Unit - I

Production function – an Introduction – Definitions and types of production systems. Strategic Management – corporate strategies, production strategies, World class manufacturing, demand forecasting for Operations.

MEANING OF PRODUCTION MANAGEMENT:

Production Management refers to the application of management principles to the production function in a factory. In other words, production management involves application of planning, organizing, directing and controlling the production process.

Production management also deals with decision-making regarding the quality, quantity, cost, etc., of production. It applies management principles to production.

Production management is a part of business management. It is also called "**Production Function**." Production management is slowly being replaced by operations management.

DEFINITION OF PRODUCTION MANAGEMENT:

It is observed that one cannot demarcate the beginning and end points of Production Management in an establishment. The reason is that it is interrelated with many other functional areas of business, viz., marketing, finance, industrial relation policies etc.

Alternately, Production Management is not independent of marketing, financial and personnel management due to which it is very difficult to formulate some single appropriate definition of Production Management.

"Production Management is the process of effective planning and regulating the operations of that section of an enterprise which is responsible for the actual transformation of materials into finished products."

This definition limits the scope of production management to those activities of an enterprise which is associated with the transformation process of inputs into outputs. & the definition does not include the human factors involved in a production process. It lays stress on materialistic features only.

Production Management deals with decision-making related to production process. So that the resulting goods and services are produced in accordance with the quantitative specifications and demand schedule with minimum cost.

FUNCTIONS OF PRODUCTION MANAGEMENT:

The definitions discussed above clearly shows that the concept of production management is related mainly to the organizations engaged in production of goods and services. Earlier these organizations were mostly in the form of one man shops having insignificant problems of managing the productions.

But with development and expansion of production organizations in the shape of factories more complicated problems like location and lay out, inventory control, quality control, routing and scheduling of the production process etc. came into existence which required more detailed analysis and study of the whole phenomenon.

This resulted in the development of production management in the area of factory management. In the beginning the main function of production management was to control labour costs which at that time constituted the major proportion of costs associated with production.

But with development of factory system towards mechanization and automation the indirect labour costs increased tremendously in comparison to direct labour costs, e.g., designing and packing of the products, production and inventory control, plant layout and location,

transportation of raw materials and finished products etc. The planning and control of all these activities required more expertise and special techniques.

IMPORTANCE OF PRODUCTION MANAGEMENT

(i) Design and development of production process.
(ii) Production planning and control.
(iii) Implementation of the plan and related activities to produce the desired output.
(iv) Administration and co-ordination of the activities of various components and departments responsible for producing the necessary goods and services.
However, the responsibility of determining the output characteristics and the distribution strategy followed by an organization including pricing and selling policies are normally outside the scope of Production Management.

OBJECTIVE OF PRODUCTION MANAGEMENT

The main **objective** of production management is to produce goods and services of the right quality, right quantity, at the right time and at minimum cost. It also tries to improve the efficiency. An efficient organisation can face competition effectively. Production management ensures full or optimum utilisation of available production capacity.

SCOPE OF PRODUCTION MANAGEMENT

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

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

PRODUCTION SYSTEM

INTRODUCTION OF PRODUCTION SYSTEM

The production system of an organization is that part, which produces products of an organization. It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management. A simplified production system is shown above.The production system has the following characteristics:

1. Production is an organized activity, so every production system has an objective.
2. The system transforms the various inputs to useful outputs.
3. It does not operate in isolation from the other organization system.

4. There exists a feedback about the activities, which is essential to control and improve system performance.

PRODUCTION FUNCTION:

INTRODUCTION

Production is the result of co-operation of four factors of production viz., land, labour, capital and organization.

This is evident from the fact that no single commodity can be produced without the help of any one of these four factors of production.

Therefore, the producer combines all the four factors of production in a technical proportion. The aim of the producer is to maximize his profit. For this sake, he decides to maximize the production at minimum cost by means of the best combination of factors of production.

The producer secures the best combination by applying the principles of equi-marginal returns and substitution. According to the principle of equi-marginal returns, any producer can have maximum production only when the marginal returns of all the factors of production are equal to one another. For instance, when the marginal product of the land is equal to that of labour, capital and organisation, the production becomes maximum.

MEANING OF PRODUCTION FUNCTION:

In simple words, production function refers to the functional relationship between the quantity of a good produced (output) and factors of production (inputs).

"The production function is purely a technical relation which connects factor inputs and output." Prof. Koutsoyiannis

Defined production function as "the relation between a firm's physical production (output) and the material factors of production (inputs)." Prof. Watson

In this way, production function reflects how much output we can expect if we have so much of labour and so much of capital as well as of labour etc.

In other words, we can say that production function is an indicator of the physical relationship between the inputs and output of a firm.

The reason behind physical relationship is that money prices do not appear in it. However, here one thing that becomes most important to quote is that like demand function a production function is for a definite period.

It shows the flow of inputs resulting into a flow of output during some time. The production function of a firm depends on the state of technology. With every development in technology the production function of the firm undergoes a change.

The new production function brought about by developing technology displays same inputs and more output or the same output with lesser inputs. Sometimes a new production function of the firm may be adverse as it takes more inputs to produce the same output.

Mathematically, such a basic relationship between inputs and outputs may be expressed as:

$Q = f(L, C, N)$

Where Q = Quantity of output

L = Labour C = Capital N = Land.

Hence, the level of output (Q), depends on the quantities of different inputs (L, C, N) available to the firm. In the simplest case, where there are only two inputs, labour (L) and capital (C) and one output (Q), the production function becomes.

Q =f (L, C)

DEFINITIONS:

"The production function is a technical or engineering relation between input and output. As long as the natural laws of technology remain unchanged, the production function remains unchanged." Prof. L.R. Klein

"Production function is the relationship between inputs of productive services per unit of time and outputs of product per unit of time." Prof. George J. Stigler

"The relationship between inputs and outputs is summarized in what is called the production function. This is a technological relation showing for a given state of technological knowledge how much can be produced with given amounts of inputs." Prof. Richard J. Lipsey

Thus, from the above definitions, we can conclude that production function shows for a given state of technological knowledge, the relation between physical quantities of inputs and outputs achieved per period of time.

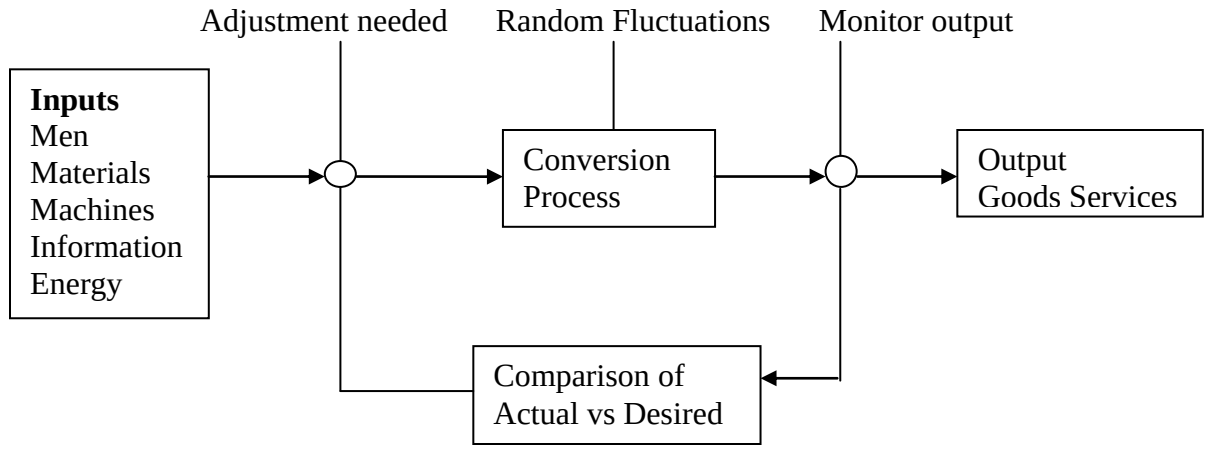
PRODUCTION SYSTEM

(The production system (function) of an organisation is that part which produces the organisations products. Production is the basic activity of all organisations and all the other activities revolve around production activity. The output of production is the creation of goods or services, which satisfy the needs of the customer.

