II UNIT
PRODUCT DESIGN

Importance of Product Design

(i) As products are designed, all the detailed characteristics of each product are established.

(ii) Each product characteristic directly affects how the product can be made or produced (i.e., process technology and process design) and

(iii) How the product is made determines the design of the production system (production design) which is the heart of production and operations strategy.

Further, product design directly affects product quality, production costs and customer satisfaction. Hence, the design of product is crucial to success in today's global competition.

A good product design can improve the marketability of a product by making it easier to operate or use, upgrading its quality, improving its appearance, and/or reducing manufacturing costs.

A distinctive design may be the only feature that significantly differentiates a product. An excellent design includes usability, aesthetics, reliability, functionality, innovation and appropriateness. An **excellent design** provides competitive advantage to the manufacturer, by ensuring appropriate quality, reasonable cost and the expected product features. Firms of tomorrow will definitely compete not on price and quality, but on product design.

Product Design and Analysis

- **Design for Function:** A product must perform the function which its customer expects it to do. If a product is designed by taking its functional features into account, then it will create satisfied customers, and will further lead to having more repeat customers. The factors which are to be considered for functional design are strength and wear-ability of the product and its components
- **Design for Making:** A product design that solves the functional problem smoothly, but is impossible to manufacture, is of no use. Attention must be given to materials, fastening devices etc., while designing a product. The hardness of the material specified at the design stage must be within the permitted range while machining. In some intricate design, to join components, we may require small size fasteners. If these are not available in the market, then the design may become infeasible at the manufacturing stage. Making use of standard parts is an important aspect of product design. Also, operational convenience of the machineries must be taken into account at the design stage.
- **Design for Selling**: A product that functions well and is easy to make, but is wanted by no one is of no avail. It makes no difference whether the product is pen or a CNC machine; it has to sell itself to the customers. The features like, appearance and convenience, depending on the customers_ needs are to be considered.

(i) Translating customer needs and wants into product and service requirements (marketing).

(ii) Refining existing products (marketing).

(iii) Developing new products (marketing, product design and production).

(iv) Formulating quality goals (quality assurance, production).

(v) Formulating cost targets (accounting).

(vi) Constructing and testing prototype (marketing, production).

(vii) Documenting specifications (product design).

Reasons for Product Design or Redesign

The most obvious reason for product design is to offer new products to remain competitive in the market. The second most important reason is to make the business grow and increase profits. Also, when productivity gains result in reduction of workforce, developing new products can mean adding jobs and retaining surplus workforce instead of downsizing by layoffs/ retrenchment.

Objectives of Product Design

(i) The overall objective is profit generation in the long run.

(ii) To achieve the desired product quality.

(iii) To reduce the development time and cost to the minimum.

(iv) To reduce the cost of the product.

(v) To ensure producibility or manufacturability (design for manufacturing and assembly).

Factors Influencing Product Design

(i) Customer requirements: The designers must find out the exact requirements of the customers to ensure that the products suit the convenience of customers for use. The products must be designed to be used in all kinds of conditions.

(ii) Convenience of the operator or user: The industrial products such as machines and tools should be so designed that they are convenient and comfortable to operate or use.

(iii) Trade off between function and form: The design should combine both performance and aesthetics or appearance with a proper balance between the two.

(iv) Types of materials used: Discovery of new and better materials can improve the product design. Designers keep in touch with the latest developments taking place in the field of materials and components and make use of improved materials and components in their product designs.

(v) Work methods and equipments: Designers must keep abreast of improvements in work methods, processes and equipments and design the products to make use of the latest technology and manufacturing processes to achieve reduction in costs.

(vi) Cost/Price ratio: In a competitive market, there is lot of pressure on designers to design products which are cost effective because cost and quality are inbuilt in the design. With a constraint on the upper limit on cost of producing products, the designer must ensure cost effective designs.

(vii) Product quality: The product quality partly depends on quality of design and partly on quality of conformance. The quality policy of the firm provides the necessary guidelines for the designers regarding the extent to which quality should be built in the design stage itself by deciding the appropriate design specifications and tolerances.

(viii) Process capability: The product design should take into consideration the quality of conformance, i.e., the degree to which quality of design is achieved in manufacturing. This depends on the process capability of the machines and equipments. However, the designer should have the knowledge of the capability of the manufacturing facilities and specify tolerances which can be achieved by the available machines and equipments.

(ix) Effect on existing products: New product designs while replacing existing product designs, must take into consideration the use of standard parts and components, existing manufacturing and distribution strategies and blending of new manufacturing technology with the existing one so that the costs of implementing the changes are kept to, the minimum.

(x) Packaging: Packaging is an essential part of a product and packaging design and product design go hand in hand with equal importance. Packaging design must take into account the objectives of packaging such as protection and promotion of the product. Attractive packaging enhances the sales appeal of products in case of consumer products (nondurable).

CHARACTERISTICS OF GOOD PRODUCT DESIGN

A good product design must ensure the following:

(i) Function or performance: The function or performance is what the customer expects the product to do to solve his/her problem or offer certain benefits leading to satisfaction. For example, a customer for a motor bike expects the bike to start with a few kicks on the kick peddle and also expects some other functional aspects such as pick-up, maximum speed, engine power and fuel consumption etc.

(ii) Appearance or aesthetics: This includes the style, colour, look, feel, etc. which appeals to the human sense and adds value to the product.

(iii) Reliability: This refers to the length of time a product can be used before it fails. In other words, reliability is the probability that a product will function for a specific time period without failure.

(iv) Maintainability: Refers to the restoration of a product once it has failed. High degree of maintainability is desired so that the product can be restored (repaired) to be used within a short time after it breaks down. This is also known as serviceability.

