have revolutionised the way companies operate. Technological changes in products and processes can have great impact on competitiveness and quality, if the advanced technology is carefully integrated into the existing system.

7. Worker Involvement: The recent trend is to assign responsibility for decision making and problem solving to the lower levels in the organisation. This is known as employee involvement and empowerment. Examples of worker involvement are quality circles and use of work teams or quality improvement teams.

8. Re-engineering: This involves drastic measures or break-through improvements to improve the performance of a firm. It involves the concept of clean-slate approach or starting from scratch in redesigning the business processes.

9. Environmental Issues: Today's production managers are concerned more and more with pollution control and waste disposal which are key issues in protection of environment and social responsibility. There is increasing emphasis on reducing waste, recycling waste, using less-toxic chemicals and using biodegradable materials for packaging.

10. Corporate Downsizing (or Right Sizing): Downsizing or right sizing has been forced on firms to shed their obesity. This has become necessary due to competition, lowering productivity, need for improved profit and for higher dividend payment to shareholders.

11. Supply-Chain Management: Management of supply-chain, from suppliers to final customers reduces the cost of transportation, warehousing and distribution throughout the supply chain.

12. Lean Production: Production systems have become lean production systems which use minimal amounts of resources to produce a high volume of high quality goods with some variety. These systems use flexible manufacturing systems and multi-skilled workforce to have advantages of both mass production and job production (or craft production).

Objectives of Operation Management

Operation Management involves management of the entire process responsible for converting inputs into outputs**.** The following are the objectives of Operations Management.

1. To provide customer service

The main objective of any operating management systems is to utilize resources judiciously for the satisfaction of customer needs and wants. Therefore, customer satisfaction is a key objective of operations management. Operation management focuses on providing the right products at a right price at the right time. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

2. Effective utilisation of resources

Resources that are used in the business organisation must be carefully utilised. Inefficient use of resources or inadequate customer service leads to commercial failure of an organisation. Operations management is concerned essentially with the utilisation of resources. It aims at obtaining maximum output from the available resources with minimum cost.

3. To reduce cost of production

Operation management aims at reduction in the cost of production of goods and services. The cost per unit of the product has to be set properly and all efforts should be taken to control the actual cost to pre-determined cost of production. Cost can be classified in to fixed cost and variable cost. The variable cost changes with every level of production. This variable cost can be checked by means of inventory and labour control techniques.

4. To improve product quality

Quality control and maintenance are the two important objectives of operations management. Quality control consists of all those activities, which are designed to define, maintain and control specific quality of products within reasonable limits. It is the systematic regulation of all variables affecting the goodness of the final product. In other words, quality control involves determination of quality standards and its actual measurement .It is necessary to ensure that the established standards are practiced and maintained. It does not attempt to achieve the perfect quality but to secure satisfactory or reasonable quality at a reasonable level of cost.

5. To fix time schedule

Another important objective of operation management is to establish time schedule for various operation activities. The schedule fixation includes the operating cycle time, inventory turnover rate, machine utilisation rate, capacity utilisation, etc.,

6. Proper utilisation of Machinery

Operation management has to take number of decisions with regard to machinery and equipment. New machines should be

installed and the old machines are to be replaced. It has to ensure judicious utilisation of machinery and equipment.

7. Material control

Based on the sales forecast and production plans, the materials planning and control is done. This involves estimating the individual requirements of parts, preparing materials budget, forecasting the levels of inventories, scheduling the orders and monitoring the performance in relation to production and sales.

Manufacturing and Non-manufacturing Operations and their Characteristics

Manufacturing and service are often similar in terms of what is done but different in terms of how it is done. For example, both involve design and operating decisions. Decisions on size of the building needed, location, schedule, control of operations and allocation of scarce resources are applicable to both manufacturing and service organisations. However, the major difference between manufacturing and service organisations is that the first is goods-oriented while the latter is act-oriented.

Following characteristics can be considered for distinguishing Manufacturing Operations with Service Operations:

1. Customer Contact: Service involves a much higher degree of customer contact than manufacturing. The performance of service often occurs at the point of consumption whereas manufacturing allows a separation between production and consumption. This permits a fair degree of latitude in selecting work methods, assigning jobs, scheduling work and exercising control over operations. Service operations, because of their contact with customers, can be much more limited in their range of options.

Manufacturing operations can build up inventories of finished goods whereas service operations cannot build up inventories of time and are much more sensitive to demand variability.

2. Uniformity of Input: Service operations are subject to greater variability of inputs than manufacturing operations. Manufacturing operations can control the amount of variability of inputs.

3. Labour Content of Jobs: Because of the on-site consumption of services and the high degree of variation of inputs, services require a higher labour content than manufacturing which is more capital intensive.

4. Uniformity of Output: Manufacturing tends to produce products with low variability because of high mechanisation whereas service activities sometimes appear to be slow and awkward and output is more variable or non-uniform.

5. Measurement of Productivity: Productivity can be measured more directly in manufacturing due to the high degree of uniformity of most manufactured items. In service operations, variations in demand intensity and in requirements from job to job make productivity measurement more difficult.

6. Quality Assurance: Is more challenging in services when production and consumption occur at the same time. In manufacturing operations, errors can be corrected before the customer receives the output.

The differences between production of goods and service operations can be summarised as below:

Differences between Goods and Services		
Characteristics	**Goods**	**Services**
Output	Tangible	Intangible

Customer contact	Low	High
Uniformity of input	High	Low
Labour content	Low	High
Uniformity of output	High	Low
Measurement of productivity	Easy	Difficult
Opportunity to correct quality problems before delivery to customer	High	Low

Interaction of Operations Management with other areas

To create goods and services, all organisations, whether manufacturing goods or providing services, perform three basic functions. They are:

(i) Marketing: which generates the demand or takes customers' orders for a product or service.

(ii) Production/Operations: which creates the product (goods or services).

(iii) Finance/Accounting: which keeps track of how well the organisation is performing, and takes care of cash inflow and cash outflow.

Production/operations managers need to build and maintain strong relationships both intra-organisationally and inter-organisationally. Inter-organisational relationship exists between production/ operations department and suppliers, whereas intra-organisational relationship calls for cross-functional coordination. Cross functional coordination is essential for effective production/operations management. For example, marketing function determines the need for new

products and services and the demand for existing ones and operations managers must bring together human and capital resources to meet these demands effectively. Also, operations managers must consider facility location and relocations to serve new markets and the design of layouts for service organisations must match the image that marketing seeks to project to the customers. Operations managers must plan output rates and capacities to match the demand forecasts and delivery promises made to the customers.

Organisation Charts for a Manufacturing and a Service Organisation

(a) Organisation chart for a Manufacturing Organisation

Automobile Manufacturing Firm

Production/Operations	Finance/Accounting	Marketing
(i) Facilities-construction and selling maintenance	*(a)* Disbursements/credit *(i)* Accounts receivable	*(a)* Personal *(b)* Advertising
(ii) Production and inventory control, scheduling, research materials control	*(ii)* Accounts payable *(b)* Funds management *(i)* Money market	*(c)* Sales *(d)* Market *(e)* Distribution
(iii) Quality control and assurance	*(ii)* International exchange	
(iv) Supply-chain management	*(c)* Capital requirements	
(v) Manufacturing – (Tooling, fabrication and assembly).	*(i)* Stock issue *(ii)* Bond issue and recall	
(vi) Product design and development		

(vii) Industrial engineering (Efficient use of resources)

(viii) Process analysis and process design.

***(b)* Organisation chart for a Service Organisation**

Commercial Bank

Operations	**Finance**	**Marketing**
(i) Teller scheduling	*(i)* Investments	*(i)* Loans
(ii) Check clearing	(Securities, Real Estate)	(Commercial,
(iii) Collection	*(ii)* Accounting	Industrial, Financial,
(iv) Transaction processing	*(iii)* Auditing	Personal,
(v) Facilities design/layout		Mortgage)
(vi) Locker operations		*(ii)* Trust department
(vii) Maintenance		
(viii) Security		

perations managers need feedback from the accounting function to understand their current performance. Financial measures help the operations managers to assess labour costs, the long-term benefits of new technologies and quality improvement projects. Accounting helps in computing the production costs and in bills payment to suppliers.

Module II

Facilities Planning

Facilities location may be defined as selection of suitable location or site or place where the factory or plant or facilities to be installed, where plant will start functioning.

The development of a location strategy depends upon the type of firm being considered. Industrial location analysis decisions focus on minimising costs; retail and professional service organisations typically have a focus of maximising revenue. Warehouse location, on the other hand, may be determined by a combination of cost and speed of delivery. The objective of location strategy is to maximise the benefit of location to the firm.

Facility planning has developed, in the past decade, into a major thriving business sector and discipline. One of the major reasons for new facilities is the global economic boom that has been accompanied by an enhancement of capacity worldwide.

In addition to the global economic boom, there are several other reasons for changing or adding locations:

1. The cost or availability of labour, raw materials, and supporting resources often change. These changes in resources may spur the decision.

2. As product markets change, the geographical region of demand may shift. For example, many international companies find it desirable to change facility location to provide better service to customers.

3. Companies may split, merge, or be acquired by new owners, making facilities redundant.

4. New products may be introduced, changing the requirement and availability of resources.

5. Political, economic and legal requirements may make it more attractive to change location. Many companies are moving facilities to regions where environment or labour laws are more favourable.

Well-planned facilities enable an organization to function at its most efficient and effective level, offering real added value improvements to the organization's core business.

Plant Location

Plant location refers to the choice of region and the selection of a particular site for setting up a business or factory. But the choice is made only after considering cost and benefits of different alternative sites. It is a strategic decision that cannot be changed once taken. If at all changed only at considerable loss, the location should be selected as per its own requirements and circumstances. Each individual plant is a case in itself. Businessman should try to make an attempt for optimum or ideal location.

An ideal location is one where the cost of the product is kept to minimum, with a large market share, the least risk and the maximum social gain. It is the place of maximum net advantage or which gives lowest unit cost of production and distribution. For achieving this objective, small-scale entrepreneur can make use of location analysis for this purpose.

Location Analysis

Location analysis is a dynamic process where entrepreneur analyses and compares the appropriateness or otherwise of

alternative sites with the aim of selecting the best site for a given enterprise. It consists the following:

(a) Demographic Analysis: It involves study of population in the area in terms of total population (in no.), age composition, per capita income, educational level, occupational structure, etc.,

(b) Trade Area Analysis: It is an analysis of the geographic area that provides continued clientele to the firm. He would also see the feasibility of accessing the trade area from alternative sites.

(c) Competitive Analysis: It helps to judge the nature, location, size and quality of competition in a given trade area.

(d) Traffic analysis: To have a rough idea about the number of potential customers passing by the proposed site during the working hours of the shop, the traffic analysis aims at judging the alternative sites in terms of pedestrian and vehicular traffic passing a site.

(e) Site economics: Alternative sites are evaluated in terms of establishment costs and operational costs under this. Costs of establishment is basically cost incurred for permanent physical facilities but operational costs are incurred for running business on day to day basis, they are also called as running costs.

Selection Criteria

The important considerations for selecting a suitable location are given as follows:

a) Natural or climatic conditions.

b) Availability and nearness to the sources of raw material.

c) Transport costs-in obtaining raw material and also distribution or marketing finished products to the ultimate users.

d) **Access to market: S**mall businesses in retail or wholesale or services should be located within the vicinity of densely populated areas.

e) Availability of Infrastructural facilities such as developed industrial sheds or sites, link roads, nearness to railway stations, airports or sea ports, availability of electricity, water, public utilities, civil amenities and means of communication are important, especially for small scale businesses.

f) Availability of skilled and non-skilled labour and technically qualified and trained managers.

g) Banking and financial institutions are located nearby.

h) Locations with links: to develop industrial areas or business centres result in savings and cost reductions in transport overheads, miscellaneous expenses.

i) Strategic considerations of safety and security should be given due importance.

j) **Government influences:** Both positive and negative incentives to motivate an entrepreneur to choose a particular location are made available. Positive includes cheap overhead facilities like electricity, banking transport, tax relief, subsidies and liberalization. Negative incentives are in form of restrictions for setting up industries in urban areas for reasons of pollution control and decentralization of industries.

k) Residence of small business entrepreneurs want to set up nearby their homelands.

One study of location considerations from small-scale units revealed that the native place or homelands of the entrepreneur was the most important factor. Heavy preference to homeland suggests that small-scale enterprise is not freely mobile. Low preference for Government incentives suggests that concessions and incentives cannot compensate for poor infrastructure.

Factors Determining Plant Location

To be systematic, in choosing a plant location, the entrepreneur would do well to proceed step by step, The location of the facilities is carried out in four stages i.e., **First stage-Selection of the country i.e., within the country or abroad; Second Stage- Selection of a general territory or region; Third Stage- Selection of a community or locality and Fourth Stage- Selection of Specific site.**

I. First stage – Selection of the country i.e., within the country or abroad

The first stage of plant location is to whether the plant should be located in home country or abroad. Due to globalization, a company can have its plant outside its own country. The increasing internationalization of business, the issue of home or foreign country is gaining greater relevance. If the management has to decide on the foreign location, next step will be to decide the particular country for location. This is necessary because countries across the world are vying with each other to attract foreign investments. The choice of particular countries depend on such factors as political stability, export and import quotas,

currency and exchange rates, cultural and economic peculiarities, and natural or physical conditions.

II. Second Stage – Selection of a general territory or region

Different factors to be considered while choosing a region are:

(i) Availability of Raw Materials: A Plant location or a manufacturing unit is in the conversion of the raw materials into finished goods, it is very essential that the transport of raw material is at minimum cost. In industries like, sugar, paper, iron and steel are engaged in solvent extraction of oil from rice bran, the china clay washery, factories manufacturing low tension porcelain insulators, and the like should be located near the sources of their raw materials. Nearness to raw materials offers such advantages as:

1. Reduced cost of transportation

2. Regular and proper supply of materials uninterrupted by transportation breakdowns

3. Saving in the cost of storage of materials. Raw materials in this context may be classified into two types, viz.

(i) Weight-losing or gross materials

(ii) Non-weight losing or pure materials: Weight-losing materials lose their weight during the manufacturing process. The cost of transporting these raw materials from the source of supply to the place of manufacture is more than the cost of transporting the finished products from the factory to the market. Examples of these raw materials are iron ore, sugarcane,

coal, timber etc. Industries using such materials tend to be located at the source to save on the cost of transportation.

The Non-weight losing materials, they grow in weight after they are converted into finished goods. The cost of transporting the finished goods is more than that of raw materials. Examples of such non-weight-losing materials are cotton and woollens.

(ii) Nearness to the Market: Since the goods are produced for sale they should be near the market. The cost of reduction in the cost of transporting finished goods depends upon the likes and dislikes of the consumers. The Consumer should get some advantages such as:

(i) The Consumer should get or render prompt service.

(ii) Consumer should be provided with after-sales service

(iii) Consumers should get replacement orders without delay. Industries like non-weight-losing raw materials, industries producing perishable or bulky products and servicing units tend to be located near their market.