In some organisations the product is a physical (tangible) good. E.g. Refrigerators motorcars,
Television, tooth paste etc, while in others it is a service (insurance, health care etc.)

The production system has the following characteristics.

1. Production is an organised activity, so every production system has an objective.
2. The system transforms the various inputs (men, material, machines, information, and energy) in to useful Outputs (Goods or Services.)
3. Production system does not operate in isolation from the other organisational systems such as finance, marketing etc.
4. There exists a feedback about the activities, which is essential to control and improve system performance.



FEATURES OF PRODUCTION FUNCTION:

1. Substitutability:

The factors of production or inputs are substitutes of one another which make it possible to vary the total output by changing the quantity of one or a few inputs, while the quantities of all other inputs are held constant. It is the substitutability of the factors of production that gives rise to the laws of variable proportions.

2. Complementarily:

The factors of production are also complementary to one another, that is, the two or more inputs are to be used together as nothing will be produced if the quantity of either of the inputs used in the production process is zero.

The principles of returns to scale is another manifestation of complementarily of inputs as it reveals that the quantity of all inputs are to be increased simultaneously in order to attain a higher scale of total output.

3. Specificity:

It reveals that the inputs are specific to the production of a particular product. Machines and equipment's, specialized workers and raw materials are a few examples of the specificity of factors of production. The specificity may not be complete as factors may be used for production of other commodities too. This reveals that in the production process none of the factors can be ignored and in some cases ignorance to even slightest extent is not possible if the factors are perfectly specific.

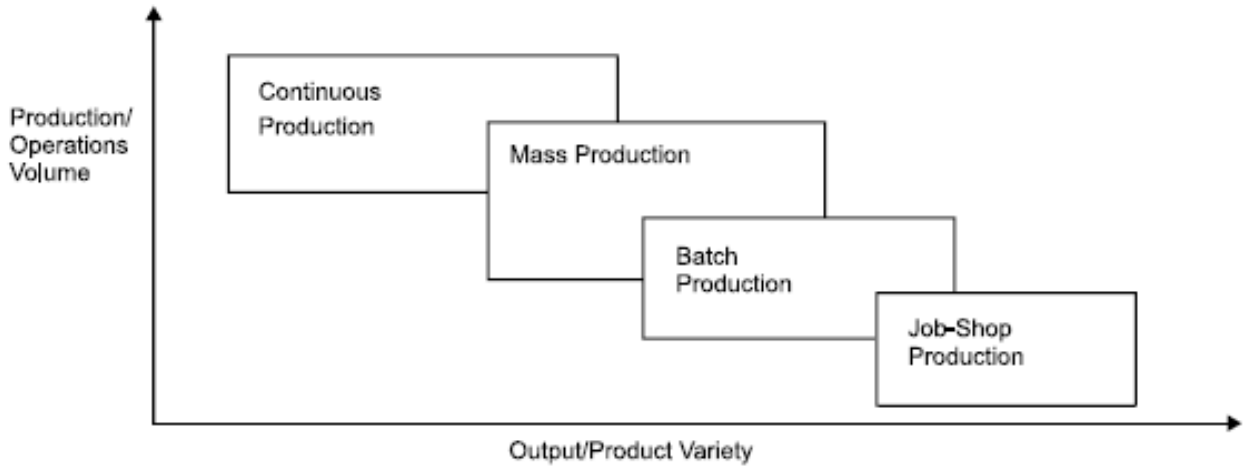
Production involves time; hence, the way the inputs are combined is determined to a large extent by the time period under consideration. The greater the time period, the greater the freedom the producer has to vary the quantities of various inputs used in the production process.

In the production function, variation in total output by varying the quantities of all inputs is possible only in the long run whereas the variation in total output by varying the quantity of single input may be possible even in the short run

TYPES OR CLASSIFICATION OF PRODUCTION SYSTEM

Production systems can be classified as Job Shop, Batch, Mass and Continuous Production systems.

Classification of production systems



Job shop production:

Job shop production are characterized by manufacturing of one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products.

A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

Characteristics

The Job-shop production system is followed when there is:

1. High variety of products and low volume.
2. Use of general purpose machines and facilities.
3. Highly skilled operators who can take up each job as a challenge because of uniqueness.
4. Large inventory of materials, tools, parts.
5. Detailed planning is essential for sequencing the requirements of each product, capacities for each work centre and order priorities.

Advantages

Following are the advantages of job shop production:

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

Limitations

Following are the limitations of job shop production:

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

Batch production:

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

Characteristics

Batch production system is used under the following circumstances:

1. When there is shorter production runs.
2. When plant and machinery are flexible.
3. When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
4. When manufacturing lead time and cost are lower as compared to job order production.

Advantages

Following are the advantages of batch production:

1. Better utilization of plant and machinery.
2. Promotes functional specialization.
3. Cost per unit is lower as compared to job order production.
4. Lower investment in plant and machinery.

5. Flexibility to accommodate and process number of products.
6. Job satisfaction exists for operators.

Limitations

Following are the limitations of batch production:

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.
3. Work in process inventory is higher compared to continuous production.
4. Higher set up costs due to frequent changes in set up.

Mass production:

Manufacture of discrete parts or assemblies using a continuous process are called mass production. This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path.

Characteristics

Mass production is used under the following circumstances:

1. Standardization of product and process sequence.
2. Dedicated special purpose machines having higher production capacities and output rates.
3. Large volume of products.
4. Shorter cycle time of production.
5. Lower in process inventory.
6. Perfectly balanced production lines.
7. Flow of materials, components and parts is continuous and without any back tracking.
8. Production planning and control is easy.
9. Material handling can be completely automatic.

Advantage

Following are the advantages of mass production:

1. Higher rate of production with reduced cycle time.
2. Higher capacity utilization due to line balancing.
3. Less skilled operators are required.
4. Low process inventory.
5. Manufacturing cost per unit is low.

Limitations

Following are the limitations of mass production:

1. Breakdown of one machine will stop an entire production line.
2. Line layout needs major change with the changes in the product design.
3. High investment in production facilities.
4. The cycle time is determined by the slowest operation.

Continuous production:

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

Characteristics

Continuous production is used under the following circumstances:

1. Dedicated plant and equipment with zero flexibility.
2. Material handling is fully automated.

3. Process follows a predetermined sequence of operations.
4. Component materials cannot be readily identified with final product.
5. Planning and scheduling is a routine action.

Advantages

Following are the advantages of continuous production:

1. Standardization of product and process sequence.
2. Higher rate of production with reduced cycle time.
3. Higher capacity utilization due to line balancing.
4. Manpower is not required for material handling as it is completely automatic.
5. Person with limited skills can be used on the production line.
6. Unit cost is lower due to high volume of production.

Limitations

Following are the limitations of continuous production:

1. Flexibility to accommodate and process number of products does not exist.
2. Very high investment for setting flow lines.
3. Product differentiation is limited.

STRATEGIC MANAGEMENT

Definition: The term 'strategic management' is used to denote a branch of management that is concerned with the development of strategic vision, setting out objectives, formulating and implementing strategies and introducing corrective measures for the deviations (if any) to reach the organization's strategic intent. It has two-fold objectives:

- To gain competitive advantage, with an aim of outperforming the competitors, to achieve dominance over the market.
- To act as a guide to the organization to help in surviving the changes in the business environment.

Here, changes refer to changes in the internal environment, i.e. within the organization, introduced by the managers such as the change in business policies, procedures etc. and changes in the external environment as in changes in the government rules that can affect business, competitors move, change in customer's tastes and preferences and so forth.

Strategic Management Process

1. Defining the levels of strategic intent of the business:
   - Establishing vision
   - Designing mission
   - Setting objectives

2. Formulation of strategy

- Performing environmental and organizational appraisal
- Considering strategies
- Carrying out strategic analysis
- Making strategies
- Preparing strategic plan

3. Implementation of strategy

- Putting strategies into practice
- Developing structures and systems
- Managing behavioural and functional implementation

4. Strategic Evaluation and Control

- Performing evaluation
- Exercising control
- Recreating strategies

Strategic Management is all about specifying organization's vision, mission and objectives, environment scanning, crafting strategies, evaluation and control.