(v) Availability: This refers to the continuity of service to the customer. A product is available for use when it is in an operational state. Availability is a combination of reliability and maintainability. High reliability and maintainability ensures high availability.

(vi) Productibility: This refers to the ease of manufacture with minimum cost (economic production). This is ensured in product design by proper specification of tolerances, use of materials that can be easily processed and also use of economical processes and equipments to produce the product quickly and at a cheaper cost.

(vii) Simplification: This refers to the elimination of the complex features so that the intended function is performed with reduced costs, higher quality or more customer satisfaction. A simplified design has fewer parts which can be manufactured and assembled with less time and cost. “

(viii) Standardisation: Refers to the design activity that reduces variety among a group of products or parts. For example, group technology items have standardised design which calls for similar manufacturing process steps to be followed. Standard designs lead to variety reduction and results in economies of scale due to high volume of production of standard products. However, standardised designs may lead to reduced choices for customers.

(ix) Specification: A specification is a detailed description of a material, part or product, including physical measures such as dimensions, volume, weight, surface finish etc. These specifications indicate tolerances on physical measures which provide production department with precise information about the characteristics of products to be produced and the processes and production equipments to be used to achieve the specified tolerances (acceptable variations).

(x) Safety: The product must be safe to the user and should not cause any accident while using or should not cause any health hazard to the user. Safety in storage, handling and usage must be ensured by the designer and a proper package has to be provided to avoid damage during transportation and storage of the product. For example, a pharmaceutical product while used by the patient, should not cause some other side effect threatening the user

PROCESS DESIGN

Process Design physical measures such as dimensions, volume, weight, surface finish etc. These specifications indicate tolerances on physical measures which provide production department with precise information about the characteristics of products to be produced and the processes and production equipments to be used to achieve the specified tolerances (acceptable variations).

Interchangeability of parts in products produced in large volumes (mass production and flow-line production) is provided by appropriate specification of tolerances to facilitate the desired fit between parts which are assembled together.

.

is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations to be used, the machines and equipments necessary to carry out the operations. The sequence of operations are determined by (a) the nature of the product, (b) the materials used, (c) the quantities to be produced and (d) the existing physical layout of the plant.

The process design is concerned with the following Characteristic:

(i) Characteristics of the product or service offered to the customers.

(ii) Expected volume of output.

(iii) Kinds of equipments and machines available in the firm.

(iv) Whether equipments and machines should be of special purpose or general purpose.

(v) Cost of equipments and machines needed.

(vi) Kind of labour skills available, amount of labour available and their wage rates.

(vii) Expenditure to be incurred for manufacturing processes.

(viii) Whether the process should be capital-intensive or labour-intensive.

(ix) Make or buy decision.

(x) Method of handling materials economically.

PROCESS PLANNING

Process planning refers to the way production of goods or services is organised. It is the basis for decisions regarding capacity planning, facilities (or plant) layout, equipments and design of work systems. Process selection is necessary when a firm takes up production of new products or services to be offered to the customers.

Three primary questions to be addressed before deciding on process selection are:

(i) How much variety of products or services will the system need to handle?

(ii) What degree of equipment flexibility will be needed?

(iii) What is the expected volume of output?

Process Strategy

A **process strategy** is an organisation’s approach to process selection for the purpose of transforming resource inputs into goods and services (outputs). The objective of a process strategy is to find a way to produce goods and services that meet customer requirement and product specification (i.e., design specifications) within the constraints of cost and other managerial limitations. The process selected will have a long-term effect on efficiency and production as well as flexibility, cost, and quality of the goods produced. Hence it is necessary that a firm has a sound process strategy at the time of selecting the process.

Key aspects in process strategy include:

(i) Make or buy decisions

(ii) Capital intensity and

(iii) Process flexibility

Make or buy decisions refer to the extent to which a firm will produce goods or provide services in-house or go for outsourcing (buying or subcontracting).

Capital intensity refers to the mix of equipment and labour which will be used by the firm

Process Flexibility refers to the degree to which the system can be adjusted to changes in processing requirements due to such factors as changes in product or service design, changes in volume of products produced and changes in technology.

Three process strategies: Virtually every good or service is made by using some variation of one of three process strategies. They are: **(i) process focus (ii) repetitive focus and (iii) product focus.**

Exhibit 1 illustrates the relationship between the three process strategies and volume and variety of products produced.

Each of these three strategies are discussed below:

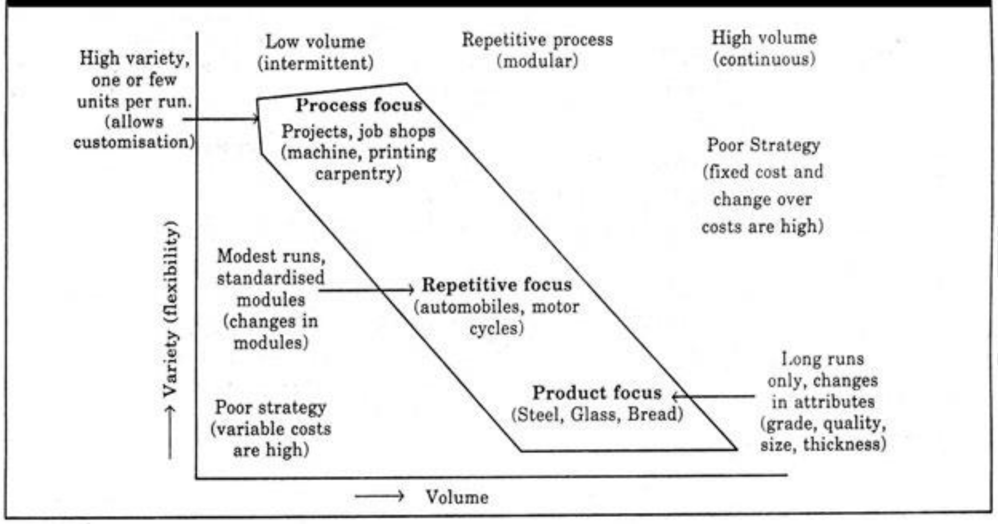
(i) Process Focus: Majority (about 75 per cent) of global production is devoted to low volume, high variety products in manufacturing facilities called job shops. Such facilities are organised around performing processes. For example, the processes might be welding, grinding or painting carried out in departments devoted to these processes. Such facilities are **process focussed** in terms of equipment, machines, layout and supervision. They provide a high degree of product flexibility as products move intermittently between processes. Each process is designed to perform a wide variety of activities and handle frequent changes. Such processes are called **intermittent processes**. These facilities have high variable costs and low utilisation of facilities.