(iii) Availability of Power: Power is essential to move the wheels of an industry. Coal, electricity, oil and natural gas are the sources of power. Industries using electricity have to be located at a place where electric power is available regularly and at cheap rates.

(iv) Transport Facilities: Transport facilities are essential for bringing raw materials and men to the factory and also for carrying the finished products from the factory to the market. A place which is well connected by rail, road, and sea is ideal for a plant location. In extreme cases, transport may follow the industries. If a public sector unit has been started in a remote

place, the government has to provide transport facilities and also cater to the requirements of the product.

(v) Suitability of Climate: The climate has its own importance with regard to the location of the plant. The nature of production depends upon the climatic conditions. Some industries are placed where humid conditions may be required for the product like the cotton textile which is in Mumbai, the jute industry in Calcutta etc. The scientific and technological developments have enabled us to create artificial conditions. The entrepreneur would do well to take advantage of a natural climate because the cost of providing an artificial climate is quite exorbitant. Extreme climatic conditions adversely affect labour efficiency. There is heavy industrial concentration in the cool and temperate regions rather than in the tropical and polar regions.

(vi) Government Policy: The influence of Government policies and programs on plant locations is apparent in every country, particularly in planned economies like ours. In India, there are several backward regions, which are selected for the location of the plant, which would generate the economy of the region and on a larger scale canvas, the national economy. The Government of India has been influencing plant location in a number of ways. Some of these are:

1. Licensing policy;

2. Freight rate policy;

3. Establishing a unit in the public sector in a remote area and developing it to attract other industries;

4. Institutional finance and government subsidies.

The influencing of government policy was only after the Independence. Before the Independence, purely commercial considerations were decided as per industrial locations. Such has been the case with TISCO and IISCO. It was because there was no over solicitous government which was ready to come to the rescue of a sick unit to save it from bankruptcy, no ideologue anxious to give a face-lift to the losing public sector concerns by allowing them to jack up prices, give protection and capitalize losses by converting them into equity.

(vii) Competition between States: States via with each other to attract new industries. Various states offer investment subsidies and sales tax exemption to new units. The incentives may not be of a big help to the big sized plants. But for small and medium-sized plants, the incentive does matter. The owner of these plants certainly consider the incentive while selecting the region.

III. Third Stage – Selection of a community or locality

Having selected the general territory / region, one would have to go in for site / community selection. Some factors relevant for this are:

(a) Community facilities: These involve factors such as quality of life which in turn depends on availability of facilities like education, places of worship, medical services, police and fire stations, cultural, social and recreation opportunities, housing, good streets and good communication and transportation facilities.

(b) Community attitudes: These can be difficult to evaluate. Most communities usually welcome setting up of a

new industry especially since it would provide employment opportunities to the local people directly or indirectly. However, in case of polluting industries, they would try their utmost to locate them as far away as possible. Sometimes because of prevailing law and order situation, companies have been forced to relocate their units. The attitude of people as well as the state government has an impact on location of polluting and hazardous industries.

(c) Ecology and pollution: These days, there is a great deal of awareness towards maintenance of natural ecological balance. There are quite a few agencies propagating the concepts to make the society at large more conscious of the dangers of certain available actions.

(d) Transportation facilities: The site should be accessible preferably by road and rail. The dependability and character of the available transport carriers, frequency of service and freight and terminal facilities is also worth considering.

(e) Supporting industries and services: The availability of supporting services such as tool rooms, plant services etc. need to be considered.

(f) Land costs: These are generally of lesser importance, as they are nonrecurring and possibly make up a relatively small proportion of the total cost of locating a new plant.

IV. Fourth Stage – Selection of Specific site

Three factors needs to be analysed in selection of an exact site, and these are:

(a) Site size: The plot of land must be large enough to hold the proposed plant and parking and access facilities and provide room for future expansion.

(b) Topography: The topography, soil structure and drainage must be suitable. If considerable land improvement is required, low priced land might turn out to be expensive.

(c) Waste disposal: The facilities required for the disposal of process waste including solid, liquid and gaseous effluent need to be considered. The plant should be positioned so that prevailing winds carry any fumes away from populated areas and that the waste may be disposed off properly and at reasonable costs.

Product Design

Product design simply means conversion of ideas into reality. In order to survive in current globally competitive environment, business organizations needs to design, develop and introduce new products in the market. It is an important part of organizations survival and growth strategy. Developing the new products and launching them in the market is the biggest challenge faced by the organizations.

The entire process of need identification to physical manufactures of product involves three functions namely, marketing, product development and manufacturing.

- Through marketing organizations tends to identify customer needs.

- Product development translates the needs of customers given by marketing into technical specifications and designing the various features into the product.

- Manufacturing has the responsibility of selecting the processes by which the product can be manufactured.

Process Design

Process design means selection of optimum decision route for converting the raw material into finished goods. During process design the operational manager needs to consider on selection of process, choice of technology, process flow analysis and layout of the facilities.

Plant Layout

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work centres and equipment in the conversion process. It is a floor plan of the physical facilities, which are used in production. According to Moore "Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of best structure to contain all these facilities".

According to Riggs, "the overall objective of plant layout is to design a physical arrangement that most economically meets the required output – quantity and quality."

Objectives of Plant Layout

The primary goal of the plant layout is to maximise the profit by arrangement of all the plant facilities to the best advantage of total manufacturing of the product. The objectives of plant layout are:

1. Streamline the flow of materials through the plant.

2. Facilitate the manufacturing process.

3. Maintain high turnover of in-process inventory.

4. Minimise materials handling and cost.

5. Effective utilisation of men, equipment and space.

6. Make effective utilisation of cubic space.

7. Flexibility of manufacturing operations and arrangements.

8. Provide for employee convenience, safety and comfort.

9. Minimize investment in equipment.

10. Minimize overall production time.

11. Maintain flexibility of arrangement and operation.

12. Facilitate the organizational structure.

Principles of Plant Layout

1) Principle of integration: A good layout is one that integrates men, materials, machines and supporting services and others in order to get the optimum utilisation of resources and maximum effectiveness.

2) Principle of minimum distance: This principle is concerned with the minimum travel (or movement) of man and materials. The facilities should be arranged such that, the total distance travelled by the men and materials should be minimum and as far as possible straight line movement should be preferred.

3) Principle of cubic space utilisation: The good layout is one that utilise both horizontal and vertical space. It is not only enough if only the floor space is utilised optimally but the third dimension, i.e., the height is also to be utilised effectively.

4) Principle of flow: A good layout is one that makes the materials to move in forward direction towards the completion stage, i.e., there should not be any backtracking.

5) Principle of maximum flexibility: The good layout is one that can be altered without much cost and time, i.e., future requirements should be taken into account while designing the present layout.

6) Principle of safety, security and satisfaction: A good layout is one that gives due consideration to workers safety and satisfaction and safeguards the plant and machinery against fire, theft, etc.

7) Principle of minimum handling: A good layout is one that reduces the material handling to the minimum.

Factors Influencing Plant Layout

Some of the major factors which affect plant layout are: (a) Policies of management (b) Plant location (c) Nature of the product (d) Volume of production (e) Availability of floor space (f) Nature of manufacturing process and (g) Repairs and maintenance of equipment and machines (h) Types of Machines (i) Climate.

Policies of management: It is important to keep in mind various managerial policies and plans before deciding plant layout. Various managerial policies relate to future volume of production and expansion, size of the plant, integration of

production processes; facilities to employees, sales and marketing policies and purchasing policies etc. These policies and plans have positive impact in deciding plant layout.

(a) Plant location: Location of a plant greatly influences the layout of the plant. Topography, shape, climate conditions, and size of the site selected will influence the general arrangement of the layout and the flow of work in and out of the building.

(b) Nature of the product: Nature of the commodity or article to be produced greatly affects the type of layout to be adopted. In case of process industries, where the production is carried in a sequence, product layout is suitable. For example, soap manufacturing, sugar producing units and breweries apply product type of layout. On the other hand in case of intermittent or assembly industries, process type of layout best suited. For example, in case of industries manufacturing cycles, typewriters, sewing machines and refrigerators etc., process layout method is best suited. Production of heavy and bulky items need different layout as compared to small and light items. Similarly products with complex and dangerous operations would require isolation instead of integration of processes.

(c) Volume of production: Plant layout is generally determined by taking into consideration the quantum of production to be produced. There are three systems of production viz.,

(i) Job production: Under this method peculiar, special or non- standardized products are produced in accordance with the orders received from the customers. As each product is non-standardized varying in size and nature, it requires separate job for production. The machines and equipment's are adjusted in

such a manner so as to suit the requirements of a particular job. Job production involves intermittent process as the work is carried as and when the order is received. Ship building is an appropriate example of this kind. This method of plant layout viz., Stationery Material Layout is suitable for job production.

(ii) Mass production: This method involves a continuous production of standardized products on large scale. Under this method, production remains continuous in anticipation of future demand. Standardization is the basis of mass production. Standardized products are produced under this method by using standardized materials and equipment. There is a continuous or uninterrupted flow of production obtained by arranging the machines in a proper sequence of operations. Product layout is best suited for mass production units.

(iii) Batch production: It is that form of production where identical products are produced in batches on the basis of demand of customers or of expected demand for products. This method is generally similar to job production except the quality of production. Instead of making one single product as in case of job production a batch or group of products is produced at one time, It should be remembered here that one batch of products has no resemblance with the next batch. This method is generally adopted in case of biscuit and confectionary manufacturing, medicines, tinned food and hardware's like nuts and bolts, etc.,

(d) Availability of floor space: Availability of floor space can be other decisive factor in adopting a particular mode of layout. If there is a scarcity of space, product layout may be undertaken. On the other hand more space may lead to the adoption of process layout.

(e) Nature of manufacturing process: The type of manufacturing process undertaken by a business enterprise will greatly affect the type of layout to be undertaken. A brief mention of various processes is given us under:

(i) Synthetic process: Under this process two or more materials are mixed to get a product. For example, in the manufacture of cement, lime stone and clay are mixed.

(ii) Analytical process: This is just the reverse of synthetic process. Under this method different products are extracted from one material. For example, from crude oil, petroleum, gas, kerosene and coal tar etc. are extracted.

(iii) Conditioning process: Under this process the original raw material is given the shape of different products and nothing is added to it. Jute is an important example of this kind.

(iv) Extractive process: This method involves the extraction of a product from the original material by the application of heat or pressure. This involves the process of separation, for example, aluminium is separated from bauxite.

(f) Repairs and maintenance of equipment and machines: The plant layout should be designed in such a manner as to take proper care with regard to repairs and maintenance of different types of machines and equipment being used in the industry. The machines should not be installed so closely that it may create the problems of their maintenance and repairs. It has been rightly said that “Not only should access to parts for regular maintenance such as oiling, be considered in layout but also access to machine parts and components when replacement and repair are fairly common”.

(g) Type of machines: Stationary layout is preferable if machines are heavy and emit more noise. Such heavy machinery can be fitted on the floor. Adequate space should be provided for the location of machines and also there should be sufficient space between them to avoid accidents.

(h) Climate: Temperature, illumination, ventilation should be considered while deciding on the type of layout. The above factors should be considered in order to improve the health and welfare of employees.

Classification of Plant Layout

Plant layout is the most effective physical arrangement, either existing or in plans of industrial facilities i.e., arrangement of machines, processing equipment and service departments to achieve greatest co-ordination and efficiency of 4 M's (Men, Materials, Machines and Methods). Some of the important types of plant layout are:

1) Product or line layout

2) Process or functional layout

3) Fixed Layout

4) Hybrid Layout

5) Cellular Manufacturing Layout

6) Services Layout

Product layout

Product layouts, also termed line layouts, arrange the resources required for a product or service around the needs of that product

or service. In manufacturing applications such as assembly lines with a high volume of a standard product the products will move in a flow from one processing station to the next. In contrast to the process layout in which products move to the resources, here the resources are arranged and dedicated to a particular product or service. The term product layout refers to the arrangement of the resources around the product or service. In services the requirements of a specific group of customers are identified and resources setup sequentially so the customers flow through the system, moving from one stage to another until the service is complete. Examples of product layouts include car assembly, self-service cafes and car valeting.

Advantages

(a) Removal of obstacles in production: Product layout ensures unrestricted and continuous production thereby minimising bottlenecks in the process of production, this is because work stoppages are minimum under this method.

(b) Economies in material handling: Under this method there are direct channels for the flow of materials requiring lesser time which considerably eliminate back-tracking of materials. On account of this, cost of material handling is considerably reduced. This is greatly helpful in achieving desired quality of the end product.

(c) Lesser manufacturing time: Under this method (as already pointed), backward and forward handling of materials is not involved, it leads to considerable saving in manufacturing time.

(d) Lesser work in progress: On account of continuous uninterrupted mass production, there is lesser accumulation of work in progress or semi-finished goods.

(e) Proper use of floor space: This method facilitates proper and optimum use of available floor space. This is due to non- accumulation of work in progress and overstocking of raw materials.

(f) Economy in inspection: Inspection can be easily and conveniently undertaken under this method and any defect in production operations can be easily located in production operations. The need for inspection under this method is much less and can be confined at some crucial points only.

(g) Lesser manufacturing cost: On account of lesser material handling, inspection costs and fullest utilisation of available space, production costs are considerably reduced under this method.

(h) Lesser labour costs: Due to specialisation and simplification of operations and use of automatic simple machines, employment of unskilled and semi-skilled workers can carry on the work. The workers are required to carry routine tasks under this method. This leads to lesser labour costs.

(i) Introduction of effective production control: Effective production control on account of simple operation of this method can be employed successfully. Production control refers to the adoption of measures to achieve production planning.

Disadvantages of Product Layout

(a) Lesser flexibility: As work is carried in sequence and process arranged in a line, it is very difficult to make adjustments in production of operations. Sometimes, certain changes under this method become very costly and impractical. On account of this drawback, this method is not suitable in the

production of goods which are subject to quick style and design changes.

(b) Large investment: Under this method, machines are not arranged in accordance with functions as such similar type of machines and equipment is fixed at various lines of production. This leads to unavoidable machinery duplication resulting in idle capacity and large capital investment on the part of the entrepreneur.

(c) Higher overhead charges: Higher capital investment leads to higher overheads (fixed overheads) under this method. This leads to excessive financial burden.

(d) Interruption due to breakdown: If one machine in the sequence stops on account of breakdown, other machines cannot operate and work will be stopped. The work stoppage may also take place on account of irregular supply of material, poor production scheduling and employee absenteeism etc.

(e) Difficulties in expanding production: Production cannot be expanded beyond certain limits under this method.

(f) Lack of specialisation in supervision: Supervision of different production jobs becomes difficult under this method as there is absence of specialised supervision as the work is carried on in one line having different processes and not on the basis of different departments for different specialised jobs. Under this method a supervisor is supposed to have detailed knowledge of all the machines and processes which leads to absence of specialisation in the process of supervision.