Importance of Strategic Management

- It guides the company to move in a specific direction. It defines organization's goals and fixes realistic objectives, which are in alignment with the company's vision.
- It assists the firm in becoming proactive, rather than reactive, to make it analyse the actions of the competitors and take necessary steps to compete in the market, instead of becoming spectators.
- It acts as a foundation for all key decisions of the firm.
- It attempts to prepare the organization for future challenges and play the role of pioneer in exploring opportunities and also helps in identifying ways to reach those opportunities.
- It ensures the long-term survival of the firm while coping with competition and surviving the dynamic environment.
- It assists in the development of core competencies and competitive advantage that helps in the business survival and growth.

The basic purpose of strategic management is to gain sustained-strategic competitiveness of the firm. It is possible by developing and implementing such strategies that create value for the company. It focuses on assessing the opportunities and threats, keeping in mind firm's strengths and weaknesses and developing strategies for its survival, growth and expansion.

CORPORATE STRATEGY

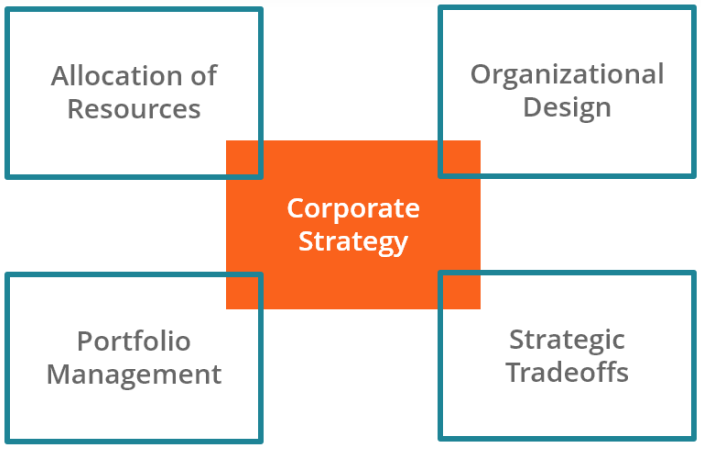
What is Corporate Strategy?

Corporate Strategy takes a portfolio approach to strategic decision making by looking across all of a firm's businesses to determine how to create the most value. In order to develop a corporate strategy, firms must look at how the various business they own fit together, how they impact each other, and how the parent company is structured in order to optimize human capital, processes, and governance. Corporate Strategy builds on top of business strategy, which is concerned with the strategic decision making for an individual business.

What are the Components of Corporate Strategy?

There are several important components of corporate strategy that leaders of organizations focus on. The main tasks of corporate strategy are:

1. Allocation of resources
2. Organizational design
3. Portfolio management
4. Strategic tradeoffs



In the following sections, this guide will break down the four main components outlined above.

#1 Allocation of Resources

The allocation of resources at a firm focuses mostly on two resources: people and capital. In an effort to maximize the value of the entire firm, leaders must determine how to allocate these resources to the various businesses or business units to make the whole greater than the sum of the parts.

Key factors related to the allocation of resources are:

- **People**

    - Identifying core competencies and ensuring they are well distributed across the firm
    - Moving leaders to the places they are needed most and add the most value (changes over time based on priorities)
    - Ensuring an appropriate supply of talent is available to all businesses
- **Capital**
    - Allocating capital across businesses so it earns the highest risk-adjusted return
    - Analyzing external opportunities (mergers and acquisitions) and allocating capital between internal (projects) and external opportunities

#2 Organizational Design

Organizational design involves ensuring the firm has the necessary corporate structure and related systems in place to create the maximum amount of value. Factors that leaders must consider are, the role of the corporate head office (centralized vs decentralized approach and the reporting structure of individuals and business units (vertical hierarchy, matrix reporting, etc.).
Key factors related to the allocation of resources are:

- **Head office (centralized vs decentralized)**
    - Determining how much autonomy to give business units
    - Deciding whether decisions are made top-down or bottom-up
    - Influence on the strategy of business units
- **Organizational structure (reporting)**
    - Determine how large initiatives and commitments will be divided into smaller projects
    - Integrating business units and business functions such that there are no redundancies
    - Allowing for the balance between risk and return to exist by separating responsibilities
    - Developing centers of excellence
    - Determining the appropriate delegation of authority
    - Setting governance structures
    - Setting reporting structures (military / top-down, matrix reporting

#3 Portfolio Management

Portfolio management looks at the way business units complement each other, their correlations, and decides where the firm will "play" (i.e. what businesses it will or won't enter).
Corporate Strategy related to portfolio management includes:

- Deciding what business to be in or to be out of
- Determining the extent of vertical integration the firm should have
- Managing risk through diversification and reducing the correlation of results across businesses
- Creating strategic options by seeding new opportunities that could be heavily invested in if appropriate
- Monitor the competitive landscape and ensure the portfolio is well balanced relative to trends in the market

#4 Strategic Tradeoffs

One of the most challenging aspects of corporate strategy is balancing the tradeoffs between risk and return across the firm. It's important to have a holistic view of all the businesses combined and ensure that the desired levels are risk management and return generation are being pursued. Below are the main factors to consider for strategic tradeoffs:

- **Managing risk**
  - Firm-wide risk is largely depending on the strategies it chooses to pursue
  - True product differentiation, for example, is a very high-risk strategy that could result in a market leadership position, or total ruin
  - Many companies adopt a copycat strategy by looking at what other risk-takers have done and modify it slightly
  - It's important to be fully aware of strategies and associated risks across the firm
  - Some areas might require true differentiation (or cost leadership) but other areas might be better suited to copycat strategies that rely on incremental improvements
  - The degree of autonomy business units have is important in managing this risk
- **Generating returns**
  - Higher risk strategies create the possibility of higher rates of return. The examples above of true product differentiation or cost leadership could provide the most return in the long run if they are well executed
  - Swinging for the fences will lead to more home runs and more strikeouts so it's important to have the appropriate number of options in the portfolio. These options can later turn into big bets as the strategy develops
- **Incentives**
  - Incentive structures will play a big role in how much risk and how much return managers seek
  - It may be necessary to separate the responsibilities of risk management and return generation so that each can be pursued to the desired level
  - It may further help to manage multiple overlapping timelines, ranging from short-term risk/return to long-term risk/return and ensuring there is appropriate dispersion

MEANING OF PRODUCTION STRATEGIES

Production strategies are broad long-term action plans. They are made for achieving the main objectives of organisation. Production strategies tell us what the production department must do to achieve the top aims of the organisation. It provides a road map for the production department.

So, production strategies are long-term action plans of the organisation, for the production of goods and services.

Production strategies decide about the investment to be made for production, the technology to be used for production, the training to be given to the production staff, the production schedule to be followed, etc. It also decides about the goods and services to be produced and when to introduce them in the market.

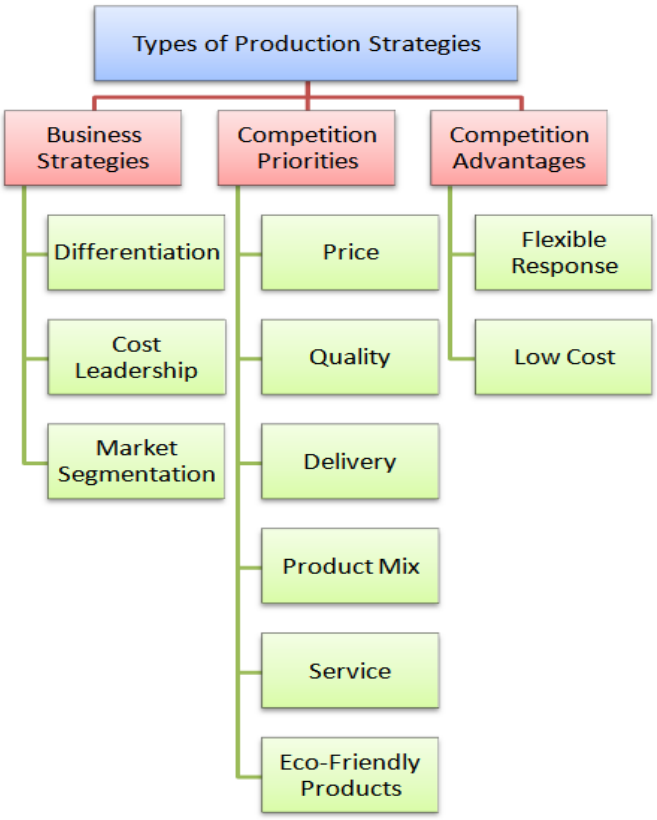
It is the top level of management that first fixes the main objectives of the organisation. Then top-level managers make strategies for achieving these objectives.