(ii) Repetitive Focus: A repetitive process is a product oriented production process that uses modules. It falls between product focus and process focus. It uses modules which are parts or components prepared often in a continuous or mass production process.

A good example of repetitive process is the **assembly line** which is used for assembling automobiles and household appliances and is less flexible than process-focused facility. Personal computer is an example of a repetitive process using modules in which the modules are assembled to get a custom product with the desired configuration.

(iii) Product Focus: It is a facility organised around products, a product oriented, high-volume low-variety process. It is also referred to as **continuous process** because it has very long continuous production run. Examples of product focussed processes are steel, glass, paper, electric bulbs, chemicals and pharmaceutical products, bolts and nuts etc. Product-focussed facilities need standardisation and effective quality control. The specialised nature of the facility requires high fixed cost, but low variable costs reward high facility utilisation.

Exhibit 1 : Process Selected Must Fit with Volume and Variety



PRODUCT LIFE CYCLE

Products, like men, are mortal. They flourish for a time, then decline and die. The life cycle of a product has many points of similarity with the human life cycle. A product is born, grows lustily, attains a dynamic maturity, then enters its declining years. Like a human being a product that has not built up its potential during its formative years is likely to be relatively unsuccessful on its maturity. But, there are critical differences between the product and the human life cycle. For instance, every person has an average life expectancy. But the life expected of a product varies widely.

The concept of product failure is applicable both to new products and the existing ones. There may, however, be varying periods of life spans for each product: some failing immediately, other living for a longer period. The product, thus, has "life cycles" just as human beings have. From its birth, a product passes through various stages, until it is finally abandoned, *i*. e.. discontinued from the market. These stages taken together are referred, to as "the product life cycle". This life cycle of the product comprises of four stages: Introduction, Growth, Maturity and Decline. It should be noted that it is purely a theoretical concept.

The **introduction stage** is preceded by 'production planning and development'.This period requires greater investment. This investment should be gradually recouped as the sales pick up. The concept of life cycle would give the management an idea as to the time within which the original investment could be recouped.

After testing, a product enters the introduction stage and the product will then become available in the national market. Sales would begin gradually as potential buyers come to know about the product through advertising and other seIIing techniques. But the profits will be low as part of the investment is to be recouped besides heavy expenditure on selling.

In the **growth stage**, both sales and profits will begin to increase. It is here that similar other new products begin to appear in the market as substitutes and offer competition. The management, therefore, should try to change its approach by changing its strategy from "buy my product" to "try my product". At the end of this stage, the distribution arrangement is likely to get completed and the prices, if necessary, are reduced a little.

The third stage is the **maturity stage**. During this stage the manufacturers introduce new models or adopt methods such as trading-in, etc., to promote the sale of their brands with a view to retaining their position in the market. The number of buyers will continue to grow, but more slowly. In economic terms this is the stage where supply exceeds demand. Some of the promotional efforts may lengthen the span of this stage but they will not offer a permanent solution.

At the final stage of **decline**, profit margins touch a low level, competition becomes severe and customers start using newer and better products. It is here that the story of a product ends-a natrural but hard end.

The above discussion concentrates only on the life cycle of a product, beginning with its introduction into the market *(i.e.,* post-marketing). But a series of processes are to be undertaken by the management prior to the introduction of a product. The diagram given above is presented in an enlarged form to incorporate the pre-introduction (or pre-marketing) stages also.

Procedure of Designing a Process:

Product Design: Designing a process begins with the consideration or a careful review of the product design and specifications to ensure that economical manufacturing is feasible. The product engineer and the process planner should collaborate on the design of the product to make sure that realistic specifications are set and the product is designed to permit the use of the most economical method.

Material List: All the materials and parts that will be used are listed. The standard quantity of each item that will be required for manufacturing one unit of final product should be determined. A bill of materials to be bought from outside.

Sequence of Operations: The labor operations to be performed on each component and their sequences (order) are decided. The sequence should be such that it will permit the desired rate and quality of output at the Optimum manufacturing cost. The process engineer must be well experienced in methods and tool design so that the most appropriate sequence of operations can be selected. The method selected must ensure optimization of cost.

Tool Design: The machines, equipment and tools most appropriate for the product and volume of output are then designed. Machine setting e.g., speed, feed temperature, pressure, etc., are also decided at this stage. If a finished product is made up of a large number of components or parts, the sub-assemblies and final assembly are determined to simplify control and to minimize costs.

Layout: The layout of production, installation of manufacturing facilities and auxiliary service is decided. Related operations should be effectively integrated. The grouping of equipment and their proximity to each other would depend upon the volume of production and available production facilities. Close integration of operations makes plant layout compact and reduces time and cost of processing materials. However, it may reduce flexibility of the manufacturing process.