(g) Under-utilisation of machines: As has already been pointed out, separate set of one type of machines is fixed at different lines of production. Usually, these machines are not

properly and fully utilised and there remains idle capacity in the form of under utilised equipment.

Process or Functional Layout

A process layout is one in which resources (such as equipment and people) which have similar processes or functions are grouped together. Process layouts are used when there is a large variety in the products or services being delivered and it may not be feasible to dedicate facilities to each individual product or service. A process layout allows the products or customers to move to each group of resources in turn, based on their individual requirements. Because of their flexibility process layouts are widely used. Examples of process layouts include supermarkets, hospitals, department stores and component manufacturers.

Advantages of Process Layout

(a) Maximum utilisation of machines: This method ensures fuller and effective utilisation of machines and consequently investment in equipment and machines becomes economical.

(b) Greater flexibility: Changes in the sequence of machines and operations can be made without much difficulty. This is because the machines are arranged in different departments in accordance with the nature of functions performed by them.

(c) Scope for expansion: Production can be increased by installing additional machines without much difficulty.

(d) Specialisation: As has already been pointed out that under this method, specialised machines are used for performing different production operations. This leads to specialisation.

(e) Effective utilisation of workers: Specialised workers are appointed to carry different type of work in different departments. This leads to effective and efficient use of their talent and capabilities.

(f) More effective supervision: As the machines are arranged on the basis of functions, performed by them, the specialised and effective supervision is ensured by the specialised knowledge of supervisors. Each supervisor can perform his task of supervision effectively as he has to supervise limited number machines operating in his department.

(g) Lesser work stoppages: Unlike the product method, if a machine fails, it does not lead to complete work stoppage and production schedules are not seriously affected. Due to breakdown in one machine, the work can be easily transferred to the other machines.

Disadvantages of Process Layout

(a) Coverage of more floor area: Under this method, more floor space is needed for the same quantum of work as compared to product layout.

(b) Higher cost of material handling: Material moves from one department to another under this method, leading to the higher cost of material handling. The mechanical devices of material handling cannot be conveniently employed under this method on account of functional division of work. Material has to be carried by applying other methods from one department to another, resulting into higher cost of material handling.

(c) Higher labour costs: As there is functional division of work, specialised workers are to be appointed in different departments for carrying specialised operations. The appointment of skilled worker leads to higher labour costs.

(d) Longer production time: Production takes longer time for completion under this method and this leads to higher inventories of work-in-progress.

(e) Difficulties in production, planning and control: Due to large variety of products and increased size of the plant, there are practical difficulties in bringing about proper coordination among various areas (departments) and processes of production. The process of production, planning and control becomes more complex and costly.

(f) Increased inspection costs: Under this type of layout more supervisors are needed and work is to be checked after every operation which makes the process of supervision costlier.

Hybrid Layout

A combination of process and product layouts combines the advantages of both types of layouts. A combination layout is possible where an item is being made in different types and sizes. Here machinery is arranged in a process layout but the process grouping is then arranged in a sequence to manufacture various types and sizes of products. It is to be noted that the sequence of operations remains same with the variety of products and sizes.

Flexibility is a very important factory, so layout should be such which can be molded according to the requirements of industry, without much investment. If the good features of all types of layouts are connected, a compromise solution can be obtained

which will be more economical and flexible.

Group or Cellular Layout

There is a trend now to bring an element of flexibility into manufacturing system as regards to variation in batch sizes and sequence of operations. A grouping of equipment for performing a sequence of operations on family of similar components or products has become all the important. The process of grouping the products or services to create a family is termed group technology.

Group Technology (GT) is the analysis and comparisons of items to group them into families with similar characteristics. GT can be used to develop a hybrid between pure process layout and pure flow line (product) layout. This technique is very useful for companies that produce variety of parts in small batches to enable them to take advantage and economics of flow line layout.

Group Technology has Three Aspects:

1. Grouping parts into families

Grouping parts or customers into families has the objective of reducing the changeover time between batches, allowing smaller batch sizes, and thus improving flexibility. Parts family formation is based on the idea of grouping parts or customers together according to factors such as processing similarity.

2. Group physical facilities into cells to reduce transportation time between processes

Physical facilities are grouped into cells with the intention of reducing material or customer movements. Whereas a process

layout involves extensive movement of materials or customers between departments with common processes, a cell comprises all the facilities required to manufacture a family of components or delivery a service. Material and customer movement is therefore restricted to within the cell and throughput times are therefore reduced. Cells can be U- shaped to allow workers to work at more than one process whilst minimising movement.

3. Creating groups of multi-skilled workers

Creating groups of multi-skilled workers enables increased autonomy and flexibility on the part of operators. This enables easier changeovers from one part to another and increases the job enrichment of members of the group. This in turn can improve motivation and have a beneficial effect on quality.

Advantages of Group Technology Layout

1. Cost: Cellular manufacturing provides for faster processing time, less material handling, less work-in-process inventory, and reduced setup time, all of which reduce costs.

2. Flexibility: Cellular manufacturing allows for the production of small batches, which provides some degree of increased flexibility. This aspect is greatly enhanced with FMSs.

3. Motivation: Since workers are cross-trained to run every machine in the cell, boredom is less of a factor. Also, since workers are responsible for their cells' output, more autonomy and job ownership is present.

Limitations of Group Technology Layout

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

product mix is completely dissimilar, then we may not have meaningful cell formation.

Fixed Position Layout

This type of layout is the least important for today's manufacturing industries. In this type of layout the major component remain in a fixed location, other materials, parts, tools, machinery, man power and other supporting equipment's are brought to this location.

The major component or body of the product remain in a fixed position because it is too heavy or too big and as such it is economical and convenient to bring the necessary tools and equipment's to work place along with the man power. This type of layout is used in the manufacture of boilers, hydraulic and steam turbines and ships etc.

Advantages of Fixed Position Layout

(a) Material movement is reduced

(b) Capital investment is minimized.

(c) The task is usually done by gang of operators, hence continuity of operations is ensured

(d) Production centers are independent of each other. Hence, effective planning and loading can be made. Thus total production cost will be reduced.

(e) It offers greater flexibility and allows change in product design, product mix and production volume.

Limitations of Fixed Position Layout

(a) Highly skilled man power is required

(b) Movement of machines equipment's to production centre may be time consuming.

(c) Complicated fixtures may be required for positioning of jobs and tools. This may increase the cost of production.

Services Layout

The major factors considered for service providers, is an impact of location on sales and customer satisfaction. Customers usually look about how close a service facility is, particularly if the process requires considerable customer contact. Hence, service facility layouts should provide for easy entrance to these facilities from the freeways. Well-organized packing areas, easily accessible facilities, well designed walkways and parking areas are some of the requirements of service facility layout.

These service layouts follow conventional layouts as required. For example, for car service station, product layout is adopted, where the activities for servicing a car follows a sequence of operation irrespective of the type of car.

Assembly Line Balancing

Assembly-line balancing often has implications for layout. This would occur when, for balance purposes, workstation size or the number used would have to be physically modified. The most common assembly-line is a moving conveyor that passes a series of workstations in a uniform time interval called the workstation cycle time (which is also the time between successive units coming off the end of the line).

The problem is complicated by the relationships among tasks imposed by product design and process technologies. This is called the precedence relationship, which specifies the order in which tasks must be performed in the assembly process.

Materials Handling

The material handling involves the movement of material form one section to another for the purpose of processing. They can be moved either manually or mechanically. For this purpose different types material handling equipment are used. The material handling system in any manufacturing setting plays an important role in the performance of the entire manufacturing system.

Material handling can be defined as the art and science involving the movement, packing and storing of substances in any form.

Objectives of Material Handling

1. To reduce material handling cost
2. To reduce production life cycle
3. Better control of the flow of material
4. To ensure safety in the movement of goods
5. To avoid damage of the goods

General Principles of Material Handling

There are some guiding principles of material handling. These are:

1. Reduce unnecessary movement by selecting the shortest path to reach the destination.

2. Reduce congestion and bottlenecks by eliminating obstruction and congestions in the material handling.

3. Use scientific factory layout to minimize the overall material movement and reduce the number of trips. This will result in reduced transportation costs.

4. Use of standard material handling equipments to facilitate easy maintenance and availability of spares.

5. Minimize handling as it reduces the chances of breakage. It also reduces loading/unloading time and cost.

6. Use gravity to transport material, wherever possible.

7. Use mechanized material handling equipment to reduce dependence on human labour.

Materials Handling Equipments

The attempt in material handling is to use flexible equipments wherever possible and specialized equipment, only if necessary. The equipment should be simple and safe with operator safety as the prime objective. Listed below are a few material-handling devices and when they might be used.

1. Overhead Cranes and Hoists: Overhead cranes and hoists are used to move heavy objects through a plant. They are used for the movement of material in a fixed route and fixed area of operation. They come in a variety of sizes, and many are able to lift twenty-five tons or more. Moving steel slabs is an example of an overhead crane application. Overhead cranes are

efficient at moving small parts only if the parts can be put together in a large batch and moved in one trip.

2. Conveyors: Conveyors are used to transport material from one fixed point to another fixed point. Some conveyors have belts that can move parts or granular material; others have a series of hooks that can move parts through a paint system. Some use gravity or a powered device to carry material. Some of the conveyor systems are portable which may be moved from time to time, but generally these are fixed. These are used for the following applications:

(a) Moving homogeneous material

(b) Fixed route of movement

(c) Constant rate of material movement

(d) Mass production units

3. Industrial Trucks: These are manual or external powered vehicles, which can move on a variety of paths. These are particularly useful for the following situations:

(a) Uneven (intermittent) supply of material

(b) Varying paths of movement

(c) Job-shop production units

4. Forklifts: Forklifts are used to move parts through varying paths. Because they have drivers, these vehicles are very flexible. Forklifts generally do not move large volumes of parts along the same path.

5. Automated Guided Vehicles (AGVs): AGV is a programmed vehicle, used to carry load from one location to another in an automated work place. They can be used to move parts through a variety of paths and are flexible in that they can be directed to follow more than one path. The most common type of such vehicles normally follows a predetermined path on floor embedded wires arranged to form closed loops. These vehicles are called as wire guided AGVs. Another variety is free-ranging AGVs, which offer more flexibility, as they need not move on a pre-specified path. An off-board controller is used to send despatcher commands for the identification of the load, destination of the load and, other instructions related to loading and unloading of the load.

6. Elevators and Lifts: These are used to raise or lower material in the vertical direction. They are just like lifts of a multi-storied building but carry material.

Efficient planning and control of the material handling system can add to efficiency.

Module III

Capacity Planning

Capacity is the amount of goods that a firm is capable of producing over a specified period of time. Capacity can be defined as highest reasonable output rate which can be achieved with the current product specifications, product mix, work force, plant and equipment. Capacity planning for manufacturing and service systems are different. Both must be designed with capacity limitations in mind. The approaches for long- term and short-term capacity planning will help the managers to make best use of resources. Capacity is the maximum possible output or use from a system under normal design or planned conditions in a given time period. The effective capacity utilisation is expressed as percentage of actual capacity used to design capacity.

Capacity Requirement Planning

A capacity requirement planning is a part of manufacturing resource planning .Capacity resource planning is carried out after a manufacturing resource planning program has been run. The important elements of the capacity requirement planning process are of establishing, measuring and adjusting the limits or levels of the production capacity based on the process of determining the amount of labour and machine resources required to accomplish the tasks of production.

Types of Capacity

1. Maximum Capacity

Maximum capacity or design capacity is the highest rate of output a process or activity can achieve. It specifies a theoretical upper limit above the usual rate of routine operations. The

operation managers calculate the maximum capacity of a manufacturing process .It is based on the number and duration of available shifts, the number of available machines and employees per shift and the working days in a period of the calculation.

2. Effective Capacity

Effective capacity identifies the output rate that managers expect for a given activity or process. It is the actual capacity to reflect current conditions and that could be less than or more than design capacity. They base production plans and schedules on this measure of output. Effective capacity normally falls short of maximum capacity by some amount.

3. Demonstrated Capacity

Demonstrated or actual capacity deals with actual rather than planned production. It measures the actual level of output for a process or activity over a specified period of time. Planners calculate theoretical values for maximum and effective capacity to guide their arrangements for production purposes. Operation managers calculate demonstrated capacity simply by averaging recorded figures for actual output over a period of time.

Guidelines for calculating Capacity

The operation managers need a methodology for evaluating capacity and the activities that determine it in specific situations. The steps in this analysis from a process for calculating capacity are as follows:

1. The first step is to describe the general flow of activities with in the process.

2. Establish the time period.

3. Establish a common unit of measurement for the entire process

4. Identify the maximum capacity for the overall process

5. Identify the effective capacity for the overall process

6. Determine the demonstrated capacity

7. Compare the demonstrated, effective and maximum capacities and take appropriate actions.

Capacity Planning

The effective management of capacity is the most important responsibility of production management. The objective of capacity management is to match the level of operations to the level of demand. Capacity planning is to be carried out keeping in mind future growth and expansion plans, market trends, sales forecasting, etc. It is easy to plan the capacity in case of stable demand. But in practice the demand will not be stable. The fluctuation in demand creates problems regarding the procurement of resources and production to meet the customer demand. Capacity decisions are strategic in nature. In simple words, capacity is the rate of productive capability of a facility. Capacity is usually expressed as volume of output per period of time. Production managers are more concerned about the capacity for the following reasons:

õ Sufficient capacity is needed to meet the customers demand in time.

õ Capacity affects the cost efficiency of production.

õ Capacity affects the scheduling system.

õ Capacity creation requires an investment.

Capacity planning is the first step when a manufacturing organisation decides to produce new products. One of the major tasks in capacity management is the decision with regard to capacity planning**.** Capacity planning is the process of predicting and defining the long -term and the short-term capacity needs of an organisation and determining how those needs will be satisfied. Capacity planning decisions are taken based upon the consumer demand. Capacity planning also takes in to consideration the human, material and financial resources of the organisation. Capacity requirements can be evaluated from two perspectives—long-term capacity strategies and short-term capacity strategies.

1. Long-term Capacity Strategies

It is difficult to predict the long term capacity requirements because the future demands are difficult to predict. Long-range capacity requirements are dependent on marketing plans, product development and life-cycle of the product. Long-term capacity planning is related with accommodating major changes that affect overall level of the output in long-term. Designing and implementing the long -term capacity plans are the major responsibilities of management. Following parameters will affect long-range capacity decisions.

- **Multiple products:** The manufacturing of multiple products will reduce the risk of failure. Production of a single product is always risky. If we produce multiple products, each products in different stages of their life cycles, it is easy to schedule them to get maximum capacity utilisation.

- **Phasing in capacity:** The rate of obsolescence is high in the case of high technology industries compared to other types of

industries. The products should be brought into the market quickly.

- **Phasing out capacity:** The out-dated manufacturing facilities cause excessive plant closures. The impact of the closure will be huge in the case of industries. The phasing out also affects the employability of employees and which in turn affect the standard lining of the society. The phasing out options makes alternative arrangements for men like shifting them to other jobs or to other locations, compensating the employees etc.