Generally, there are two types of strategies, viz.,

1. **Business Strategies** are strategies made for the entire organisation. It covers all departments of the organisation. These are made by the top-level management.
2. **Functional or Departmental Strategies** are strategies made for a particular department. Each department has its own strategy such as production and marketing strategy. These strategies support the business strategy to achieve the main objectives of the organisation. They are made by middle-level management, i.e. by Departmental Heads. So, production strategy is a functional strategy.

DIFFERENT TYPES OF PRODUCTION STRATEGIES

The different types of production strategies are grouped, listed and explained under following three categories, viz.,



The types of production strategies under Business Strategies are as follows:

1. Differentiation strategy
2. Cost leadership strategy
3. Market segmentation strategy

The production strategies under Competitive Priorities are as follows:

1. Price or cost strategy
2. Quality strategy
3. Delivery strategy
4. Product mix or flexibility strategy
5. Service strategy
6. Eco-friendly products

The production strategies under Competitive Advantages are as follows

1. Flexible response strategy
2. Low cost strategy

The types of production strategies listed above are discussed as follows:

1. Differentiation strategy

Under a differentiation strategy, the company tries to be different and unique from its competitors. It may offer better quality, quantity, pricing, appearance, and after sales-service, when compared to its competitors. It may offer more features and facilities in its product. It may be more flexible while dealing with its customers. It may also offer quick and better delivery of its products. So, there are many ways, in which a company can remain different from its competitors. If it maintains this uniqueness and difference in its product quality and customer service, then it can charge higher prices.

2. Cost leadership strategy

Under a cost leadership strategy, the company tries to reduce its cost of production. This is done by producing goods on a very huge scale. By doing so, the company will get the benefits of economies of large scale. Higher the scale of production, lower will be the cost of production. This is because per unit cost of raw materials, labour, advertising, sales promotion, R & D, etc. will decrease.

3. Market segmentation strategy

In market segmentation strategy, the company divides the market according to the type of customers it has to focus and target. It sells different products and services to different types of customers. To achieve this goal, it produces and sells goods and services as per the needs of the customers. Therefore, market segmentation strategy is also called Focus Strategy.

4. Price or cost strategy

Under price or cost strategy, the company sells its product at a very low price. This strategy is used when the products are homogeneous (same) in nature. That is, when the customers cannot distinguish the company's product from the competitors' products. In this case, the company will fix a low price. So, the customers will purchase the company's product and not the competitors' products.

5. Quality strategy

Under quality strategy, the company produces and sells high-quality goods and services. The prices of such goods and services are naturally very high. However, this strategy attracts those customers who prefer top quality products and are ready to pay necessary appropriate prices. The company must pay special attention to the design of its products. It must upgrade product design and add new product features to satisfy the current needs and demands of its customers. Products which are designed badly will naturally fail in the market. To gain success in the market, the company must smartly invest to make quality innovative products that are free from any defects.

6. Delivery strategy

Here under delivery strategy, the company delivers its product and services to their customers as early as possible that too within a fixed time period. The company gives top priority to fast delivery of products and providing quickest accessibility of services. Speed delivery of products and fastest accessibility of services removes the problem of scarcity and unnecessary delays in the market. Delivery strategy is used as a selling tactic to fight cut-throat competition.

7. Product mix or flexibility strategy

Under this strategy, the company produces and sells a product mix. A product mix is a group of products, which are sold by the same company. Here, the company does not depend only on one product for its survival and growth. It uses a product mix because it offers many advantages to the company. However, only large companies with huge production capacity can use this strategy.

8. Service strategy

Under this strategy, the company uses a service to attract the customers. It gives quicker and better after-sales service. It gives around the clock, i.e. 24-hour customer service. It may render this service directly via the company or through the network of call centres. Service is required for both consumer goods as well as industrial goods.

9. Eco-friendly products

Under eco-friendly strategy, the company produces and sells environment-friendly products also called as Green Products. For e.g. producing and selling lead-free petrol to reduce pollution, manufacturing mercury-free television panels, etc., are some good steps to preserve nature. This is a new type of production strategy. It is used to reduce pollution and protect the biosphere. Companies may also recycle certain materials like plastic, metals and papers. The properly recycled products are later used for manufacturing new products and in packaging. Companies use biodegradable packing material to reduce the problem of waste disposal. Recycling reduces continuous demand cycle of natural resources and hence somewhat minimize the exploitation of environment. The company informs the public about their environment-friendly manufacturing approach through advertisements.

10. Flexible response strategy

Flexible response strategy is said to be used when a company makes necessary changes in its production plans that too in accordance with the emerging changes in the market. Here, importance is given to speed and reliability. That is, the company must make quick changes as per the arising changes in the market demand. It must also be reliable. That is, it must give a regular supply of goods to its customers. There must not be any shortage of goods in the market. To achieve this, the company must follow a strict production schedule.

11. Low cost strategy

Under low cost strategy, the company fights massive market competition by selling its products at very lower prices. Simultaneously, it must also maintain the quality of its products. A company can only sell its goods at minimum prices if it maintains a low cost of production and distribution. This can be done by producing and distributing goods on a large scale. That is, company must take advantage of economies of large-scale production.

WORLD CLASS MANUFACTURING

Introduction

Manufacturing has evolved considerably since the advent of industrial revolution. In current global and competitive age, it is very important for organization to have manufacturing practice which is lean, efficient, cost-effective and flexible.

World class manufacturing is a collection of concepts, which set standard for production and manufacturing for another organization to follow. Japanese manufacturing is credited with pioneer in concept of world-class manufacturing. World class manufacturing was introduced in the automobile, electronic and steel industry.

World class manufacturing is a process driven approach where various techniques and philosophy are used in one combination or other.

Some of the techniques are as follows:

- Make to order
- Streamlined Flow
- Smaller lot sizes
- Collection of parts
- Doing it right first time
- Cellular or group manufacturing
- Total preventive maintenance
- Quick replacement
- Zero Defects
- Just in Time
- Increased consistency
- Higher employee involvement
- Cross Functional Teams
- Multi-Skilled employees
- Visual Signaling
- Statistical process control

Idea of using above techniques is to focus on operational efficiency, reducing wastage and creating cost efficient organization. This leads to creation of high-productivity organization, which used concurrent production techniques rather than sequential production method.

World Class Manufacturers

World class manufacturers tend to implement best practices and also invent new practices as to stay above the rest in the manufacturing sector. The main parameters which determine world-class manufacturers are quality, cost effective, flexibility and innovation.

World class manufacturers implement robust control techniques but there are five steps, which will make the system efficient. These five steps are as follows:

- **Reduction of set up time and in tuning of machinery:** It is important that organizations are able to cut back time in setting up machinery and also tune machinery before production.
- **Cellular Manufacturing:** It is important that production processes are divided into according to its nature, with similar nature combined together.
- **Reduce WIP material:** It is normal tendency of manufacturing organization to maintain high levels of WIP material. Increased WIP leads to more cost and decreased WIP induces more focus on production and fast movement of goods.

- **Postpone product mutation:** For to achieve a higher degree of customization many changes are made to final product. However, it is important that mutation conceived for the design stage implement only after final operation.
- **Removal the trivial many and focus on vital few:** It is important for organization to focus on production of products which are lined with forecast demand as to match customer expectation.

Principles of World Class Manufacturing

There are three main principles, which drive world-class manufacturing.