Control System: Necessary control of materials, machines and manpower is established to ensure effective utilization of the manufacturing facilities and most economical production ofQuantity, Quality, Time and Cost encompass the production system of which production planning and control is the nerve center or brain.

Objectives of Production Planning and Control

- To ensure maximum utilization of all resources.
- To ensure production of quality products.
- To minimize the product through put time or production/manufacturing cycle time.
- To maintain optimum inventory levels.
- To maintain flexibility in manufacturing operations.
- To co-ordinate between labor machines and various supporting departments.
- To plan for capacities between labor and machines and various supporting departments.
- To plan for plant capacities for future requirements.
- To ensure effective cost reduction and cost control.
- To prepare production schedules and ensure that promised delivery dates are met.
- To produce effective results for least total cost.
- The ultimate objective is to contribute to profit of the enterprise.

PROCESS SELECTION

Process choice determines whether resources are organised around products or processes in order to implement the flow strategy. It depends on the volumes and degree of customisation to be provided.

1. Process Choice: The production manager has to choose from five basic process types — (i) job shop, (ii) batch, (iii) repetitive or assembly line, (iv) continuous and (v) project.

(i) Job shop process: It is used in job shops when a low volume of high-variety goods are needed. Processing is intermittent, each job requires somewhat different processing requirements. A job shop is characterised by high customisation (made to order), high flexibility of equipment and skilled labour and low volume. A tool and die shop is an example of job shop, where **job process** is carried out to produce one-of-a kind of tools. Firms having job shops often carry out job works for other firms. A job shop uses a flexible flow strategy, with resources organised around the process.

(ii) Batch process: Batch processing is used when a moderate volume of goods or services is required and also a moderate variety in products or services. A batch process differs from the job process with respect to volume and variety. In batch processing,volumes are higher because same or similar products or services are repeatedly provided, examples of products produced in batches include paint, ice cream, soft drinks, books and magazines.

(iii) Repetitive process: This is used when higher volumes of more standardised goods or services are needed. This type of process is characterised by slight flexibility of equipment (as products are standardised) and generally low labour skills. Products produced include automobiles, home appliances, television sets, computers, toys etc. Repetitive process is also referred to as **line process** as it include **production lines** and **assembly lines** in mass production. Resources are organised around a product or service and materials move in a line flow from one operation to the next according to a fixed sequence with little work-in-progress inventory. This kind of process is suitable to **"manufacture-to-stock"** strategy with standard products held in finished goods inventory. However, **"assemble-to-order"** strategy and **"mass customisation"** are also possible in repetitive process.

(iv) Continuous process: This is used when a very highly standardised product is desired in high volumes. These systems have almost no variety in output and hence there is no need for equipment flexibility. A continuous process is the extreme end of high volume, standardised production with rigid line flows. The process often is capital intensive and operate round the clock to maximise equipment utilisation and to avoid expensive shut downs and shut ups. Examples of products made in continuous process systems include petroleum products, steel, sugar, flour, paper, cement, fertilisers etc.

(v) Project process: It is characterised by high degree of job customisation, the large scope for each project and need for substantial resources to complete the project. Examples of projects are building a shopping centre, a dam, a bridge, construction of a factory, hospital, developing a new product, publishing a new book etc. Projects tend to be complex, take a long time and consist of a large number of complex activities. Equipment flexibility and labour skills can range from low to high depending on the type of projects.

RESPONSIBILITIES OF PROCESS PLANNING ENGINEER

- Prepare various strategies for all planning activities for projects.
- Maintain all asset investment plans and ensure compliance to capital expenditure.
- Ensure accuracy for all operational requirements for projects and achieve all investment objectives.
- Evaluate all system capacity and analyze all production requirement and system deficiencies.
- Provide support to all operations and extension requests.

- Manage work as per component technical resource for all Water System Plans and assist to prepare all capital plans and project requirements.
- Analyze all engineering activities for all internal and external departments.
- Prepare required presentation for all regulatory agencies.
- Develop required to enhance performance of planning projects.
- Manage all communication and provide efficient feedback for all processes.
- Ensure optimal utilization of all common tools and processes.
- Prepare plans and schedule for all project delivery.
- Recommend appropriate improvements and ensure optimal quality of all project schedules and evaluate reports.
- Perform regular analysis of all schedule trends.
- Maintain an efficient performance of all schedule and analyze all software tools and assist in transmission and distribution of all various projects.
- Administer all distribution and transmission system.
- Manage all customer site and maintain product suite for all applications.
- Evaluate all alternative transmissions for all distribution systems and install all required AMSC products.

CAPACITY PLANNING – CONCEPT

Capacity planning refers to determining what kind of labor and equipment capacities are required and when they are required. Capacity is usually planned on the basis of labor or machine hours available within the plant. Thus, capacity planning is planning for quantity or scale of output.

- Level of demand
- Production
- Availability of fund
- Management Policy

IMPORTANCE OF CAPACITY PLANNING

Capacity limits the rate of output: Therefore, capacity planning determines the ability of an enterprise to meet future demand for its products and services.

Capacity influences the operating costs: Capacity is determined on the basis of estimated demand. Actual demand is often different from estimated demand. As a result, there arises excess capacity or under capacity. Excess or idle capacity increases the cost per unit of output. Whereas under capacity results in the loss of sales.

Capacity decisions result in Long-term commitment of funds. Such long-term decisions cannot be reversed except at major costs.

TYPES OF CAPACITY

Licensed capacity - denotes the capacity licensed by the Government authoritiesc oncerned
.