2. Short-term Capacity Strategies:

Another task in capacity planning is to develop short term capacity strategies. Managers can predict the future demand for the product in the near future based on statistical tools. Managers then compare requirements with existing capacity and then take decisions as to when the capacity adjustments are needed.

Fundamental capacity is fixed for short period. Major facilities will not be changed. Many short-term adjustments for increasing or decreasing capacity are possible. The adjustments to be required depend upon the conversion process like whether it is capital intensive or labour intensive or whether product can be stored as inventory. Capital-intensive processes depend on physical facilities, plant and equipment. Short-term capacity can be modified by operating these facilities more or less intensively than normal.

Short-term Capacity Strategies

The following are different types of short term capacity strategies**:**

(a) Inventories: Stock of finished goods during slack periods to meet the demand during peak period.

(b) Backlog: During peak periods, the willing customers are requested to wait and their orders are fulfilled after a peak demand period.

(c) Employment level: Hire additional employees during peak demand period and lay off employees when demand decreases.

(d) Employee training: Develop multi skilled employees through training so that they can be rotated among different jobs.

(e) Subcontracting: During peak periods, hire the capacity of other firms temporarily to produce the component parts or products.

(f) Process design: Change job contents by redesigning the job.

Process of Capacity Planning

The process involved in capacity planning is as follows:

1. Demand forecasting

Capacity planning starts with the setting of up of a business plan which sets out the types of goods or services to be produced. The Manager has to take a long range forecast of demand in order to determine the resources needed to produce and offer specified goods and services. Market trend changes, competitor's role and technological changes have to be carefully examined.

2. Capacity decisions

The demand forecasting of goods and services then must be translated in to a measure of capacity needed. On the basis of forecasting of demand for products, organisation will be able to determine the various resources needed for producing such goods.

3. Facilities planning

Capacity decisions automatically lead to the setting up of necessary facilities in order to produce goods and services as determined the previous steps. Facility planning can be done either by the expansion or contraction of existing facilities or by setting up of additional new facilities.

4. Decisions and implementation

Finally, alternative resource requirements plan should be properly evaluated. The feasibility of plans along with its economic impact needs to be analysed. Detailed study of economic impact of resource requirements is essential to make the capacity planning a reality.

Importance of Capacity Planning

1. Capacity decisions have an impact on the ability of the organisation to meet future demands for products and Services.

2. Capacity decisions affect operating costs. It should be seen that capacity and demand requirements will be matched, which will tend to minimize operating costs. In practice, this is not always achieved because actual demand either differs from expected demand or tends to vary. In such cases, a decision might be made to attempt to balance the costs of over and under capacity.

3. Capacity is usually a major determinant of initial cost.

4. Capacity decisions often involve long-term commitment of funds.

5. Capacity decisions can affect competitiveness.

6. Capacity planning reduces the complexity in manufacturing operation.

Principles of Capacity Planning

The following are the principles for planning for the adequate capacity resources within an infrastructure.

1. Agree on a common definition of capacity planning

Capacity planning means different things to different people. Agreeing on a common, formal definition of the process is essential in designing and implementing an effective capacity planning program. Proper care should be taken in defining various concepts of capacity planning.

2. Select a capacity planning process owner

The next step is to select a suitable qualified individual to serve as the process owner. The person will be responsible for designing, implementing and maintaining the process and will be empowered to negotiate and delegate with developers and other support groups.

3. Identify the key resources to be measured

Once the process is selected, the next task is to identify the infrastructure resources to be measured.

4. Compare current utilisation to maximum capacities

This principle aims to determine how much excess capacity is available for selected components. The utilisation or performance of each component measured should be compared to the maximum usable capacity.

Maintenance Management

Equipment must be kept at the best operating condition. Otherwise, there will be interruption of production if it is used in a mass production line. Poor working of equipment will lead to quality related problems. It is a necessity to maintain the equipment in good operating conditions with economical cost. Therefore, an integrated approach to minimize the cost of maintenance is essential. In certain cases, the equipment will be obsolete over a period of time. If a firm wants to be in the same business competitively, it has to take decision on whether to replace the equipment or to retain the old equipment by taking the cost of maintenance into account.

Types of Maintenance

Equipment requires periodic maintenance. Belts need adjustment, alignment needs to be maintained, and proper lubrication on rotating equipment is required. In some cases, certain components need replacement. The following are the different types of maintenance are given below:

1. Break Down Maintenance

Under this type of method, a machine allows to operate till it breaks. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached. In the case of new equipment, we can expect minimal incidents of failure.

Advantages

- Low cost investment for maintenance.
- Less staff is required for maintenance.
-

Disadvantages

- Increased cost due to unplanned downtime of equipment.
- Increased labour cost.
- Possible process damage from equipment failure.

2. Preventive Maintenance

This type of maintenance is preventive in nature. Preventive maintenance is for increasing the reliability of the equipment. By simply expending the necessary resources to conduct maintenance activities intended by the equipment designer, equipment life is extended and its reliability is increased.

Advantages

- Cost effective.
- Flexibility allows for the adjustment of maintenance periodicity.
- Increased component life cycle.
- Energy savings.
- Reduced equipment or process failure.

Disadvantages

- Labour intensive.
- Includes performance of unneeded maintenance.

3. Predictive Maintenance

Predictive maintenance differs from preventive maintenance. Preventive maintenance is time-based. Predictive maintenance

can be defined as Measurements that detect the onset of a degradation mechanism, thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state. Results indicate current and future functional capability.

Advantages

- Increased component operational life.
- Allows for pre-emptive corrective actions.
- Decrease in equipment or process downtime.
- Decrease in costs for parts and labour.
- Better product quality.
- Improved worker and environmental safety.

Disadvantages

- High investment in diagnostic equipment.
- High investment in staff training.
- Savings potential not readily seen by management.

Maintenance Planning

Maintenance planning deals with taking decisions in advance about maintenance activities, It deals with what, How, where, when the maintenance activities are to be taken.

Reliability Cantered Maintenance:

Reliability cantered maintenance (RCM) is defined as a process used to determine the maintenance requirements of any physical asset in its operating context. It recognizes that equipment

design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. Therefore different types of maintenance have to be followed.

Work Study

Work study is a technique which is employed to ensure the best possible use of men, machine, materials and energy in carrying out a specific activity. It deals with the techniques of method study and work measurement.

Work study is based on the principle that for every job, there is:

a) One best way of doing it.

b) A scientific method is the best and surest way of finding this best way.

c) The time taken for doing the job by the best way can be measured and set as standards.

Method Study

Dividing and analysing a job is called method study. The approach takes a systematic approach to reducing waste, time and effort. The approach can be analysed in a six-step procedure:

1. Select

Tasks most suitable will probably be repetitive, require extensive labour input and be critical to overall performance.

2. Record

This involves observation and documentation of the correct method of performing the selected tasks. Flow process charts are often used to represent a sequence of events graphically. They are intended to highlight unnecessary material movements and unnecessary delay periods.

3. Examine

This involves examination of the current method, looking for ways in which tasks can be eliminated, combined, rearranged and simplified. This can be achieved by looking at the flow process chart for example and re-designing the sequence of tasks necessary to perform the activity.

4. Develop

Developing the best method and obtaining approval for this method. This means choosing the best alternative considered taking into account the constraints of the system such as the performance of the firm's equipment. The new method will require adequate documentation in order that procedures can be followed. Specifications may include tooling, operator skill level and working conditions.

5. Install

Implement the new method. Changes such as installation of new equipment and operator training will need to be undertaken.

6. Maintain

Routinely verify that the new method is being followed correctly

New methods may not be followed due to inadequate training or support. On the other hand people may find ways to gradually improve the method over time. Learning curves can be used to analyse these effects.

Work Measurement

The second element of work-study is work measurement which determines the length of time it will take to undertake a particular task. This is important not only to determine pay rates but also to ensure that each stage in a production line system is of an equal duration (i.e. 'balanced') thus ensuring maximum output. Usually the method study and work measurement activities are undertaken together to develop time as well as method standards. Setting time standards in a structured manner permits the use of benchmarks against which to measure a range of variables such as cost of the product and share of work between team members. However the work measurement technique has been criticised for being misused by management in determining worker compensation. The time needed to perform each work element can be determined by the use of historical data, work sampling or most usually time study.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are as follows:

- Comparing alternative methods.
- Manpower requirement planning
- Planning and control.

- Realistic costing.
- Financial incentive schemes.
- Delivery date of goods.

Techniques of Work Measurement

For the purpose of work measurement, work can be regarded as:

1. Repetitive work: The type of work in which the main operation repeats continuously during the time spent at the job.

2. Non-repetitive work: It includes some type of maintenance and construction work, where the work cycle is not repeated.

Various Techniques of Work Measurement are:

1. 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. Time study is for analysing the data so as to determine the time necessary for carrying out the job at the defined level of performance.

2. Synthetic data:

It is the method of totaling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.

3. Work sampling:

A technique in which a large number of observations are made over a period of time of one or group of machines, processes or

workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

4. Predetermined motion time study:

A work measurement technique whereby times established for basic human motions are used to build up the time for a job.

5. Analytical estimating:

A work measurement technique, whereby the time required carrying out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience.

Time Study

The purpose of Time Study is through the use of statistical techniques to arrive at a standard time for performing one cycle of a repetitive job. This is arrived at by observing a task a number of times. The standard time refers to the time allowed for the job under specific circumstances, taking into account allowances for rest and relaxation.

The main objectives of time study are:

1) To determine the standard time for various operations which helps in fixing wage rates and incentives.

2) To estimate the cost of product accurately.

3) To predict accurately the duration for a particular work and customer is promised accordingly.

4) To determine the number of machines an operator can run.

5) To determine the optimum number of men and machine.

6) To provide information for planning and scheduling.

7) To balance the work of all workers working in a group.

8) To compare the work efficiency of different workers/operators.

Motion Study

Motion study is the study of the individual human motions that are used in a job task. The purpose of motion study is to try to ensure that the job does not include any unnecessary motion or movement by the worker and to select the sequence of motions that ensure that the job is being carried out in the most efficient manner possible. For even more detail videotapes can be used to study individual work motions in slow motion and analyse them to find improvement a technique termed micro-motion analysis. The principles are generally categorised according to the efficient use of the human body, efficient arrangement of the workplace and the efficient use of equipment and machinery. These principles can be summarised into general guidelines as follows:

1. Efficient Use of the Human Body: Work should be rhythmic, symmetrical and simplified. The full capabilities of the human body should be employed. Energy should be conserved by letting machines perform tasks when possible.

2. Efficient Arrangement of the Workplace: Tools, materials and controls should have a defined place and be located to minimise the motions needed to get to them. The workplace should be comfortable and healthy.

3. Efficient use of Equipment: Equipment and mechanised tools enhance worker abilities. Controls and foot-

operated devices that can relieve the hand/arms of work should be maximised. Equipment should be constructed and arranged to fit worker use.

Motion study is seen as one of the fundamental aspects of scientific management and indeed it was effective in the design of repetitive, simplified jobs with the task specialisation which was a feature of the mass production system. The use of motion study has declined as there has been a movement towards greater job responsibility and a wider range of tasks within a job. However the technique is still a useful analysis tool and particularly in the service industries, can help improve process performance.

Module IV

Aggregate Planning

An organization can finalize its business plans on the recommendation of demand forecast. Once business plans are ready, an organization can do backward working from the final sales unit to raw materials required. Thus annual and quarterly plans are broken down into labour, raw material, working capital, etc. requirements over a medium-range period (6 months to 18 months). This process of working out production requirements for a medium range is called aggregate planning.

Factors Affecting Aggregate Planning

Aggregate planning is an operational activity critical to the organization as it looks to balance long-term strategic planning with short term production success. Following factors are critical before an aggregate planning process can actually start;

- Complete information is required about available production facility and raw materials.
- A solid demand forecast covering the medium-range period
- Financial planning surrounding the production cost which includes raw material, labour, inventory planning, etc.,
- Organization policy around labour management, quality management, etc.,

For aggregate planning to be a success, following inputs are required;

- An aggregate demand forecast for the relevant period

- Evaluation of all the available means to manage capacity planning like sub-contracting, outsourcing, etc.,

- Existing operational status of workforce (number, skill set, etc.), inventory level and production efficiency

Aggregate planning will ensure that organization can plan for workforce level, inventory level and production rate in line with its strategic goal and objective.

Importance of Aggregate Planning

Aggregate planning plays an important role in achieving long-term objectives of the organization. Aggregate planning helps in:

- Achieving financial goals by reducing overall variable cost and improving the bottom line

- Maximum utilization of the available production facility

- Provide customer delight by matching demand and reducing wait time for customers

- Reduce investment in inventory stocking

- Able to meet scheduling goals there by creating a happy and satisfied work force

Aggregate Planning Strategies

Several different strategies have been employed to assist in aggregate planning. Three “pure” strategies are recognized. The pure strategies stem from early models that depicted production

results when only one of the decision variables was permitted to vary all others being held constant. Three focussed strategies are:

1. Vary production to match demand by changes in employment (Chase demand strategy): This strategy permits hiring and layoff of workers, use of overtime, and subcontracting as required in each period. However, inventory build-up is not used.

2. Produce at a constant rate and use inventories. (Level production strategy): This strategy retains a stable work force producing at a constant output rate. Inventory can be accumulated to satisfy peak demands. In addition, subcontracting is allowed and back orders can be accepted. Promotional programmes may also be used to shift demand.

3. Produce with stable workforce but vary the utilization rate (Stable work-force strategy): This strategy retains a stable work force but permits overtime, part-time, and idle time. Some versions of this strategy permit back orders, subcontracting, and use of inventories. Although this strategy uses overtime, it avoids the detrimental effects of layoff.

Master Production Schedule (MPS)

The Master Production Schedule (MPS) formalizes the production plan and translates it into specific end-item requirements over a short to intermediate planning horizon. The end items are then exploded into specific material and capacity requirements by the Material Requirements Planning (MRP) and Capacity Requirements Planning (CRP) systems. Thus, the MPS essentially drives the entire production and inventory system.

The major inputs to the master production schedule are:

1. Forecasts of demand, e.g., of end items and service parts.

2. Customer orders, i.e., including any warehouse and interplant needs.

3. Inventory on-hand from the previous period.

Forecasts of demand are the major input for make-to-stock items. However, to be competitive, many make-to-order firms must anticipate orders by using forecasts for long lead-time items and by matching the forecasts with customer orders as the orders become available.

Material Requirement Planning (MRP)

MRP is one of the most widely used systems for harnessing computer power to automate the manufacturing process. IBM engineer Joseph Orlicky developed MRP in 1964 after he studied the Toyota Production System, which was the model for the production methodology. Power tool maker Black & Decker built the first computerized MRP system that same year, according to several sources. It's important to note, however, that MRP and lean production are not the same and are considered by some practitioners to be antithetical, though some say MRP can help with lean production.