- Implementation of just in time and lean management leads to reduction in wastage thereby reduction in cost.
- Implementation of total quality management leads to reduction of defects and encourages zero tolerance towards defects.
- Implementation of total preventive maintenance leads to any stoppage of production through mechanical failure.

Aspects of World Class Manufacturing

The main aspects of the world-class manufacturing are as follows:

- Industrial culture area
- Market/client area
- Product development area
- Operations area
- E-Performance area

DEMAND FORECASTING: CONCEPT

An organization faces several internal and external risks, such as high competition, failure of technology, labor unrest, inflation, recession, and change in government laws.

Therefore, most of the business decisions of an organization are made under the conditions of risk and uncertainty.

An organization can lessen the adverse effects of risks by determining the demand or sales prospects for its products and services in future. Demand forecasting is a systematic process that involves anticipating the demand for the product and services of an organization in future under a set of uncontrollable and competitive forces.

DEFINITIONS OF DEMAND FORECASTING ARE AS FOLLOWS:

According to Evan J. Douglas, "Demand estimation (forecasting) may be defined as a process of finding values for demand in future time periods."

In the words of Cundiff and Still, "Demand forecasting is an estimate of sales during a specified future period based on proposed marketing plan and a set of particular uncontrollable and competitive forces."

Demand forecasting enables an organization to take various business decisions, such as planning the production process, purchasing raw materials, managing funds, and deciding the price of the product. An organization can forecast demand by making own estimates called guess estimate or taking the help of specialized consultants or market research agencies. Let us discuss the significance of demand forecasting in the next section.

SIGNIFICANCE OF DEMAND FORECASTING:

Demand plays a crucial role in the management of every business. It helps an organization to reduce risks involved in business activities and make important business decisions. Apart from this, demand forecasting provides an insight into the organization's capital investment and expansion decisions.

The significance of demand forecasting is shown in the following points:

i. Fulfilling objectives:

Implies that every business unit starts with certain pre-decided objectives. Demand forecasting helps in fulfilling these objectives. An organization estimates the current demand for its products and services in the market and move forward to achieve the set goals.

For example, an organization has set a target of selling 50, 000 units of its products. In such a case, the organization would perform demand forecasting for its products. If the demand for the organization's products is low, the organization would take corrective actions, so that the set objective can be achieved.

ii. Preparing the budget:

Plays a crucial role in making budget by estimating costs and expected revenues. For instance, an organization has forecasted that the demand for its product, which is priced at Rs. 10, would be 10, 00, 00 units. In such a case, the total expected revenue would be 10* 100000 = Rs. 10, 00, 000. In this way, demand forecasting enables organizations to prepare their budget.

iii. Stabilizing employment and production:

Helps an organization to control its production and recruitment activities. Producing according to the forecasted demand of products helps in avoiding the wastage of the resources of an organization. This further helps an organization to hire human resource according to requirement. For example, if an organization expects a rise in the demand for its products, it may opt for extra labor to fulfill the increased demand.

iv. Expanding organizations:

Implies that demand forecasting helps in deciding about the expansion of the business of the organization. If the expected demand for products is higher, then the organization may plan to expand further. On the other hand, if the demand for products is expected to fall, the organization may cut down the investment in the business.

v. Taking Management Decisions:

Helps in making critical decisions, such as deciding the plant capacity, determining the requirement of raw material, and ensuring the availability of labor and capital.

vi. Evaluating Performance:

Helps in making corrections. For example, if the demand for an organization's products is less, it may take corrective actions and improve the level of demand by enhancing the quality of its products or spending more on advertisements.

vii. Helping Government:

Enables the government to coordinate import and export activities and plan international trade.

OBJECTIVES OF DEMAND FORECASTING:

Demand forecasting constitutes an important part in making crucial business decisions.

The objectives of demand forecasting are divided into short and long-term objectives, which are shown in Figure-1:

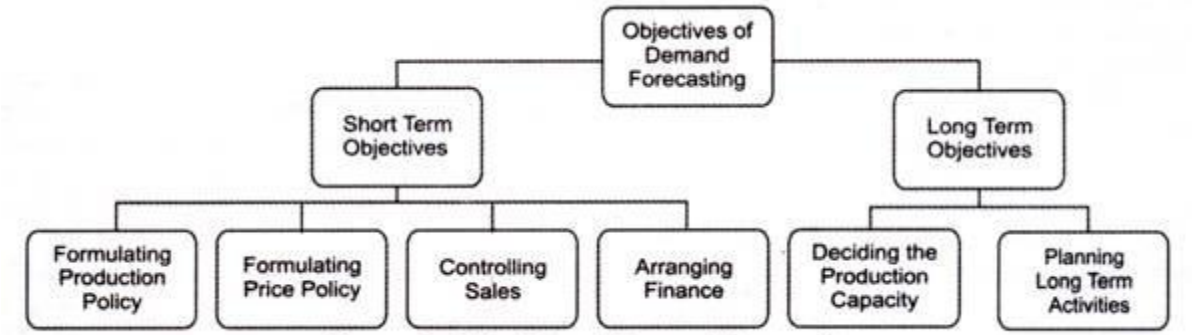


Figure-1: Objectives of Demand Forecasting

The objectives of demand forecasting (as shown in Figure-1) are discussed as follows:

i. Short-term Objectives:
Include the following:
a. Formulating production policy:
Helps in covering the gap between the demand and supply of the product. The demand forecasting helps in estimating the requirement of raw material in future, so that the regular supply of raw material can be maintained. It further helps in maximum utilization of resources as operations are planned according to forecasts. Similarly, human resource requirements are easily met with the help of demand forecasting.
b. Formulating price policy:
Refers to one of the most important objectives of demand forecasting. An organization sets prices of its products according to their demand. For example, if an economy enters into depression or recession phase, the demand for products falls. In such a case, the organization sets low prices of its products.
c. Controlling sales:
Helps in setting sales targets, which act as a basis for evaluating sales performance. An organization make demand forecasts for different regions and fix sales targets for each region accordingly.
d. Arranging finance:
Implies that the financial requirements of the enterprise are estimated with the help of demand forecasting. This helps in ensuring proper liquidity within the organization.
ii. Long-term Objectives:
Include the following:
a. Deciding the production capacity:
Implies that with the help of demand forecasting, an organization can determine the size of the plant required for production. The size of the plant should conform to the sales requirement of the organization.
b. Planning long-term activities:
Implies that demand forecasting helps in planning for long term. For example, if the forecasted demand for the organization's products is high, then it may plan to invest in various expansion and development projects in the long term.

FACTORS INFLUENCING DEMAND FORECASTING:

Demand forecasting is a proactive process that helps in determining what products are needed where, when, and in what quantities. There are a number of factors that affect demand forecasting.

Some of the factors that influence demand forecasting are shown in Figure-2:

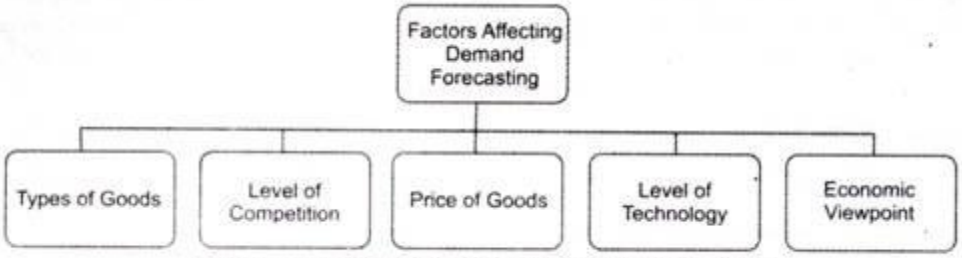


Figure-2: Factors Affecting Demand Forecasting

The various factors that influence demand forecasting ("as shown in Figure-2) are explained as follows:

i. Types of Goods:

Affect the demand forecasting process to a larger extent. Goods can be producer's goods, consumer goods, or services. Apart from this, goods can be established and new goods. Established goods are those goods which already exist in the market, whereas new goods are those which are yet to be introduced in the market.