Potential capacity - The decision on potential capacity is taken mostly by a senior most executive of the organization
.

Immediate capacity - is that which can be made available within the current budget period. Immediate capacity is subject to certain constrains like plant equipment size, availability of equipment, availability of manpower, financial policy, sub-contracting policy, the technical demands of the tasks, and the number of different tasks being undertaken. For example, the capacity of a restaurant is limited by the size of the dining area or the number of tables.

Design or Installed capacity - It is the maximum output that can be achieved in a given time period form a particular plant. It is a theoretical capacity as it does not take into consideration power breakdown, pool planning, non-availability of materials, labor absenteeism, etc. This capacity is reliable only if certain conditions are satisfied. They are:

- There are no interruptions of any kind.
- There is 100% utilization of capacity.
- Men and machines work in ideal conditions.
- Quality of inputs according to specification.

Effective or Practical or Operating capacity: Effective capacity can be influenced by technical abilities in the pre-operations stages, organizational skills in the planning stages, purchasing skills, sub-contracting skills, maintenance policies and abilities, efficiency of workforce, multiple shift operation, etc. No plant can work up to the maximum or theoretical capacity due to plant efficiency factor and scrap factor. A portion of the available hours cannot be worked due to scheduling delays, machine breakdown, preventive maintenance, etc. This results in the efficiency of plant being less than what is rated.

Actual or Utilized capacity: This is the actual output achieved during a particular time period. If installed capacity is 100,000 tonnes and the actual production is 80,000 tonnes, we say that capacity utilization is 80% or the plant worked at 80% of the capacity.

Normal Capacity or Rated capacity: It is the capacity estimated by a qualified authority as to the amount of production that should be usually secured Actual capacity is usually expressed as a percentage of the rated capacity.

Excess capacity: Generally plant and equipment are indivisible in nature. Plant and equipment are long term facilities and constitute the major part of production cost. It is not possible to adjust fully and immediately the size of the plant and machinery to suit day to day changes in sales and production. Therefore, excess (unutilized) capacity may occur frequently.

PROCEDURE FOR CAPACITY PLANNING

Assessment of Existing Capacity: Capacity of a unit can be measured in terms of output or inputs. Output measure is appropriate in case of manufacturing concerns. e.g., automobile plant (number of cars), iron and steel plant (tons of steel), cannery (tons of food), etc. Service concerns like hospitals (number of beds), theatres (number of seats), etc., can measure capacity in terms of inputs.

Forecasting Future Capacity Needs: Short term capacity requirements can be estimated by forecasting product demand at different stages of the product life cycle. It is more difficult to anticipate long-term capacity requirements due to uncertainties of market and technology. Capacity forecast helps to determine the gap between the existing capacity and estimated capacity so that necessary adjustments may be made.

Identifying Alternative ways of Modifying Capacity: In case where the existing capacity is inadequate to meet the forecast demand capacity, the expansion is required to meet the shortage. Additional shifts may be employed to expand the capacity. Expansion will provide economies of scale and help in meeting the forecast demand. But it involves additional investment and danger of fall in forecast demand in future. When the existing capacity exceeds forecast capacity, there is a need for reduction of excess capacity. Developing new products, selling of existing facilities, layout of workers or getting work from other firms are the methods of overcoming it.

Evaluation of Alternatives: Various alternatives for capacity expansion or reduction are evaluated from economic, technical and other viewpoints. Reactions of employees and local community should also be considered. Cost-Benefit analysis, Decision theory and Queuing theory are the main techniques of evaluating alternatives.

Choice of Suitable Course of Action: After performing the cost-benefit analysis of various alternatives to expand or reduce the capacity, the most appropriate alternative is selected.

CAPACITY REQUIREMENT PLANNING (CRP) – CONCEPT

Capacity is a measure of the productive capability of a facility per unit of time. Capacity decisions begin with the initial facility layout and extend to aggregate planning, master scheduling, capacity requirements planning .CRP is a technique for determining what personnel and equipment capacities are needed to meet the production objectives embodied in the master Schedule and the material requirements plan.

CRP is an effort to develop a match between the MRP schedule and the production capacity of the company. Determination of the capacity of the work center and the capacity requirements imposed on those work centers by a particular product mix enables a company to know the level of sales its production system can support. Thus, company will be able to make realistic sales commitments. Capacity planning helps to avoid under-utilization of capacity and also CRP enables the company to anticipate production bottlenecks in some work centers in time to take corrective actions.

MRP and CRP programmes translate the master schedule to requirements for components and capacity, simulating the impact of the master schedule that provided the input for MRP programme. CRP can be used to refine the master production schedule (MPS) further after MRP is run.

Inputs for CRP Process

- Planned orders and released orders from the MRP system.
- Loading information from work center status file.
- Routing information from the shop routing file.
- Changes which modify capacity give alternative routings or alter planned orders.
- The released and planned orders from the MRP system are converted into standard hours of load by
- the CRP system. MRP system assumed that capacity is available when needed unless otherwise ndicated.

PLANT LOCATION AND PLANT LAYOUT

FACTORS INFLUENCING PLANT LOCATION

***(i)* Availability of Raw Materials:**

One of the most important considerations involved in selection of industrial location has been the availability of raw materials required. The biggest advantage of availability of raw material at the location of industry is that it involves less cost in terms of _transportation cost. If the raw materials are perishable and to be consumed as such, then the industries always tend to locate nearer to raw material source. Steel and cement industries can be such examples. In the case of small- scale industries, these could be food and fruit processing, meat and fish canning, jams, juices and ketchups, etc.