MRP is considered a "push" system inventory needs are determined in advance, and goods produced to meet the forecasted need while lean is a "pull" system in which nothing is made or purchased without evidence of actual not forecasted demand. Orlicky's ideas spread rapidly throughout the manufacturing sector after the 1975 publication of his book, Material Requirements Planning: The New Way of Life in

Production and Inventory Management, and by the early 1980s, there were hundreds of commercial and home grown MRP software programs.

Basics of MRP

Material requirements planning (MRP) is a system for calculating the materials and components needed to manufacture a product. It consists of three primary steps: taking inventory of the materials and components on hand, identifying which additional ones are needed and then scheduling their production or purchase. MRP uses information from the bill of materials (a list of all the materials, subassemblies and other components needed to make a product, along with their quantities), inventory data and the master production schedule to calculate the required materials and when they will be needed during the manufacturing process.

Objectives

- Not surprisingly, the primary objective of MRP is to make sure that materials and components are available when needed in the production process and that manufacturing takes place on schedule.

- Effective inventory management and optimization is another goal of MRP.

- While MRP is designed to ensure adequate inventory at the required times, a company can be tempted to hold more inventory than is necessary, thereby driving up inventory costs.

- MRP can also improve manufacturing efficiency by using accurate scheduling to optimize the use of labour and equipment.

Elements of MRP

Following are some of the terminology used to describe the functioning of MRP systems.

- **MRP:** A technique for determining the quantity and timing dependent demand items.

- **Dependent demand:** Demand for a component that is derived from the demand for other items.

- **Parent and component items:** A parent is an assembly made up of basic parts, or components. The parent of one subgroup may be a component of a higher-level parent.

- **Bill of materials:** A listing of all components (subassemblies and materials) that go into an assembled item. It frequently includes the part numbers and quantity required per assembly.

- **Level code:** The level on which an item occurs in the structure, or bill-of-materials format.

- **Requirements explosion:** The breaking down (exploding) of parent items into component parts that can be individually planned and scheduled.

- **Time phasing:** Scheduling to produce or receive an appropriate amount (lot) of material so that it will be available in the time periods when needed-not before or after.

- **Time bucket:** The time period used for planning purposes in MRP-usually a week.

- **Lot size.** The quantity of items required for an order. The order may be either purchased from a vendor or produced in-house. Lot sizing is the process of specifying the order size.

- **Lead-time offset:** The supply time, or number of time buckets between releasing an order and receiving the materials.

MRP Inputs and Outputs

The essential inputs and outputs in an MRP system are listed below:

Inputs	Outputs
• MPS of end items required. • Inventory status file of on-hand and on-order items, lot sizes, lead times, etc. • Product structure (BOM) file of what components and subassemblies go into each end product.	• Order release data to CRP for load profiles • Orders to purchasing and in-house production shops. • Rescheduling data to MPS. • Management reports and inventory updates.

Meaning of Inventory

Inventory generally refers to the materials in stock. It is also called the idle resource of an enterprise. Inventories represent those items which are either stocked for sale or they are in the process of manufacturing or they are in the form of materials, which are yet to be utilised. The interval between receiving the

purchased parts and transforming them into final products varies from industries to industries depending upon the cycle time of manufacture.

It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient operation of the system. Thus, an effective control on inventory is a must for smooth and efficient running of the production cycle with least interruptions.

Reasons for Keeping Inventories

1. To stabilise production: The demand for an item fluctuates because of the number of factors, e.g., seasonality, production schedule etc. The inventories (raw materials and components) should be made available to the production as per the demand failing which results in stock out and the production stoppage takes place for want of materials. Hence, the inventory is kept to take care of this fluctuation so that the production is smooth.

2. To take advantage of price discounts: Usually the manufacturers offer discount for bulk buying and to gain this price advantage the materials are bought in bulk even though it is not required immediately. Thus, inventory is maintained to gain economy in purchasing.

3. To meet the demand during the replenishment period: The lead time for procurement of materials depends upon many factors like location of the source, demand supply condition, etc. So inventory is maintained to meet the demand during the procurement (replenishment) period.

4. To prevent loss of orders (sales): In this competitive scenario, one has to meet the delivery schedules at 100 per cent

service level, means they cannot afford to miss the delivery schedule which may result in loss of sales. To avoid the organizations have to maintain inventory.

5. To keep pace with changing market conditions: The organizations have to anticipate the changing market sentiments and they have to stock materials in anticipation of non-availability of materials or sudden increase in prices.

Sometimes the organizations have to stock materials due to other reasons like suppliers minimum quantity condition, seasonal availability of materials or sudden increase in prices.

Inventory Control or Management

Inventory control is a planned approach of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales. Inventory control basically deals with two problems: (i) When should an order be placed? (Order level), and (ii) How much should be ordered? (Order quantity).

These questions are answered by the use of inventory models. The scientific inventory control system strikes the balance between the loss due to non-availability of an item and cost of carrying the stock of an item. Scientific inventory control aims at maintaining optimum level of stock of goods required by the company at minimum cost to the company.

Objectives of Inventory Control

1. To ensure adequate supply of products to customer and avoid shortages as far as possible.

2. To make sure that the financial investment in inventories is minimum (i.e., to see that the working capital is blocked to the minimum possible extent).

3. Efficient purchasing, storing, consumption and accounting for materials is an important objective.

4. To maintain timely record of inventories of all the items and to maintain the stock within the desired limits

5. To ensure timely action for replenishment.

6. To provide a reserve stock for variations in lead times of delivery of materials.

7. To provide a scientific base for both short-term and long-term planning of materials.

Benefits of Inventory Control

It is an established fact that through the practice of scientific inventory control, following are the benefits of inventory control:

1. Improvement in customer's relationship because of the timely delivery of goods and service.

2. Smooth and uninterrupted production and, hence, no stock out.

3. Efficient utilisation of working capital. Helps in minimising loss due to deterioration, obsolescence damage and pilferage.

4. Economy in purchasing.

5. Eliminates the possibility of duplicate ordering.

Techniques of Inventory Control

In any organization, depending on the type of business, inventory is maintained. When the number of items in inventory is large and then large amount of money is needed to create such inventory, it becomes the concern of the management to have a proper control over its ordering, procurement, maintenance and consumption. The control can be for order quality and order frequency.

The different techniques of inventory control are: (1) ABC analysis, (2) HML analysis, (3) VED analysis, (4) FSN analysis, (5) SDE analysis, (6) GOLF analysis and (7) SOS analysis. The most widely used method of inventory control is known as ABC analysis. In this technique, the total inventory is categorised into three sub-heads and then proper exercise is exercised for each sub-heads.

1. ABC analysis: In this analysis, the classification of existing inventory is based on annual consumption and the annual value of the items. Hence we obtain the quantity of inventory item consumed during the year and multiply it by unit cost to obtain annual usage cost. The items are then arranged in the descending order of such annual usage cost. The analysis is carried out by drawing a graph based on the cumulative number of items and cumulative usage of consumption cost. Classification is done as follows:

Once ABC classification has been achieved, the policy control can be formulated as follows:

(a) A-Item: Very tight control, the items being of high value. The control need be exercised at higher level of authority.

(b) B-Item: Moderate control, the items being of moderate value. The control need be exercised at middle level of authority.

(c) C-Item: The items being of low value, the control can be exercised at gross root level of authority, i.e., by respective user department managers.

2. HML analysis: In this analysis, the classification of existing inventory is based on unit price of the items. They are classified as high price, medium price and low cost items.

3. VED analysis: In this analysis, the classification of existing inventory is based on criticality of the items. They are classified as vital, essential and desirable items. It is mainly used in spare parts inventory.

4. FSN analysis: In this analysis, the classification of existing inventory is based consumption of the items. They are classified as fast moving, slow moving and non-moving items.

5. SDE analysis: In this analysis, the classification of existing inventory is based on the items.

6. GOLF analysis: In this analysis, the classification of existing inventory is based sources of the items. They are classified as Government supply, ordinarily available, local availability and foreign source of supply items.

7. SOS analysis: In this analysis, the classification of existing inventory is based nature of supply of items. They are classified as seasonal and off-seasonal items.

For effective inventory control, combination of the techniques of ABC with VED or ABC with HML or VED with HML analysis is practically used.

Opposing Views of Inventory

Inventories today have a good-guy, bad-guy image. There are many reasons why we like to have inventories, but there are also reasons why holding inventories is considered to have.

1. Why we want to Hold Inventories: Most businesses hold inventory for many reasons. Among them are:

- **Meeting unexpected demands:** The chain of supply and demand really comes into consideration here. Business people know that consumers expect goods and services when they need them. Thus, businesses usually stock up their inventories to meet these unexpected demands. These demands may result in overcrowding of inventories because we never know when the storm strikes and consumers would flock to buy the items.

- **Smoothing seasonal demands:** With the comings and goings of major events and the changing seasons, most businesses have inventories at hand to smoothen the seasonal demands. For example, Christmas is just round the corner. With the coming season, retail outlets as well as other businesses are busy meeting and stabilizing the upcoming Christmas demands of consumers. If they do not have any inventory, they can meet these demands.

- **Taking advantage of price discounts:** When a business purchase goods from the manufacturers and suppliers, they usually get price discounts if they buy in bigger bulks. Manufacturers and suppliers give these discounts to attract and

maintain regular buyers. Taking advantage of price discounts is helpful at times but one must always remember not to overstock the inventory because inefficient buying may cause failure of the business.

- **Hedging against price increase:** Businesses usually hold inventory to avoid from the ever fluctuating market price of inventories. Thus, by having efficient and good inventory system, businesses can control their inventory cost.

- **Getting quality discounts:** When businesses have inventory in store, they can get quality discounts because they know which goods and services to buy from the suppliers and manufacturers. It helps to learn where to get better deals than no deal at all.

2. Why we not want to Hold Inventories: Ordering, Holding, and Shortage Costs, even so inventory decisions involve a delicate balance between three classes of cost. These costs are:

- Ordering Cost – Cost of replenishing Inventory

- Carrying Cost – Cost of holding an item in inventory

- Shortage Cost – Temporary or permanent loss of sales when demand cannot be met.

Having inventory constantly at hand is good but sometimes there are hidden costs that would prove to be a menace for businesses. These costs include could cause:

- Longer lead times

- Reduce responsiveness

- Underlying problems are hidden rather than being exposed and solved
- Quality problems are not identified immediately
- No incentive for improvement of the process

Reorder Point

The **reorder point** (**ROP**) is the level of inventory which triggers an action to replenish that particular inventory stock. It is a minimum amount of an item which a firm holds in stock, such that, when stock falls to this amount, the item must be reordered. It is normally calculated as the forecast usage during the replenishment lead time plus safety stock. In the EOQ (Economic Order Quantity) model, it was assumed that there is no time lag between ordering and procuring of materials.

The reorder point for replenishment of stock occurs when the level of inventory drops down to zero. In view of instantaneous replenishment of stock the level of inventory jumps to the original level from zero level.

In real life situations one never encounters a zero lead time. There is always a time lag from the date of placing an order for material and the date on which materials are received. As a result the reorder point is always higher than zero, and if the firm places the order when the inventory reaches the reorder point, the new goods will arrive before the firm runs out of goods to sell. The decision on how much stock to hold is generally referred to as the order point problem, that is, how low should the inventory be depleted before it is reordered.

The two factors that determine the appropriate order point are the delivery time stock which is the Inventory needed during the

lead time (i.e., the difference between the order date and the receipt of the inventory ordered) and the safety stock which is the minimum level of inventory that is held as a protection against shortages due to fluctuations in demand.

Therefore:

Reorder Point = Normal consumption during lead-time + Safety Stock

Several factors determine how much delivery time stock and safety stock should be held. In summary, the efficiency of a replenishment system affects how much delivery time is needed. Since the delivery time stock is the expected inventory usage between ordering and receiving inventory, efficient replenishment of inventory would reduce the need for delivery time stock. And the determination of level of safety stock involves a basic trade-off between the risk of stock out, resulting in possible customer dissatisfaction and lost sales, and the increased costs associated with carrying additional inventory.

Safety Stock

Safety stock is a term used by logisticians to describe a level of extra stock that is maintained to mitigate risk of stock outs (shortfall in raw material or packaging) caused by uncertainties in supply and demand. Adequate safety stock levels permit business operations to proceed according to their plans. Safety stock is held when uncertainty exists in demand, supply, or manufacturing yield, and serves as an insurance against stock outs.

Safety stock is an additional quantity of an item held in the inventory to reduce the risk that the item will be out of stock. It acts as a buffer stock in case sales are greater than planned

and/or the supplier is unable to deliver the additional units at the expected time.

Lead Time

A **lead time** is the latency between the initiation and completion of a process. For example, the lead time between the placement of an order and delivery of new cars by a given manufacturer might be between 2 weeks and 6 months, depending on various particularities. One business dictionary defines "manufacturing lead time" as the total time required to manufacture an item, including order preparation time, queue time, setup time, run time, move time, inspection time, and put-away time. For make-to-order products, it is the time between release of an order and the production and shipment that fulfill that order. For make-to-stock products, it is the time taken from the release of an order to production and receipt into finished goods inventory.

Basic EOQ Model

The EOQ model provides a solution to the problem of determining when an order should be placed and how much should be ordered so as to minimize average annual variable costs. The basic approach to determining fixed order sizes are shown by the Economic Order Quantity (EOQ) models. The basic EOQ model is concerned primarily with the cost of ordering and the cost of holding inventory.

The basic assumptions in the model are as follows:

1. The rate of demand for the item is deterministic and is a constant ‘D’ units per annum independent of time.

2. Production rate is infinite, i.e., production is instantaneous.

3. Shortages are not allowed.

4. Lead time is zero or constant and it is independent of both demand as well as the quantity ordered.

5. The entire quantity is delivered as a single package (or produced in a single run).

The objective of the model is to minimize the average annual variable costs, and it provides a solution to the problem of determining when an order should be placed and how much should be ordered.

Inventory Classification Models

Because inventory policies affect profitability, the choice among policies depends upon their relative profitability. Some of the costs that determine this profitability are (1) the ordering costs, (2) holding costs, and (3) shortage costs. Other relevant factors include (4) revenues, (5) salvage costs, and (6) discount rates.

There are a number of other lot-sizing techniques available in addition to EOQ. These include the fixed-order quantity, fixed-order-interval model, the single-period model, and part-period balancing.

1. Fixed-Order-Quantity Model

EOQ is an example of the fixed-order-quantity model since the same quantity is ordered every time an order is placed. A firm might also use a fixed-order quantity when it is captive to packaging situations.

If you were to walk into an office supply store and ask to buy 22 paper clips, chances are you would walk out with 100 paper

clips. You were captive to the packaging requirements of paper clips, i.e., they come 100 to a box and you cannot purchase a partial box. It works the same way for other purchasing situations. A supplier may package their goods in certain quantities so that their customers must buy that quantity or a multiple of that quantity.

2. Fixed-Order-Interval Model

The fixed-order-interval model is used when orders have to be placed at fixed time intervals such as weekly, biweekly, or monthly. The lot size is dependent upon how much inventory is needed from the time of order until the next order must be placed (order cycle). This system requires periodic checks of inventory levels and is used by many retail firms such as drug stores and small grocery stores.