Information regarding the demand, substitutes and level of competition of goods is known only in case of established goods. On the other hand, it is difficult to forecast demand for the new goods. Therefore, forecasting is different for different types of goods.

ii. Competition Level:

Influence the process of demand forecasting. In a highly competitive market, demand for products also depends on the number of competitors existing in the market. Moreover, in a highly competitive market, there is always a risk of new entrants. In such a case, demand forecasting becomes difficult and challenging.

iii. Price of Goods:

Acts as a major factor that influences the demand forecasting process. The demand forecasts of organizations are highly affected by change in their pricing policies. In such a scenario, it is difficult to estimate the exact demand of products.

iv. Level of Technology:

Constitutes an important factor in obtaining reliable demand forecasts. If there is a rapid change in technology, the existing technology or products may become obsolete. For example, there is a high decline in the demand of floppy disks with the introduction of compact disks (CDs) and pen drives for saving data in computer. In such a case, it is difficult to forecast demand for existing products in future.

v. Economic Viewpoint:

Play a crucial role in obtaining demand forecasts. For example, if there is a positive development in an economy, such as globalization and high level of investment, the demand forecasts of organizations would also be positive.

Apart from aforementioned factors, following are some of the other important factors that influence demand forecasting:

a. Time Period of Forecasts:

Act as a crucial factor that affect demand forecasting. The accuracy of demand forecasting depends on its time period.

Forecasts can be of three types, which are explained as follows:

1. Short Period Forecasts:

Refer to the forecasts that are generally for one year and based upon the judgment of the experienced staff. Short period forecasts are important for deciding the production policy, price policy, credit policy, and distribution policy of the organization.

2. Long Period Forecasts:

Refer to the forecasts that are for a period of 5-10 years and based on scientific analysis and statistical methods. The forecasts help in deciding about the introduction of a new product, expansion of the business, or requirement of extra funds.

3. Very Long Period Forecasts:

Refer to the forecasts that are for a period of more than 10 years. These forecasts are carried to determine the growth of population, development of the economy, political situation in a country, and changes in international trade in future.

Among the aforementioned forecasts, short period forecast deals with deviation in long period forecast. Therefore, short period forecasts are more accurate than long period forecasts.

4. Level of Forecasts:

Influences demand forecasting to a larger extent. A demand forecast can be carried at three levels, namely, macro level, industry level, and firm level. At macro level, forecasts are undertaken for general economic conditions, such as industrial production and allocation of national income. At the industry level, forecasts are prepared by trade associations and based on the statistical data.

Moreover, at the industry level, forecasts deal with products whose sales are dependent on the specific policy of a particular industry. On the other hand, at the firm level, forecasts are done to estimate the demand of those products whose sales depends on the specific policy of a particular firm. A firm considers various factors, such as changes in income, consumer's tastes and preferences, technology, and competitive strategies, while forecasting demand for its products.

5. Nature of Forecasts:

Constitutes an important factor that affects demand forecasting. A forecast can be specific or general. A general forecast provides a global picture of business environment, while a specific forecast provides an insight into the business environment in which an organization operates. Generally, organizations opt for both the forecasts together because over-generalization restricts accurate estimation of demand and too specific information provides an inadequate basis for planning and execution.

STEPS OF DEMAND FORECASTING:

The Demand forecasting process of an organization can be effective only when it is conducted systematically and scientifically.

It involves a number of steps, which are shown in Figure-3:

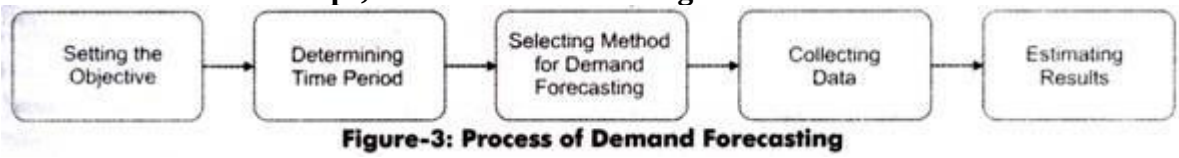


Figure-3: Process of Demand Forecasting

The steps involved in demand forecasting (as shown in Figure-3) are explained as follows:

1. Setting the Objective:

Refers to first and foremost step of the demand forecasting process. An organization needs to clearly state the purpose of demand forecasting before initiating it.

Setting objective of demand forecasting involves the following:

a. Deciding the time period of forecasting whether an organization should opt for short-term forecasting or long-term forecasting

b. Deciding whether to forecast the overall demand for a product in the market or only- for the organizations own products

c. Deciding whether to forecast the demand for the whole market or for the segment of the market

d. Deciding whether to forecast the market share of the organization

2. Determining Time Period:

Involves deciding the time perspective for demand forecasting. Demand can be forecasted for a long period or short period. In the short run, determinants of demand may not change significantly or may remain constant, whereas in the long run, there is a significant change in the determinants of demand. Therefore, an organization determines the time period on the basis of its set objectives.

3. Selecting a Method for Demand Forecasting:

Constitutes one of the most important steps of the demand forecasting process Demand can be forecasted by using various methods. The method of demand forecasting differs from organization to organization depending on the purpose of forecasting, time frame, and data requirement and its availability. Selecting the suitable method is necessary for saving time and cost and ensuring the reliability of the data.

4. Collecting Data:

Requires gathering primary or secondary data. Primary' data refers to the data that is collected by researchers through observation, interviews, and questionnaires for a particular research. On the other hand, secondary data refers to the data that is collected in the past; but can be utilized in the present scenario/research work.

5. Estimating Results:

Involves making an estimate of the forecasted demand for predetermined years. The results should be easily interpreted and presented in a usable form. The results should be easy to understand by the readers or management of the organization.

Unit – II

Product Design – New product development, process planning and design, value analysis, capacity planning

DEFINITION OF PRODUCT DESIGN

Design of a product means determining the shape, standard and pattern of broadest sense includes the whole development of a product through all preliminary stage until actual manufacturing begins". This definition of design cannot be said to be satisfactory because it does not clarify the aspect of design completely. The Indian Patents and Design Act explains the design as "the feature or shape, configuration, pattern or ornament applied to any article by any industrial process whether manual, mechanical or chemical, which in the finished article appeal to and are judged soley by the eye, but does not include any mode or principle of constructing or anything which is a mere mechanical device and does not include any trademark".

The term designing the product refers to the determination of shape, standard and pattern of the product. It includes (i) specification, (ii) experimental and development work for the production of desired product, (iii) calculation of estimates and drafting estimates of contracts for new inquiries, and (iv) issuing necessary instructions to the production department for production.

Generally, a separate technical department is established in big industries that are assigned the responsibility of designing the product. The technical department must clearly specify what is to be produced by the production department not only because it has been entrusted with the task of designing the product, but also for gaining and retaining the goodwill of other manufacturers and consumers who will use the product. It is advisable that the cooperation of other concerning departments should be sought in designing the product. Production and sales departments are two main departments concerned. Thus, designing of a product must be integrated with production and sales functions.

Characteristics of a Good Product Design

A good product design should posses the following characteristics:

i. Function: A product can be sold if it meets the needs of the consumer d as such the product must be designed to meet such needs. For example, L customer expects a gas lighter to be convenient (i.e., to instantly light the gas stove), If the gas lighter cannot achieve that, then the purpose is lost as the basic function is not met.

ii) Reliability: It is the probability that there will not be any major failure of the product during its use. For example, if certain components of a product are put into use very often, the reliability of each component should be staggeringly high which may not be practical from production point of view. To overcome this problem, duplicate components can be operated in parallel i.e., if one component fails its duplicate may be put into operation.

(**iii) Maintainability:** The lubrication points and other areas for servicing of the product to be designed ought to be easily accessible even though the physical form may have to be altered a bit. The alternative is to make a trouble free product with expensive design. The trade-off between being trouble-free and maintainability is an important decision at the design stage and it mainly depends on the nature of the product. The after sales feedback from customers is quite valuable in improving upon the maintainability of a product.

(iv) Producibility: A product should be designed in such a manner that it can be produced easily at a reasonable cost. Least number of operations is required to produce a product quickly and cheaply. This may be possible with change in technology. For example, instead of machining an intricate part such as gear, it can be moulded, without affecting its function.