***(ii)* Proximity to Market:**

If the proof of pudding lies in eating, the proof of production lies in consumption. Production has no value without consumption. Consumption involves market that is, selling goods and products to the consumers. Thus, an industry cannot be thought of without market. Therefore, while considering the market an entrepreneur has not only to assess the existing segment and the region but also the potential growth, newer regions and the location of competitors. Similarly if the transportation costs add substantially to ones product costs, then also a location close to the market becomes all the more essential. If the market is widely scattered over a vast territory, then entrepreneur needs to find out a central location that provides the lowest distribution cost. In case of goods for export, availability of processing facilities gains importance in deciding the location of one_s industry. Export Promotion Zones (EPZ) are such examples.

***(iii)* Infrastructural Facilities:**
Of course, the degree of dependency upon infrastructural facilities may vary from industry to industry, yet there is no denying of the fact that availability of infrastructural facilities plays a deciding role in the location selection of an industry. The infrastructural facilities include power, transport and communication, water, banking, etc.
Yes, depending upon the types of industry these could assume disproportionate priorities. Power situation should be studied with reference to its reliability, adequacy, rates

***(iv)* Government Policy:** In order to promote the balanced regional development, the Government also offers several incentives, concessions, tax holidays for number of years, cheaper power supply, factory shed, etc., to attract the entrepreneurs to set up industries in less developed and backward areas. Then, other factors being comparative, these factors become the most significant in deciding the location of an industry.

***(v)* Availability of Manpower:**
Availability of required manpower skilled in specific trades may be yet another deciding factor for the location of skill- intensive industries. As regards the availability of skilled labour, the existence of technical training institutes in the area proves useful. Besides, an entrepreneur should also study labour relations through turnover rates, absenteeism and liveliness of trade unionism in the particular area. Such information can be obtained from existing industries working in the area. Whether the labour should be rural or urban; also assumes significance in selecting the location for one_s industry. Similarly, the wage rates prevalent in the area also have an important bearing on selection of location decision. While one can get cheaper labour in industrially backward areas, higher cost of their training and fall in quality of production may not allow the entrepreneur to employ the cheap manpower and, thus, establish his/her enterprise in such areas.

***(vi)* Local Laws, Regulations and Taxes:**
Laws prohibit the setting up of polluting industries in prone areas particularly which are environmentally sensitive. Air (Prevention and Control of Pollution) Act, 1981 is a classical example of such laws prohibiting putting up polluting industries in prone areas. Therefore, in order to control industrial growth, laws are enforced to decongest some areas while simultaneously encourage certain other areas. For example, while taxation on a higher rate may discourage some industries from setting up in an area, the same in terms of tax holidays for some years may become the dominant decisional factor for establishing some other industries in other areas. Taxation is a Centre as well as State Subject. In some highly competitive consumer products, its high quantum may turn out to be the negative factor while its relief may become the final deciding factor for some other industry.

(vii) **Ecological and Environmental Factors:**

In case of certain industries, the ecological and environmental factors like water and air pollution may turn out to be negative factor in deciding enterprise location. For example, manufacturing plants apart from producing solid waste can also pollute water and air. Moreover, stringent waste disposal laws, in case of such industries, add to the manufacturing cost to exorbitant limits. In view of this, the industries which are likely to damage the ecology and environment of an area will not be established in such areas. The Government will not grant permission to the entrepreneurs to establish such industries in such ecologically and environmentally sensitive areas.

(viii) **Competition:**

In case of some enterprises like retail stores where the revenue of a particular site depends on the degree of competition from other competitors_ location nearby plays a crucial role in selecting the location of an enterprise. The areas where there is more competition among industries, the new units will not be established in these areas. On the other hand, the areas where there is either no or very less competition, new enterprises will tend to be established in such areas.

(ix) **Incentives, Land Costs, Subsidies for Backward Areas:**

With an objective to foster balanced economic development in the country, the Government decentralizes industries to less developed and backward areas in the country. This is because the progress made in islands only cannot sustain for long. The reason is not difficult to seek. —Poverty anywhere is dangerous for prosperity everywhere.‖ That many have-not_s will not tolerate a few haves is evidently clear from ongoing protests leading to problems like terrorism. Therefore, the Government offers several incentives, concessions, tax holidays, cheaper lands, assured and cheaper power supply, price concessions for departmental (state) purchases, etc. to make the backward areas also conducive for setting up industries. It is seen that good number of entrepreneurs considers these facilities as decisive factor to establish industries in these locations. However, it has also been observed that these facilities can attract entrepreneurs to establish industries in backward areas provided other required facilities do also exist there. reasons why people in-spite of so many incentives and concessions on offer by the Government, are not coming forward to establish industries in some backward areas.

(x) **Climatic Conditions:**

Climatic conditions vary from place to place in any country including India. And, climatic conditions affect both people and manufacturing activity. It affects human efficiency and behavio ur to a great extent. Wild and cold climate is conducive to higher productivity. Likewise, certain industries require specific type of climatic conditions to produce their goods. For example, jute and textiles manufacturing industries require high humidity. As such, these can be established in Kashmir experiencing humidity-less climate. On the other hand, industrial units manufacturing precision goods like watches require cold climate and hence, will be established in the locations having cold climate like Kashmir and Himachal Pradesh.