3. Single-Period Model

The single-period model is used in ordering perishables, such as food and flowers, and items with a limited life, such as newspapers. Unsold or unused goods are not typically carried over from one period to another and there may even be some disposal costs involved. This model tries to balance the cost of lost customer goodwill and opportunity cost that is incurred from not having enough inventory, with the cost of having excess inventory left at the end of a period.

4. Part-Period Balancing

Part-period balancing attempts to select the number of periods covered by the inventory order that will make total carrying costs as close as possible to the set-up/order cost.

When a proper lot size has been determined, utilizing one of the above techniques, the reorder point, or point at which an order should be placed, can be determined by the rate of demand and the lead time. If safety stock is necessary it would be added to the reorder point quantity.

Reorder point = Expected demand during lead time + Safety stock

Thus, an inventory item with a demand of 100 per month, a two-month lead time and a desired safety stock of two weeks would have reorder point of 250. In other words, an order would be placed whenever the inventory level for that good reached 250 units.

Reorder point = 100/month × 2 months + 2 weeks' safety stock = 250

Module V

Quality Control

Concept of Quality

Quality, as it is said, is not by chance but by intention. All successful companies value quality as a system in their manufacturing systems. It is on account of high quality that German cars, Swiss watches, Japanese electronics etc. have established global acceptance. Thus, it is imperative for all organizations to make systems for quality management and control. Let us now study the techniques and standards for quality control accepted globally.

"Quality is never by an accident, it is always the result of an intelligent effort". – John Ruskin

"Quality is never by an accident, it has always to be pre-planned". – Juran

The quest for efficiency is eternal to mankind. In industrial parlance, efficiency means maximising production of quality products at optimal cost. Quality has been defined in different ways by different persons, such as:

1. Degree of Excellence
2. Life of Product
3. Cost of Product
4. Fitness for use
5. Conformance to requirements

6. Customer's satisfaction

These need based definitions represent only certain facets of quality. The achievement of satisfactory quality involves all stages of the quality loop as a whole e.g.

1. Quality due to definition of needs (as defined above)

2. Quality due to product design

3. Quality due to conformance and product support throughout its life time.

Quality Loop

From this it is evident that quality cannot be built into the product during manufacturing alone and instead it has to be built into the product right from the stage of assessing the marketing conditions to design, procurement, manufacturing, sales and distribution and finally after-sales-service to the customer. The concept has led the industry to shift emphasis from Quality Control (QC) to Quality Assurance (QA) and ISO: 9000 System is the outcome of the quest of the industry to meet challenges of technology upgradation and ever increasing competition in the International market.

Quality Planning

The role of quality planning is to design a process that will be able to meet established goals under operating conditions.

Quality planning is a methodology which can be used when a situation exhibits one or more of the following characteristics:

- A service has never existed before.
- Customer requirements are not known.

- The existing service/process performance is not capable of meeting customer requirements.

- The service/process is ad hoc; extremely variable; never been well defined or worked on before as a whole.

- The environment is unstable, characterized by major market, technology or organizational change.

- Performance data does not exist or it would require excessive time/expense to collect data.

Quality Planning Tools and Techniques

Various tools and techniques are employed on each of these three major processes.

1. Cost-Benefit Analysis: The cost-benefit analysis is similar to a cost-benefit ratio. The costs and benefits are measured to analyze the trade-offs of providing quality.

2. Cost of Quality: Cost of quality (COQ) includes all the costs that conform to the required quality of the project, including the cost to ensure conformance to requirements as well as the cost of non-conformance, and finding the right balance. Modern quality management philosophy emphasizes preventing mistakes rather than detecting them later because the cost of non-conformance is very high.

3. Brainstorming is a technique for gathering information, where multiple unfiltered inputs and ideas are solicited and captured for later analysis and decision making.

4. Force field analysis (FFA) is a technique for analyzing ideas by grouping characteristics or factors that are for (pros) and against (cons) the idea.

5. Nominal group technique (NGT) is an enhancement of brainstorming that adds mechanisms for ranking ideas. It is based on the assumption that a nominal group (one that has agreed to work as a team) will produce better results than a group engaging in traditional brainstorming. NGT collects anonymous input from group members and encourages discussion of all input. Then each member prioritizes the input items. The items are further prioritized based on their cumulative score.

Meaning of Control

Control is a system for measuring and checking (inspecting) a phenomenon. It suggests when to inspect, how often to inspect and how much to inspect. In addition, it incorporates a feedback mechanism which explores the causes of poor quality and takes corrective action.

Control differs from 'inspection', as it ascertains quality characteristics of an item, compares the same with prescribed quality standards and separates defective items from non-defective ones. Inspection, however, does not involve any mechanism to take corrective action.

Meaning of Quality Control

Quality Control is a systematic control of various factors that affect the quality of the product. The various factors include material, tools, machines, type of labour, working conditions, measuring instruments, etc.,

Quality Control can be defined as the entire collection of activities which ensures that the operation will produce the optimum Quality products at minimum cost.

As per A.Y. Feigorbaum Total Quality Control is: “An effective system for integrating the quality development, Quality maintenance and Quality improvement efforts of the various groups in an organization, so as to enable production and services at the most economical levels which allow full customer satisfaction”.

In the words of Alford and Beatly, “Quality Control” may be broadly defined as that “Industrial management technique means of which products of uniform accepted quality are manufactured.” Quality Control is concerned with making things right rather than discovering and rejecting those made wrong.

In short, we can say that quality control is a technique of management for achieving required standards of products.

Objectives of Quality Control

- To decide about the standard of quality of a product that is easily acceptable to the customer and at the same time this standard should be economical to maintain.

- To take different measures to improve the standard of quality of product.

- To take various steps to solve any kind of deviations in the quality of the product during manufacturing.

Advantages of Quality Control

- Quality of product is improved which in turn increases sales.
- Scrap rejection and rework are minimized thus reducing wastage. So the cost of manufacturing reduces.
- Good quality product improves reputation.
- Inspection cost reduces to a great extent.
- Uniformity in quality can be achieved.
- Improvement in manufacturer and consumer relations.

Methods used to assure or to Control the Quality

Quality of a product can be assured by the following methods:

1. Inspection method

2. Statistical Quality Control Method

1. Inspection

Inspection is the process of examining an object for identification of verification in quality and quantity. It is an important tool for ascertaining and controlling the quality of product. Inspection is the art of applying tests, preferably by the aid of measuring appliances to observe whether a given item or product is within the specified limits of variability or not. According to Sprigel and Lansburg, 'Inspection is the process of measuring the qualities of a product or services in terms of established standards'.

Functions of Inspection

The following are some of the important functions of inspection:

(i) Maintenance of specified standards of the quality of products.

(ii) Developing means for conducting inspection at lower cost.

(iii) Maintaining inspection equipment in good condition.

(iv) Detection of defects at source to reduce defective work.

(v) Furnishing advice to Managers when production difficulties arise.

(vi) Reporting source of manufacturing troubles to management.

Essential Steps for Inspection

The following are the different steps involved in the process of inspection:

(i) Carefully define the characteristics of the items to be inspected.

(ii) To take decision regarding the time and place of conducting the inspection.

(iii) Take decision on total number of items to be inspected.

(iv) If sampling is employed, the sampling scheme for the selection of items from the lots should be selected.

(v) Specification limits for the acceptance and rejection of items should be formulated.

2. Statistical Quality Control

Using statistical techniques, S.Q.C. collects and analyses data in assessing and controlling product quality. The technique of S.Q.C. was though developed in 1924 by Dr. Walter A. Shewartan, American scientist; it got recognition in industry only second world war. The technique permits a more fundamental control.

"Statistical quality control can be simply defined as an economic & effective system of maintaining & improving the quality of outputs throughout the whole operating process of specification, production & inspection based on continuous testing with random samples." – YA LUN CHOU

"Statistical quality control should be viewed as a kit of tools which may influence decisions to the functions of specification, production or inspection". – EUGENE L. GRANT

Techniques of SQC

1. Quality Control during Production:

SQC brings to light the deviations outside these limits, i.e. the purpose of Statistical Quality Control is to discover and correct only those forces which are also responsible for variations outside the suitable pattern through SQC techniques.

While acceptance through sampling is used for controlling the materials input to the process, the process itself may be controlled by Statistical Sampling procedures i.e. by taking samples from the output of the process. The samples may be checked for:

- Their measurable characteristics such as length, diameter, hardness, tensile strength etc.,

- 'Fraction Defectives' "p", when the characteristics cannot or need not to be measured.

- Number of defects in the sample (c).

The Process is said to be within control if the sample points fall within the pre-established control limits. The crux of the Process Control lies in establishing the appropriate control limits. The charts showing these control limits are called 'Process Control Charts'.

2. Quality Assurance while Purchasing

Acceptance Sampling can be described as the post-mortem of the quality of the product that has already been produced. The term Acceptance Sampling 'relates to the acceptance of a consignment/batch of items on the basis of its quality.' It is used for:

- Acceptance/rejection of the raw-material delivered.

- Passing/non-passing of the batch of items manufactured.

- Shipment of items for delivery to customer.

If for instance from a consignment or a batch of 'N' items, a sample of size 'n' is taken, in which 'c' or less number of items are found defective, then the consignment or batch gets accepted if more than 'c' items are found defective, the entire consignment/batch is rejected.

Thus, the inference or decision regarding a large quantity (or population) of n items is made on the basis of a sample quantity (n).

Here (N, n, c) as a set, constitute the sampling plan, called Sampling Plan Attributes.

Importance or Benefits of SQC

The technique of SQC has become very popular since the days of World War II. In modern Industry it has become a necessity as it offers the following benefits:

1. It saves on rejection: In the absence of SQC technique, many products may be found defective and worthless at the manufacturing process and have to be thrown away as a scrap. SQC helps to avoid such a situation and thus saves the cost of labour & material involved in the production of defective items. SQC technique measures the extent of defect and certain defective products may be approved with reworking to the level of acceptable standards. It helps in deciding whether to do reworking or not and hence helps in reduction of loses due to unnecessary working.

2. It maintains high standards of quality: The SQC technique as described above (though Control Charts and Acceptance Sampling Techniques) helps in removing rejections and/ or by improving through reworking whether felt necessary and hence the outgoing standard is quite higher as compared to in the absence of SQC Technique. This increases the goodwill of the company which gives intangible benefits.

3. Reduces expenses of inspection: It reduces the expenses of as lot size to be inspected is very small as compared

to 100% inspection and thus enables the product to be manufactured at lower cost.

4. Ensures standard price: As the outgoing quality of the product is a standard/uniform, hence the producer is able to secure the standard price for all standard products. Thus, it increases the profitability of the concern.

5. Feeling of responsibility among the workers: Among the workers a feeling of responsibility develops because they begin to understand that their work is being inspected very minutely, hence they work carefully and it helps in increasing their morale.

6. Reduces monotony & unnecessary fatigue of inspection: As 100% inspection is very monotonous and is likely to cause unwillingness at the part of quality inspection, thus SQC which is a technique implying sampling/acceptance plans is not monotonous & hence helps in reducing their unwillingness & increasing degree of quality.

Mean (X-Bar) Chart

A mean control chart is often referred to as an x-bar chart. It is used to monitor changes in the mean of a process. To construct a mean chart we first need to construct the center line of the chart. To do this we take multiple samples and compute their means. Usually these samples are small, with about four or five observations. Each sample has its own mean. The center line of the chart is then computed as the mean of all sample means, where _ is the number of samples:

1. It shows changes in process average and is affected by changes in process variability.

2. It is a chart for the measure of central tendency.

3. It shows erratic or cyclic shifts in the process.

4. It detects steady progress changes, like tool wear.

5. It is the most commonly used variables chart.

6. When used along with R chart:

a. It tells when to leave the process alone and when to chase and go for the causes leading to variation;

b. It secures information in establishing or modifying processes, specifications or inspection procedures;

c. It controls the quality of incoming material.

7. X-Bar and R charts when used together form a powerful instrument for diagnosing quality problems

Range (R) Chart

These are another type of control chart for variables. Whereas x-bar charts measure shift in the central tendency of the process, range charts monitor the dispersion or variability of the process. The method for developing and using R-charts are the same as that for x-bar charts. The center line of the control chart is the average range, and the upper and lower control limits are computed. The R chart is used to monitor process variability when sample sizes are small ($n<10$), or to simplify the calculations made by process operators. This chart is called the R chart because the statistic being plotted is the sample range.

1. It controls general variability of the process and is affected by changes in process variability.

2. It is a chart for measure of spread.

3. It is generally used along with X-bar chart.

Seven Tools of Analysis

The first guru who proposed seven basic tools was Dr. Kaoru Ishikawa in 1968, by publishing a book entitled “Gemba no QC Shuho” that was concerned managing quality through techniques and practices for Japanese firms. It was intended to be applied for “self-study, training of employees by foremen or in QC reading groups in Japan. It is in this book that the seven basic quality control tools were first proposed.

The **seven basic tools of quality** is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality. They are called *basic* because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues.

The seven tools are:

1. Control chart

2. Pareto chart

3. Cause-and-effect diagram (also known as the "fishbone diagram" or Ishikawa diagram)

4. Histogram

5. Scatter diagram

6. Check sheet

7. Stratification (alternatively, flow chart or run chart)

Control Charts

A Control Chart is the graphical representation between the order of sampling along x-axis and statistics (functions of the observed values of the Variable) along y-axis.

The Central Line (CL) displays the standard line, and UCL and LCL display the Upper Control Limits and Lower Control Limits. These Control Limits (usually 11.7% of the values arising from Chance causes) are used to distinguish between the Chance causes and the Assignable causes of variation. The control charts are useful for operators and hence should be displayed at convenient positions.

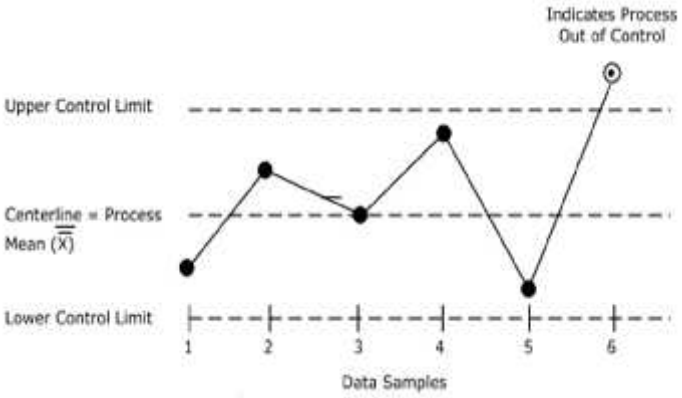

Figure 1 Control Chart

Maintenance and Usage of Control Charts

The samples are taken at regular suitable intervals and statistic plotted on a chart. If the point remains within the 'UCL and

LCL', the process is allowed to continue. The product so produced is called a good lot.

If there is evidence of lack of control, the process should be stopped, investigated, corrected and restarted. Till the process gets stabilised, keep these goods separately segregated for good and bad separately.