Producibility can also be enhanced by reducing work content of the job involved. For example, the instrument penal of a car used to be maize of wires. This has been redesigned with a printed circuit board where only multiple pin plugs needs to be connected into it. This has resulted into reduced work content and greater product reliability.

(v) Simplification: Simplification and producibility go hand in hand. The simpler the design of the product, the easier it is to produce, the lesser it costs and more reliable it is.

(vi) Product standardisation and variety reduction: Variety to a large extent depends on market forces. The larger the market, the greater is the degree of standardisation possible which makes economies of scale possible. If there is a competitive market, products can have a selling edge if variety is offered. This will involve a design for the product in such a way which will lend itself to modularisation so as to gain advantage of large production.

(vii) Quality: A good quality product design ensures that the quality of a final product is obtained through its individual components. The tolerance specified at every stage ensures a end product with the desired quality.

(viii) Minimum cost: Design influences manufacturing cost. A good product must ensure minimum manufacturing. Some of the areas is which savings he effected at the design stage have been discussed already.

(ix) Warranties: Whether or not a manufacturer is legally bound to put right whatever wrong the customer does is the question here. The point is customer is too valuable to be lost, especially if the manufacturer wishes retain him and established his goodwill, Breakdown of a component may or may not owe their origin to poor maintenance or misuse of the component by a customer-it may be due to faulty material, faulty designs and faulty processing. The manufacturer must keep in mind the importance of a customer and the costs to he incurred in fixing up a product for the customer.

(X) Modular design: The products should consist of detachable components or sub-assemblies so that whenever a component fails, it can be replaced by a new one easily, The use of standard sub-assemblies gives rise to numerous end-products in different combinations, The concept is known as modularity. The need of a modular design is enforced by the customer who wants a variety to choose from what he she likes the best. Maintaining stocks of modules and assembling them promptly enable the manufacturer to offer variety in customer's hands. Thus, the advantages of modular diversity can be listed as:

- Diversity can be offered to the customers
- Inventories can be substantially reduced.
- Cannibalisation L.e., using parts of one equipment salvaged for use in another application is made easy.
- Repairing a product becomes in expensive because only a few standard tools are needed,
- The company can contract or expand its capacity. An example of modular design is a gasoline pump that permits the customer to mix his own blend.

TYPES OF DESIGN

Product design may be of four types:

(a) Functional design. (b) Aesthetic design, (c) production design and (d) packing design.

(a) Functional Design: Functional design involves developing an idea into a rough model of the proposed products. This first necessity making a rough sketch of the proposed products to give some idea of the shape of its parts necessary to accomplish its purpose. Then, the designer makes draft-room sketches of the proposed products. After this, experimental models are prepared which are thoroughly tested to make sure that they function properly for a certain period of time

and under varying conditions. If, for example, a company designing a lawn-mower, the designer must make sure that the functional design is such that the model is able to cut grass properly, evenly and cleanly. It is also important that it is pushed easily. After all these, a life-test should also be conducted to see how long it will function and remain in good condition. It can he conducted within the company itself or the product may be given to a few selected customers for a trial cum actual use.

(b) Aesthetic Design: Before production on a commercial scale is undertaken another type of design must be integrated with the functional design and it is aesthetic design (style) for market acceptability. The emphasis on style has become more evident during recent years. It is not sufficient if the functional design of the proposed product is good and economical, it should also be appealing to the customers in its appearance inducing them to buy.

(c) Production Design or Product Design: Generally, the functional design is translated into production design to make it easy for manufacturing. Product design pertains to a design which may result in affecting its economics without affecting its functional efficiency. As soon as the product has been fully tested to determine whether it is functioning properly, it must be checked to see whether any design changes can be made which will affect economics when the item is produced but will not affect its functional efficiency.

(d) Packing Design: Packing design should also be appealing to the consumers depending upon the size and nature of the product. Different packing materials can be used to suit the consumers' tastes and to maintain the chemical properties of the product.

The product designer should use standard parts or assemblies as far as possible to reduce the cost of production because standard parts in some cases may be purchased cheaper from outside firms specialising such manufacture. The product designer should be aware of possibility of simplification and diversification of the product. To sum up, design excellence should achieve functional perfection, low cost of production and win over consumers' appeal.

OBJECTIVES OF DESIGNING A PRODUCT

The object of designing a product may be summarised as follows:

(i) The first object is to create attention for the product for increasing sale-potentials.

(ii) To enhance the importance of product from customers' point of view.

(iii) To produce better quality at the lowest possible price.

FACTORS AFFECTING THE DESIGN OF A PRODUCT

The designer or the technical department must consider the following factors in designing a product which influence the design of the product:

(i) Customers' requirement and Psychological effects: The designer must, first of all, ascertain the basic requirements and the psychology of the customers He/she must then evaluate the extent to which wishes of the customers are fulfilled in the product. For this purpose, he/she must prepare a comprehensive questionnaire keeping in mind the marketing and economic aspects to analyse the psychology and needs of the customers and the product may be designed accordingly.

(ii) Facility to Operator: The second factor which the designer must consider carefully is the facilities available to the operator on the shop floor. The designer must ensure that the operator is provided with all the comforts necessary while at work, unnecessary movements may irritate and tire the operator soon.

(iii) Functionality: The design should not merely be stylish but should cover the utility aspect also. There must be a proper balance between beauty and utility.

(iv) Materials: The next factor to be considered by the designer is the materials to be used on the proposed product and the development of improvements in this field as materials have profound influence over the product. Referring to industrial, scientific and technical journals and being aware of the tastes and preferences of the consumers will provide necessary information in taking appropriate decisions in this regard.

(v) Work Method and Equipment: Another important factor affecting the product design is the work method and the equipment to be used in the manufacture of proposed product. A designer must be aware of the latest developments in work methods and equipment. Possibility of modification in the existing work methods and techniques must be evaluated because, modification in work methods can affect the cost of production to a great extent.

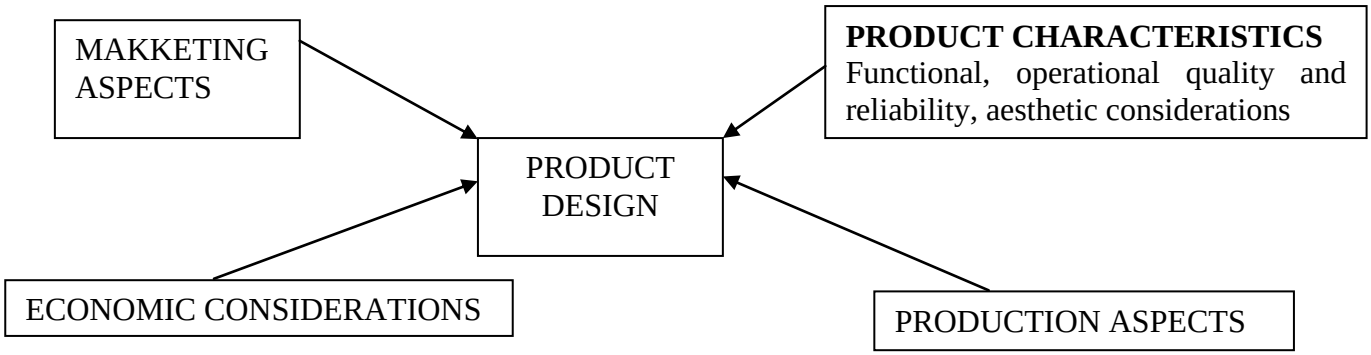
(vi) Cost/price Ratio: Cost is one of the major factors which influence the design of a product. In a competitive market, usually the designer is given a unit cost figure for each product within which he/she must work. This gives the designer little freedom for every design. However, contract-based 'cost plus a margin of profit' arrangement allows a designer the latitude for over designing particularly if the margin is expressed as a percentage of total cost.

(vii) Quality Policy: Quality of design ultimately reflects on a product quality. The quality of a design must be fixed at the corporate level to provide the designer with suitable guidelines. Such a policy will set the design trend for future and build a distinct quality 'image' of the company's product.