***(xi)* Political Conditions:**
Political stability is essential for industrial growth. That political stability fosters industrial activity and political upheaval derails industrial initiates is duly confirmed by political situations across the countries and regions within the same country. The reason is not difficult to seek. The political stability builds confidence and political instability causes lack of confidence among the prospective and present entrepreneurs to venture into industry which is filled with risks. Community attitudes such as the ―Sons of the Soil Feeling‖ also affect entrepreneurial spirits and may not be viable in every case. Besides, an entrepreneur will have also to look into the availability of community services such as housing, schools and colleges, recreational facilities and municipal services. Lack of these facilities makes people hesitant and disinterested to move to such locations for work. Very closer to political conditions is law and order situation prevalent in an area also influences selection of industrial location. Hardly any entrepreneur will be interested to establish his / her industry in an area trouble-torn by nexalites and terrorists like Jharkhand, Nagaland and Jammu & Kashmir

BREAK EVEN ANALYSIS

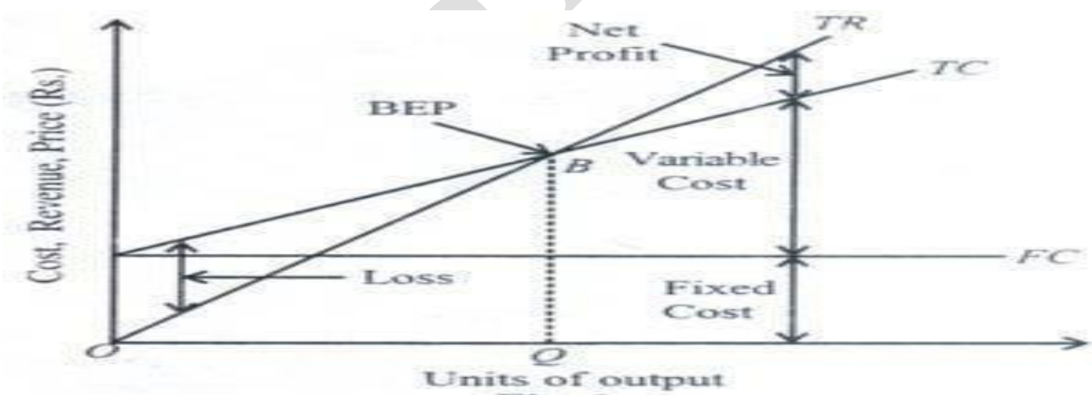


Fig. 1.

The break-even point (BEP) or break-even level represents the sales amount—in either unit (quantity) or revenue (sales) terms—that is required to cover total costs, consisting of both fixed and variable costs to the company. Total profit at the break-even point is zero. It is only possible for a firm The break-even point is one of the most commonly used concepts of financial analysis, and is not only limited to economic use, but can also be used by entrepreneurs, accountants, financial planners, managers and even marketers. Break-even points can be useful to all avenues of a business, as it allows employees to identify required outputs and work towards meeting these. The Breakeven value is not a generic value and will vary dependent on the individual

business. Some businesses may have a higher or lower breakeven point, however it is important that each business develop a break-even point calculation, as this will enable them to see the number of units they need to sell to cover their variable costs. Each sale will also make a contribution to the payment of fixed costs as well. For example, a business that sells tables needs to make annual sales of 200 tables to break- even. At present the company is selling fewer than 200 tables and is therefore operating at a loss. As a business, they must consider increasing the number of tables they sell annually in order to make enough money to pay fixed and variable costs. If the business does not think that they can sell the required number of units, they could consider the following options:
1. Reduce the fixed costs. This could be done through a number of negotiations, such as reductions in rent, or through better management of bills or other costs.

2. Reduce variable costs by, for example, finding a new supplier that sells tables for less.

Either option can reduce the break-even point so the business need not sell as many tables as before, and could still pay fixed costs
\

PLANT LAYOUT: CONCEPT, OBJECTIVES, PRINCIPLES AND TYPES

Concept of Plant Layout:
The concept of plant layout may be described as follows: Plant layout is a plan for effective utilization of facilities for the manufacture of products; involving a most efficient and economical arrangement of machines, materials, personnel, storage space and all supporting services, within available floor space. ―Plant layout is a plan of optimum arrangement of facilities including personnel, equipment_s, storage space, material handling equipment and all other supporting services along with the decision of best structure to contain all these facilities.

(i) Plant layout is very complex in nature; because it involves concepts relating to such fields as engineering, architecture, economics and business management.

(ii) Most of managers now realize that after the site for plant location is selected; it is better to develop the layout and build the building around it – rather than to construct the building first and then try to fit the layout into it.

Objectives/Advantages of Plant Layout:

(i) Streamline flow of materials through the plant

(ii) Minimize material handling

(iii) Facilitate manufacturing progress by maintaining balance in the processes

(iv) Maintain flexibility of arrangements and of operation

(v) Maintaining high turnover of in-process inventory

(vi) Effective utilization of men, equipment and space

(vii) Increase employee morale

(viii) Minimize interference (i.e. interruption) from machines

(ix) Reduce hazards affecting employees

(x) Hold down investment (i.e. keep investment at a lower level) in equipment.

Principles of Plant Layout:

(i) Principle of Minimum Movement: Materials and labour should be moved over minimum distances; saving cost and time of transportation and material handling.

(ii) Principle of Space Utilization: All available cubic space should be effectively utilized – both horizontally and vertically.

(iii) Principle of Flexibility: Layout should be flexible enough to be adaptable to changes required by expansion or technological development.

(iv) Principle of Interdependence: Interdependent operations and processes should be located in close proximity to each other; to minimize product travel.

(v) Principle of Overall Integration: All the plant facilities and services should be fully integrated into a single operating unit; to minimize cost of production.

(vi) Principle of Safety: There should be in-built provision in the design of layout, to provide for comfort and safety of workers.

(vii) Principle of Smooth Flow: The layout should be so designed as to reduce work bottlenecks and facilitate uninterrupted flow of work throughout the plant.

(viii) Principle of Economy: The layout should aim at effecting economy in terms of investment in fixed assets.