A point outside the control limit is an index of out of control situation whereas the pattern of points indicate the nature of action desired at any point of time.

Advantages of Control Charts

There are numerous advantages of the Control charts. The alphabets of the 'Control Charts' itself can be used to highlight the advantages of Control Charts:

C – Controls the process (at desired Economic levels).

O – Optimises technical resources (as it provides the information) as to take remedial action).

N – Narrows the heterogeneity (among units of a product).

T – Traces differences among Operators, Supervisors, Machines etc.,

R – Reduces cost of Inspection.

O – Overhauling and maintenance of machines, indicated whenever necessary.

L – Leads to the detection of inspection errors.

C – Creates quality consciousness.

H – Histories the process at a glance.

A – Acceptability of the product by consumer is enhanced.

R – Reduces waste of materials.

T – Trains the Operator and improves his skill.

S – Standardises the stage processes.

Check Sheets

Check sheets are simple forms with certain formats that can aid the user to record data in a firm systematically. Data are "collected and tabulated" on the check sheet to record the frequency of specific events during a data collection period. They prepare a "consistent, effective, and economical approach" that can be applied in the auditing of quality assurance for reviewing and to follow the steps in a particular process. Also, they help the user to arrange the data for the utilization later.

The main advantages of check sheets are to be very easily to apply and understand, and it can make a clear picture of the situation and condition of the organization. They are efficient and powerful tools to identify frequently problems, but they don't have effective ability to analyze the quality problem into the workplace. The check sheets are in several, three major types are such as Defect-location check sheets; tally check sheets, and; defect-cause check sheets.

Defect	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Solder	I	II		I		4
Part	II		I	II	I	6
Not-to-Print	III	II	I	III	II	11
Timing		I	I		I	3
Other		I				1

Figure. 2 Checklist for Detects Found

Figure 2 shows a checklist used to determine the causes of defects in a hypothetical assembly process. It indicates that "not-to-print" is the biggest cause of defects, and hence, a good subject for improvement. Checklist items should be selected to be mutually exclusive and to cover all reasonable categories. If too many checks are made in the "other" category, a new set of categories is needed.

Figure 2 could also be used to relate the number of defects to the day of the week to see if there is any significant difference in the number of defects between workdays. Other possible column or row entries could be production line, shift, product type, machine used, operator, etc., depending on what factors are considered useful to examine. So long as each factor can be considered mutually exclusive, the chart can provide useful data. An Ishikwa Diagram may be helpful in selecting factors to consider. The data gathered in a checklist can be used as input to a Pareto chart for ease of analysis. Note that the data does not directly provide solutions. Knowing that "not-to-print" is the biggest cause of defects only starts the search for the root cause of "not- to-print" situations. (This is in contrast to the design of experiments which could yield the optimal settings for controllable process settings such as temperature and wave height.)

Pareto Diagram

It introduced by an Italian economist, named Vilfredo Pareto, who worked with income and other unequal distributions in 19th century, he noticed that 80% of the wealth was owned by only 20% of the population. Later, Pareto principle was developed by Juran in 1950. A Pareto chart is a special type of histogram that can easily be apply to find and prioritize quality problems, conditions, or their causes of in the organization (Juran and

Godfrey, 1998). On the other hand, it is a type of bar chart that shows the relative importance of variables, prioritized in descending order from left to right side of the chart. The aim of Pareto chart is to figure out the different kind of "nonconformity" from data figures, maintenance data, repair data, parts scrap rates, or other sources. Also, Pareto chart can generate a mean for investigating concerning quality improvement, and improving efficiency, "material waste, energy conservation, safety issues, cost reductions", etc.,

Pareto Diagram is a tool that arranges items in the order of the magnitude of their contribution, thereby identifying a few items exerting maximum influence. This tool is used in SPC and quality improvement for prioritizing projects for improvement, prioritising setting up of corrective action teams to solve problems, identifying products on which most complaints are received, identifying the nature of complaints occurring most often, identifying most frequent causes for rejections or for other similar purposes.

Procedure:

The steps in the preparation of a Pareto Diagram are:

1. From the available data calculate the contribution of each individual item.

2. Arrange the items in descending order of their individual contributions. If there are too many items contributing a small percentage of the contribution, group them together as "others". It is obvious that "others" will contribute more than a few single individual items. Still it is kept last in the new order of items.

3. Tabulate the items, their contributions in absolute number as well as in percent of total and cumulative contribution of the items.

4. Draw X and Y axes. Various items are represented on the X-axis. Unlike other graphs Pareto Diagrams have two Y-axes - one on the left representing numbers and the one on right representing the percent contributions. The scale for X-axis is selected in such a manner that all the items including others are accommodated between the two Y-axes. The scales for the Y-axes are so selected that the total number of items on the left side and 100% on the right side occupy the same height.

5. Draw bars representing the contributions of each item.

6. Plot points for cumulative contributions at the end of each item. A simple way to do this is to draw the bars for the second and each subsequent item at their normal place on the X-axis as well as at a level where the previous bar ends. This bar at the higher level is drawn in dotted lines. Drawing the second bar is not normally recommended in the texts.

7. Connect the points. If additional bars as suggested in step 6 are drawn this becomes simple. All one needs to do is - connect the diagonals of the bars to the origin. 8. The chart is now ready for interpretation. The slope of the chart suddenly changes at some point. This point separates the 'vital few' from the 'useful many' like the A, B and C class items in materials management.

Figure 3 shows the data from the checklist shown in Figure 2 organized into a Pareto chart.

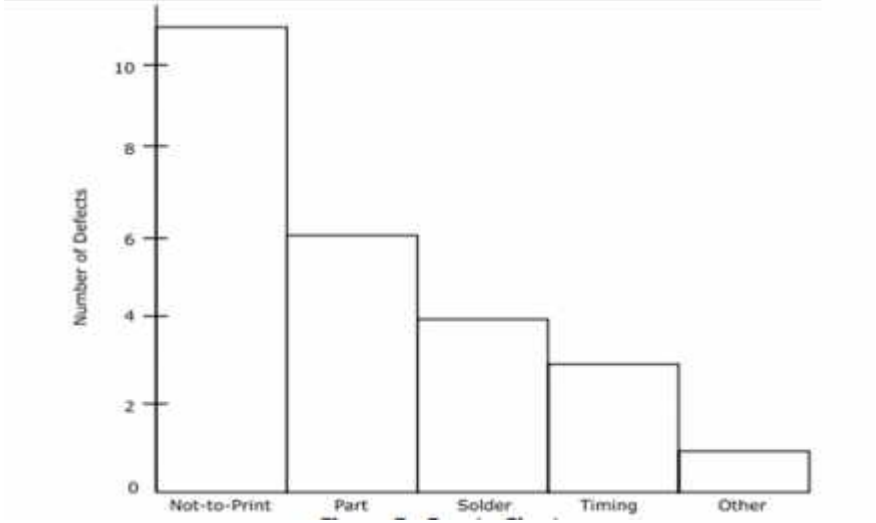

Figure 3 – Pareto Chart

Figure 3, like Figure 2, shows the "not-to-print" category as the chief cause of defects. However, suppose the not-to-print problems could be cheaply corrected (e.g., by resoldering a mis-routed wire) while a defect due to "timing" was too expensive to fix and resulted in a scrapped assembly. It may then be useful to analyze the data in terms of the cost incurred rather than the number of instances of each defect category. This might result in the chart shown in Figure 4, which would indicate eliminating the timing problems to be most fruitful.

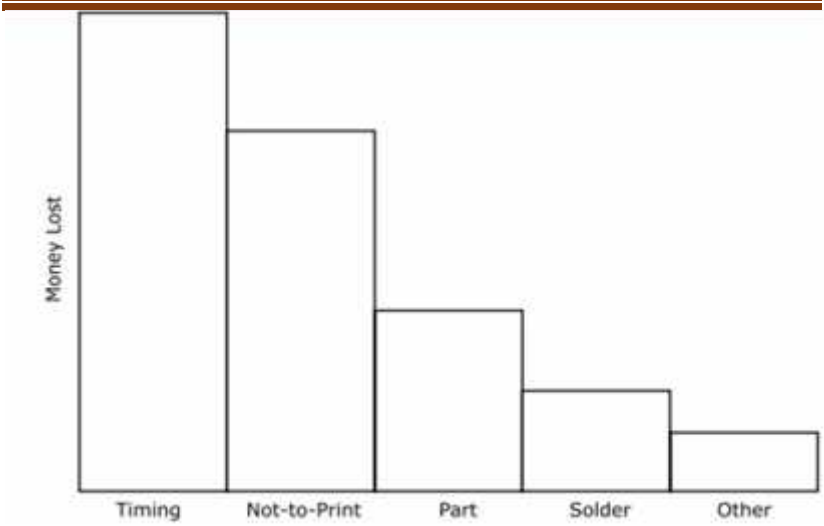

Figure 4 – Pareto Chart of Costs of Defects

Stratification

A technique that separates data gathered from a variety of sources so that patterns can be seen (some lists replace stratification with flowchart or run chart). Stratification is defined as the act of sorting data, people, and objects into distinct groups or layers. It is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be difficult to see. This data collection and analysis technique separates the data so that patterns can be seen and is considered one of the seven basic quality tools.

Stratification Procedure

1. Before collecting data, consider which information about the sources of the data might have an effect on the results.

Set up the data collection so that you collect that information as well.

2. When plotting or graphing the collected data on a scatter diagram, control chart, histogram, or other analysis tool, use different marks or colours to distinguish data from various sources. Data that are distinguished in this way are said to be "stratified."

3. Analyze the subsets of stratified data separately. For example, on a scatter diagram where data are stratified into data from source 1 and data from source 2, draw quadrants, count points, and determine the critical value only for the data from source 1, then only for the data from source 2.

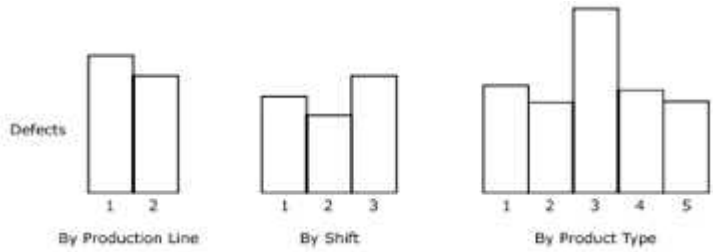

Figure 5 – Stratification

Stratification is simply the creation of a set of Pareto charts for the same data, using different possible causative factors. For example, Figure 5 plots defects against three possible sets of potential causes. The figure shows that there is no significant difference in defects between production lines or shifts, but product type three has significantly more defects than do the others. Finding the reason for this difference in number of defects could be worthwhile.

Ishikawa Diagram

Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Fishikawa) are causal diagrams created by Kaoru Ishikawa that show the potential causes of a specific event. Common uses of the Ishikawa diagram are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify and classify these sources of variation.

They are also called fishbone charts, after their appearance, or cause and effect diagrams after their function. Their function is to identify the factors that are causing an undesired effect (e.g., defects) for improvement action, or to identify the factors needed to bring about a desired result (e.g., a winning proposal). The factors are identified by people familiar with the process involved. As a starting point, major factors could be designated using the "four M's": Method, Manpower, Material, and Machinery; or the "four P's": Policies, Procedures, People, and Plant. Factors can be subdivided, if useful, and the identification of significant factors is often a prelude to the statistical design of experiments. Figure 6 is a partially completed Ishikawa diagram attempting to identify potential causes of defects in a wave solder process.

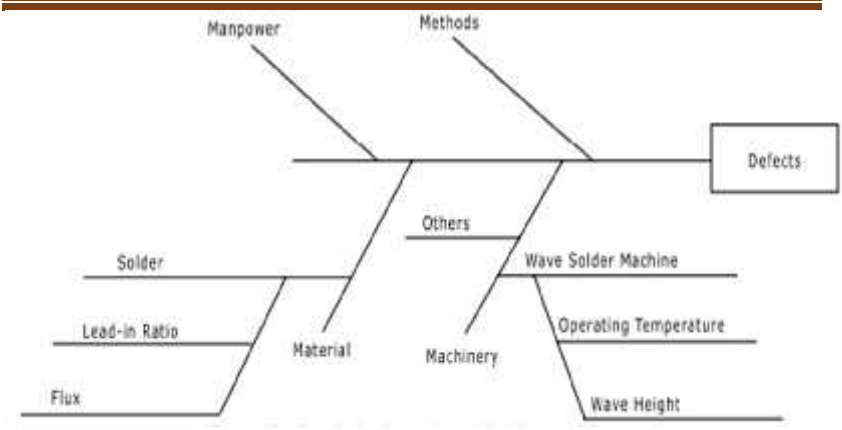

Figure 6 – Partially Completed Ishikawa Diagram

Procedure:

The steps in the procedure to prepare a cause-and-effect diagram are:

1. Agree on the definition of the 'Effect' for which causes are to be found. Place the effect in the dark box at the right. Draw the spine or the backbone as a dark line leading to the box for the effect.

2. Determine the main groups or categories of causes. Place them in boxes and connect them through large bones to the backbone.

3. Brainstorm to find possible causes and subsidiary causes under each of the main groups. Make sure that the route from the cause to the effect is correctly depicted. The path must start from a root cause and end in the effect.

4. After completing all the main groups, brainstorm for more causes that may have escaped earlier.

5. Once the diagram is complete, discuss relative importance of the causes. Short list the important root causes.

Advantages

- Highly visual brainstorming tool which can spark further examples of root causes
- Quickly identify if the root cause is found multiple times in the same or different causal tree
- Allows one to see all causes simultaneously
- Good visualization for presenting issues to stakeholders

Disadvantages

- Complex defects might yield a lot of causes which might become visually cluttering
- Interrelationships between causes are not easily identifiable.

Histogram

Histograms or Frequency Distribution Diagrams are bar charts showing the distribution pattern of observations grouped in convenient class intervals and arranged in order of magnitude. Histograms are useful in studying patterns of distribution and in drawing conclusions about the process based on the pattern.

For example, in Figure 7, X could represent the length of a rod in inches. The figure shows that most rods measure between 0.9 and 1.1 inches. If the target value is 1.0 inches, this could be good news. However, the chart also shows a wide variance,

with the measured values falling between 0.5 and 1.5 inches. This wide a range is generally a most unsatisfactory situation.

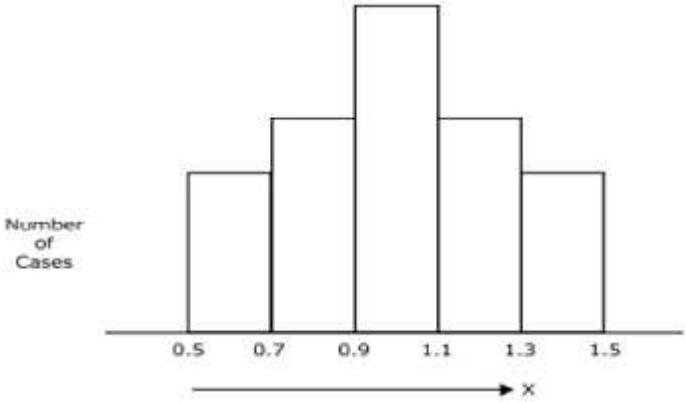

Figure 7 – Histogram

Besides the central tendency and spread of the data, the shape of the histogram can also be of interest. For example, Figure 8 shows a bi-modal distribution. This indicates that the measurements are not from a homogeneous process, since there are two peaks indicating two central tendencies. There are two (or more) factors that are not in harmony. These could be two machines, two shifts, or the mixed outputs of two suppliers. Since at least one of the peaks must be off target, there is evidence here that improvements can be made.

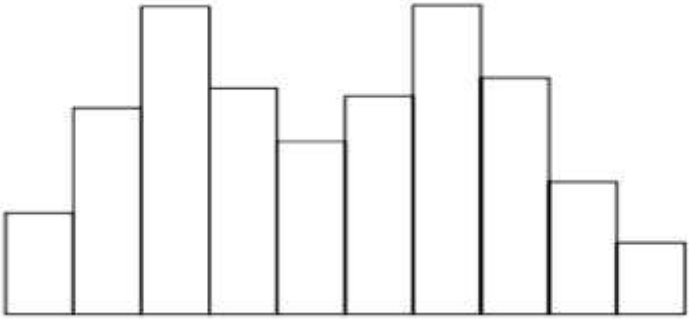

Figure 8 – Bi-modal Histogram

In contrast, the histogram of Figure 9 shows a situation in which the spread of measurements is lower on one side of the central tendency than on the other. These could be measurements of miles per gallon attained by an automobile. There are many situations that decrease fuel economy, such as engine settings, tire condition, bad weather, traffic jams, etc., but few situations that can significantly improve it. The wider variance can be attacked by optimizing any of the controllable factors such as tuning the engine, replacing the tires used, etc. Moving the central tendency in the direction of the smaller variance is unlikely unless the process is radically changed (e.g., reducing the weight of the vehicle, installing a new engine, etc.).

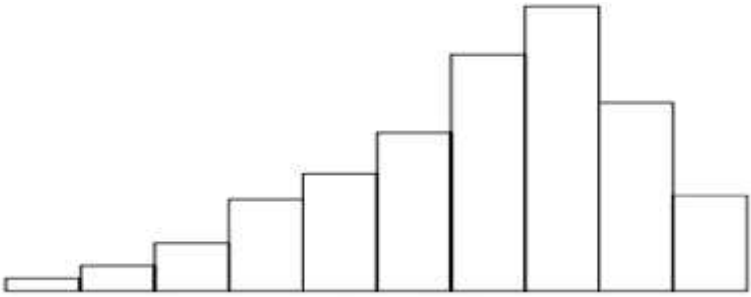

Figure 9 – Skewed Histogram

Procedure:

The Procedure to prepare a Histogram consists of the following steps:

1. Collect data (preferably 50 or more observations of an item).

2. Arrange all values in an ascending order.

3. Divide the entire range of values into a convenient number of groups each representing an equal class interval. It is customary to have number of groups equal to or less than the square root of the number of observations. However one should not be too rigid about this. The reason for this cautionary note will be obvious when we see some examples.

4. Note the number of observations or frequency in each group.

5. Draw X-axis and Y-axis and decide appropriate scales for the groups on X-axis and the number of observations or the frequency on Y-axis.

6. Draw bars representing the frequency for each of the groups.

7. Provide a suitable title to the Histogram.

8. Study the pattern of distribution and draw conclusion

Flow Charts

Flowchart presents a diagrammatic picture that indicates a series of symbols to describe the sequence of steps exist in an operation or process. On the other hand, a flowchart visualize a picture including the inputs, activities, decision points, and outputs for using and understanding easily concerning the overall objective through process. This chart as a problem

solving tool can apply methodically to detect and analyze the areas or points of process may have had potential problems by "documenting" and explaining an operation, so it is very useful to find and improve quality into process.

Figure 10 shows the flow chart for a hypothetical technical report review process. Measurements could be taken at each step to find the most significant causes of delays, these may then be flagged for improvement.

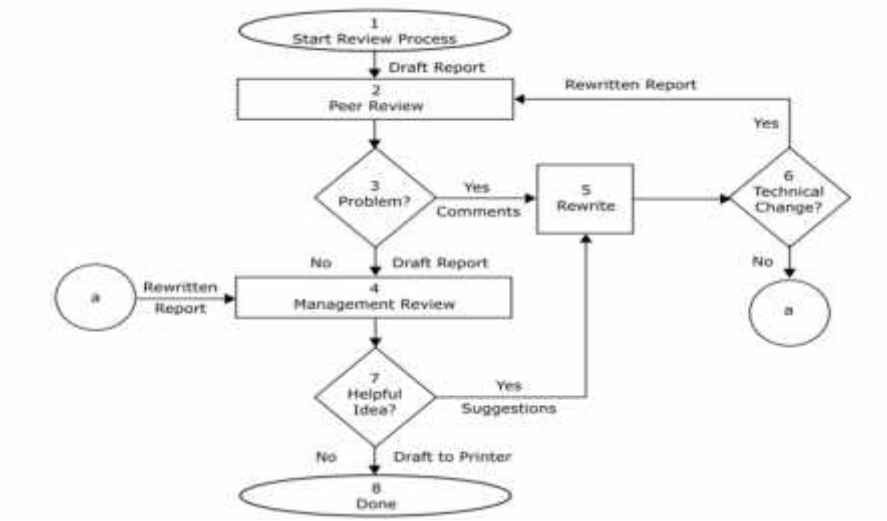

Figure 10 – Flow Chart of Review Process

In making a flow chart, the process owner often finds the actual process to be quite different than it was thought to be. Often, non-value-added steps become obvious and eliminating these provides an easy way to improve the process. When the process flow is satisfactory, each step becomes a potential target for improvement. Priorities are set by measurements. In Figure 10, the average time to complete peer review (get from Step 2 to

Step 4) and to complete management review (get from Step 4 to Step 8) may be used to decide if further analysis to formulate corrective action is warranted. It may be necessary to expand some steps into their own flow charts to better understand them.

For example, if we have an unsatisfactory amount of time spent in management review we might expand Step 4 as shown in Figure 11.

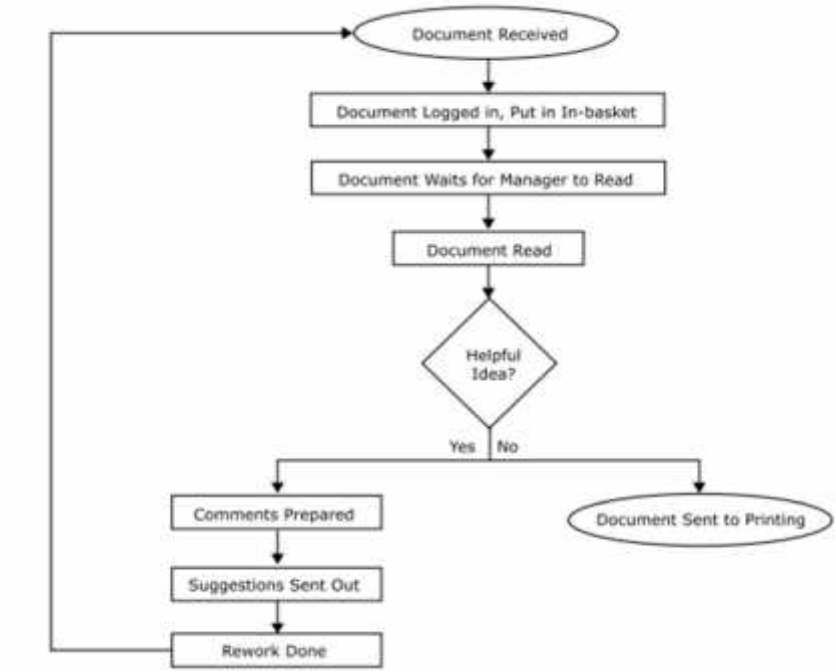

Figure 11 – Flow Chart of Management Review

Figure 11 shows many possibilities for delay in management review. It may be that it takes too long for the manager to get around to reading the document. Or, too much time may be consumed in rework to address the comments of the manager.

Only some more measurements will tell. Corrective actions to the former may include the delegation of review authority. Training the technical writers to avoid the most frequent complaints of the managers could possibly cure the latter. It may also be found that the manager feels obligated to make some comment on each report he reviews, and changing this perception may be helpful. Whatever the solution, information provided by the flow chart would point the way.

A danger in flow charting is the use of assumed or desired steps rather than actual process steps in making the chart. The utility of the chart will correlate directly to its accuracy. Another danger is that the steps plotted may not be under the control of the user. If the analyst does not "own the process" the chart may not be too helpful. It may, however, be quite useful to a process improvement team including all the functions involved.

Scatter Diagram

When solving a problem or analysing a situation one needs to know the relationship between two variables. A relationship may or may not exist between two variables. If a relationship exists, it may be positive or negative, it may be strong or weak and may be simple or complex.

A tool to study the relationship between two variables is known as Scatter Diagram. It consists of plotting a series of points representing several observations on a graph in which one variable is on X-axis and the other variable in on Y-axis. If more than one set of values are identical, requiring more points at the same spot, a small circle is drawn around the original dot to indicate second point with the same values. The way the points lie scattered in the quadrant gives a good indication of the relationship between the two variables.

Figure 12 shows a plot of defect rate vs. temperature with a strong positive correlation, while Figure 13 shows a weak negative correlation.

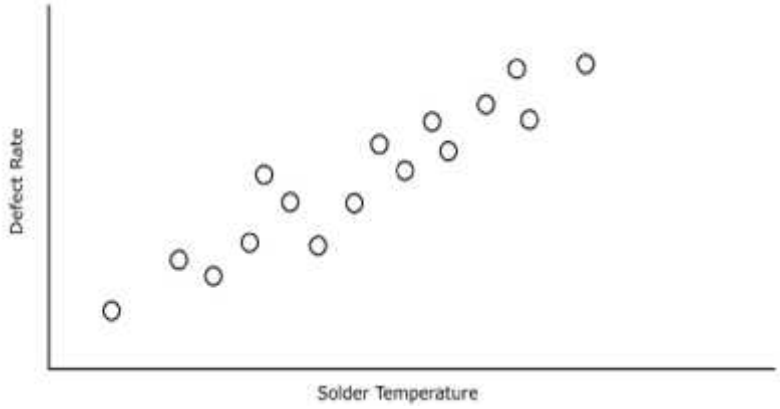

Figure 11 – Scatter Diagram Showing Strong Correlation

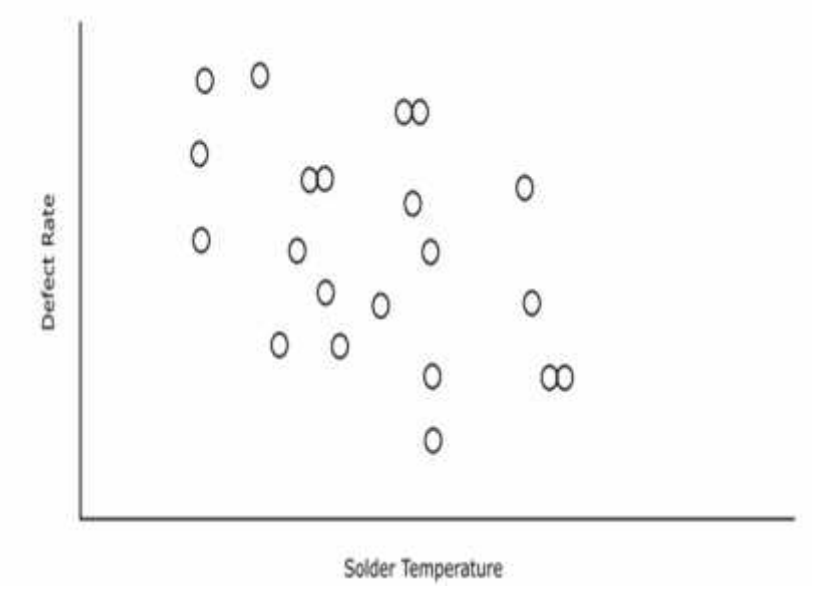

Figure 13 – Scatter Diagram Showing Weak Correlation

It should be noted that the slope of a line drawn through the center of the cloud is an artifacts of the scales used and hence not a measure of the strength of the correlation. Unfortunately, the scales used also affect the width of the cloud, which is the indicator of correlation. When there is a question on the strength of the correlation between the two parameters, a correlation coefficient can be calculated. This will give a rigorous statistical measure of the correlation ranging from -1.0 (perfect negative correlation), through zero (no correlation) to +1.0 (perfect correlation).

Concept of Quality Circle

Quality circle may be defined as a small group of workers (5 to 10) who do the same work voluntarily meeting together regularly during their normal working time usually under the leadership of their own supervisor to identify, analyze and solve work related problems. This group presents the solution to the management and wherever possible implement the solution themselves. The QC concept was first originated in Japan in 1960. The basic cycle of a quality circle starts from identification of problem.

Philosophical Basis of QC

1. A belief that people will take pride and interest in their work if they get autonomy and take part in decision making.

2. It develops a sense of belongingness in the employees towards a particular organization.

3. A belief that each employee desires to participate in making the organization a better place.

4. It is a mean/method for the development of human resources through the process of training, work experience and participation in problem solving.

5. A willingness to allow people to volunteer their time and effort for improvement of performance of organization.

6. The importance of each member's role in meeting organizational goal.

Characteristics of Quality Circle

1. QCs are small primary groups of employees/workers whose lower limit is 3 and upper limit is 12.

2. Membership is voluntary. The interested employees in some areas may come together to form a quality circle.

3. Each quality circle is led by area supervisor.

4. The members meet regularly every week/ as per agreeable schedule.

5. The QC members are specially trained in technique of analysis and problem solving in order to play their role efficiently.

6. The basic role of quality circle is to identify work related problems for improving quality and productivity.

7. QC enables the members to exercise their hidden talents, creative skills, etc.

8. It promotes the mutual development of their member through cooperative participation.

9. It gives job satisfaction because of identifying and solving challenging problems while performing the job.

10. It provides their member with opportunities for receiving public recognition from the company's management.

11. The members also receive recognition in the form of memento, certificate and privileges.

12. It also contributes to their self-esteem and self-confidence through acceptance of their recommendation by the management.

Objectives of Quality Circle

1. To improve the quality and productivity.

2. To reduce the cost of products/ services by waste reduction, effective utilization of resources eliminating error/ defects.

3. To utilize the hidden creative intelligence of the employees.

4. To identify and solve work related problems.

5. To motivate people for solving challenging tasks.

6. To improve communication within the organization.

7. To increase employee's loyalty and commitment to organizational goals.

8. To enrich human capability, confidence, morale, attitude and relationship.

9. To pay respect to humanity and create a happy bright workplace.

10. To satisfy the human needs of recognition and self-development.

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