(ix) Principle of Supervision: A good layout should facilitate effective supervision over workers.
(x) Principle of Satisfaction: A good layout should boost up employee morale, by providing them with maximum work satisfaction.

Types of Plant Layout:
Two basic plans of the arrangement of manufacturing facilities are – product layout and process layout. The only other alternative is a combination of product and process layouts, in the same plant.
(a) Product Layout (or Line Layout):
In this type of layout, all the machines are arranged in the sequence, as required to produce a specific product. It is called line layout because machines are arrange in a straight line. The raw materials are fed at one end and taken out as finished product to the other end. Special purpose machines are used which perform the required jobs (i.e. functions) quickly and reliably.

Advantages:
1. Reduced material handling cost due to mechanized handling systems and straight flow

2. Perfect line balancing which eliminates bottlenecks and idle capacity.

3. Short manufacturing cycle due to uninterrupted flow of materials

4. Simplified production planning and control; and simple and effective inspection of work.

5. Small amount of work-in-progress inventory

6. Lesser wage cost, as unskilled workers can learn and manage production.

Disadvantages:
1. Lack of flexibility of operations, as layout cannot be adapted to the manufacture of any other type of product.

2. Large capital investment, because of special purpose machines.

3. Dependence of whole activity on each part; any breakdown of one machine in the sequence may result in stoppage of production.

4. Same machines duplicated for manufacture of different products; leading to high overall operational costs.

5. Delicate special purpose machines require costly maintenance / repairs.

Suitability of product layout:
Product layout is suitable in the following cases:
1. Where one or few standardized products are manufactured.

2. Where a large volume of production of each item has to travel the production process, over a considerable period of time.

3. Where time and motion studies can be done to determine the rate of work.

4. Where a possibility of a good balance of labour and equipment exists.

5. Where minimum of inspection is required, during sequence of operations.

6. Where materials and products permit bulk or continuous handling by mechanical parts.

7. Where minimum of set-ups are required.

(b) Process Layout (or Functional Layout):
In this type of layout, all machines performing similar type of operations are grouped at one location i.e. all lathes, milling machines etc. are grouped in the shop and they will be clustered in like groups. A typical process layout is depicted below:
Advantages:
1. Greater flexibility with regard to work distribution to machinery and personnel. Adapted to frequent changes in sequence of operations.

2. Lower investment due to general purpose machines; which usually are less costly than special purpose machines.

3. Higher utilization of production facilities; which can be adapted to a variety of products.
4. Variety of jobs makes the work challenging and interesting.

5. Breakdown of one machine does not result in complete stoppage of work.

Disadvantages:

1. Backtracking and long movements occur in handling of materials. As such, material handling costs are higher.

2. Mechanization of material handling is not possible.

3. Production planning and control is difficult

4. More space requirement; as work-in-progress inventory is high-requiring greater storage space.

5. As the work has to pass through different departments; it is quite difficult to trace the responsibility for the finished product.

Suitability of process layout:

Process layout is suitable in the following cases, where:

1. Non-standardized products are manufactured; as the emphasis is on special orders.

2. It is difficult to achieve good labour and equipment balance.

3. Production is not carried on a large scale.

4. It is difficult to undertake adequate time and motion studies.

5. It is frequenStly necessary to use the same machine or work station for two or more difficult operations.

6. During the sequence of operations, many inspections are required.

7. Process may have to be brought to work, instead of **"vice-versa"**; because materials or products are too large or heavy to permit bulk or continuous handling by mechanical means.

(c) Group Technology Layout or Combined Layout:

Product layouts are feasible only in case of mass production systems. When the production volume is less, it may be difficult to justify dedication of resource to individual products. Therefore, organizations have been using process layouts for such situations. However, since process layouts create more problems in production planning and control_ due to complex routing of various components on the shop floor, operation managers were looking for alternatives to the process layout. On the other hand, there has been an increasing trend towards more variety. The industrial fans and blowers division of ABB Ltd, a multinational company operating in India manufactures about 725 models, Titan Industries increased the jumpers of watch models from 850 in 1993 to 1200 in 1996, an average more than 100 new models every year. Group Technology (GT) layout provides an alternative method for configuring resources in organizations that have mid-value, mid variety product portfolios. Group Technology is a philosophy that seeks to exploit commonality in manufacturing and uses this as the basis for grouping components and resources. The implications of GT are often known as cellular manufacturing. In cellular manufacturing, the available components are grouped part families. An approximate measure for manufacturing similarity is used to identify part families. Corresponding to each part family, machine groups are identified and layout is formed accordingly.

Advantage of GT Layout

The benefits of GT are many. Once the part families and the machine groups are identified, the layout ensures that each cell has only a certain number of components to be processed. In essence, it is akin to breaking a monolith structure into smaller, more manageable and independent units of production. The components seldom travel outside their respective cell for processing. Therefore, material handling becomes easier and traceability improves. Moreover, employees are able to relate better to their workplace and make concerned improvements. The new structure also helps to implement several other operations management practices such as small group improvement, Kaizen and JIT manufacturing practices.

(d) Fixed Position Layout:

There are several situations in which the product manufactured is very bulky, difficult to move and is often made in quantities of one or few pieces. In such situations, the layout design ought to be very different. Typical examples include building very large machines tools and equipments, ships, and aircraft building. Since the equipments are very large and bulky they dictate several choices with respect to layout. The specific orientation of the equipment will dictate the placement of specific resources required for the process. Layout planning in such cases is often a question of a good work place organization Some examples include the nuclear engineering division of Bharat Heavy Electrical Division at Tiruchirapalli, the final assembly panel of advanced helicopter division.