(Viii) Process Capability: Product design is governed by quality policy of the firm on one side and availability of the plant and machinery to meet specifications on the other side. There is no sense in designing a product which cannot be manufactured by the machines available with the company. Machines would also be capable of meeting the needs of the designer with regard to the design quality. The process capability of the machines should be such that they meet the company's quality standards. It is the responsibility of the production department to keep their plant in top condition. It is also their responsibility to replace worn out machines and justify such expenditure to the top management. However, the designer must be aware of the capacity of the machines available in the organisation and design the products to satisfy their process capability.

(ix) Effect on Other Products: The designer should also consider the effect of the raw products on the existing ones. If the new product is to replace an existing one, it should (i) fit into the manufacturing and distribution plans of the original product, (ii) use the same standard parts and components, and (iii) accept the same manufacturing technology, On the other hand, if the new product requires different distribution arrangements and use of a different technology, the effect on the sale of other products must be considered.

(x) Packaging: Good packaging is as important as good design of the product. Packaging is required for (i) protection of the product when in shelf or in transit and (ii) promotion (advertising) of the product. Consumer products generally require attractive packaging to enhance sales appeal while industrial goods require sturdy packaging to avoid damage during transit. Packaging, particularly in a consumer product is a design activity.



STAGES IN PRODUCT DESIGN

Every product design passes through the following six stages:

(i) Conception
(ii) Acceptance
(iii) Execution
(iv) Evaluation
(v) Translation and
(vi) Pre-production

(i) Conception: Conception stage is the first and the most important stage in any product design. A draft specification is prepared at this stage by the marketing department in consultation with the design department. Such specification provides an opportunity to:

(a) Designers to understand exactly the wants of the customers.

(b) Marketing personnel to understand the feasibility and the cost of the proposed product and if required, to discuss the relevant aspects of the product with the potential customers.

Basic information to be provided on design specifications are:

• Performance requirements
• Esteem requirements
• Safety requirements
• Reliability and maintainability requirements.
•. Price limitations, if any, (i. e., maximum price to the customer)
• Delivery requirements (i.e., date by which the production should commence,
• Estimated quantity of the product.
• Maximum acceptable cost of designing.

(ii) Acceptance: Draft specification prepared earlier is scrutinised for its viability by subjecting it to all possible calculations model making, preliminary drawings, laboratory scale processes, etc. Based on outcome of these tests the specifications are:

Accepted and taken up for the next stage or rejected as impracticable or modified in consultation with the marketing department. Acceptance stage in simple projects may coincide with the previous stage and decision regarding the acceptance/rejection/modification of the specification may be taken in the meeting between the design and the marketing departments. However, in case of complex projects, this function is carried out in the design department as a 'back-room' function by designers and draftsmen. For such design projects work orders are raised to account for and assign design costs to the projects.

(iii) Execution: Execution concerns conversion of the selected proposal into physical embodiment. It involves conversion of specifications of materials, functional performance, reliability and appearance, etc., into blue prints, drawings and diagrams so as to facilitate making

of a prototype. The first physical embodiment of the new product is the model prototype. The prototype must serve the following factors:
(a) Manufacturing feasibility,
(b) Aesthetic or style requirements,
(c) Specific processes or equipment required to produce the product,
(d) Reliability
(e) Maintainability
(f) Packaging requirements
(g) Transportability,
(h) Feasibility of using standard parts,
(i) Identification of assembly problems,
(i) Refinements (if any).
Execution phase is a time consuming space. Any haste in getting a product into production can cost the organisation dearly. More than one prototype may be prepared. Critical analysis of the prototype may bring out limitations/deficiencies and therefore the need for another prototype. Since, prototypes are prepared (or pilot plans are made) based on ideas, specifications and other details drawn under acceptance stage and on general design considerations both theoretical and practical, the prototype models are expected to conform as closely to specifications as possible. Deviations, if any, are recorded their causes are identified and their effects are considered.
Though technical and appearance aspects are the major considerations at this stage, the cost of the final product is not ignored (though it is considered as a major factor at the next stage). At the execution stage, thus, the sole aim is to establish clearly the feasibility of the proposed design in meeting the specifications.
(iv) Evaluation and Review of the Design: This exercise should be done by persons from finance, manufacturing, marketing and service departments to achieve optimal design (i.e., the overall best combinations of product qualities at the lowest per unit production cost). A system concept is usually helpful which should be directed towards the following:
1. Are functional requirements for which the product is designed met?
2. Are the aesthetic requirement met?
3. Have basic materials and process alternatives and their costs thereof been identified?
4. Does the design allow for economical assembly?
5. Does the design allow for ready inspection and repair?
6. Does the design require special quality and production control?
7. Are any manufacturing bottlenecks foreseen?
8. What lead time is required for employee training and new process installation and run-in?
Once when these questions have been answered adequately, the firm may proceed to the next stage (translation stage) or return to innovation prototype stage to correct deficiencies (execution stage).
(v) Translation stage: Translation stage concerns with conversion of design into a form that is convenient for the production department to manufacture the product in a routine manner. At this stage, (1) production and service departments are involved in the design work, manufacturing problems are discussed and design reviews are made to resolve manufacturing difficulties if any. (ii) blue prints, drawings, diagrams, material lists are prepared to summarise all design and development work. Dimensions, tolerance and materials are described in detail. A set of engineering drawings furnishing all details is produced by the engineering department. In addition, diagrams, sketches, or schematics may also be prepared to aid in manufacturing the

parts or assembling them into components or products. (iii) detailed estimates of costs are prepared for each component, also components whose costs seem to be excessive are subjected to design reviews.

(vi) Pre-production: On conclusion of the above five stages, a pilot production run is carried out. The quantity produced can be adequate to check design, specifications, production techniques and tools. Pre-production stage brings out in open hidden deficiencies of design and specifications from manufacturing point of view and thereby provides an opportunity to redesign the components. The pilot run provides a quantity of the product for studying further the market acceptance.

Generally, a pilot run would employ a scaled down or modified equipment But it is desirable to use the specific type of equipment, processes and procedures that will be used for full scale operations. Subcontracting may be resorted to demonstrate the feasibility of the design and manufacturing process. The set-up for the pilot run should be as close as possible to the final production facilities. On successful completion of the pilot run, the drawings are finalized and the design is frozen.

NEW PRODUCT DEVELOPMENT:

A new product is a one that is perceived new by a majority of people in the given market. It is something which is new to the market, which may be due to product innovation or product modification. Newness may be slight change in packaging, new product lines, duplicate of competitor's product, launching the product in different market and such other changes.

New products pull the attention of the customers. It helps in reaping higher profit margins and boosts the declining product. Launch of a new product marks the growth and expansion of the company.

Every new product goes through a product planning process comprising of following stages:

1. Idea Generation:

The new product development starts with the search and generation of ideas which may arise from various sources like company's R&D department, market and consumers trends, competitors, focus groups, employees, sales people and such other.

2. Idea Screening:

At this stage, the generated ideas are screened down on the basis of their feasibility and viability, only practical and workable ideas are developed. The purpose of screening is to have a critical evaluation of product ideas and drop the poor ideas.

3. Concept Development and Testing:

The company may have considered the idea to be feasible, but is has to be tested with the target audience. Here the product idea is converted into meaningful consumer item and presented to appropriate target consumers to know their reactions. If the reaction is positive, the company moves to next stage.

4. Market Strategy Development:

After successful concept testing, the marketing manager will develop a preliminary marketing strategy for introducing the product in the market. The marketing strategy will highlight the segmentation, targeting and positioning strategy.

5. Business Analysis:

Business analysis is the study of economic feasibility of the new product i.e. whether the product will be financially worthwhile in long run or not. This stage estimates the expected future profitability of the new product, i.e. what cash flow product can generate, what will be the cost of production, what will be the expected life of the product, share of market product may get etc.

6. Product Development:

Once the product is declared economically feasible, the company gives the product its physical shape. This stage involves huge investments to be made, as compared to the pervious stages. The physical product as it would appear is prepared so that it can be tested.

7. Test Marketing:

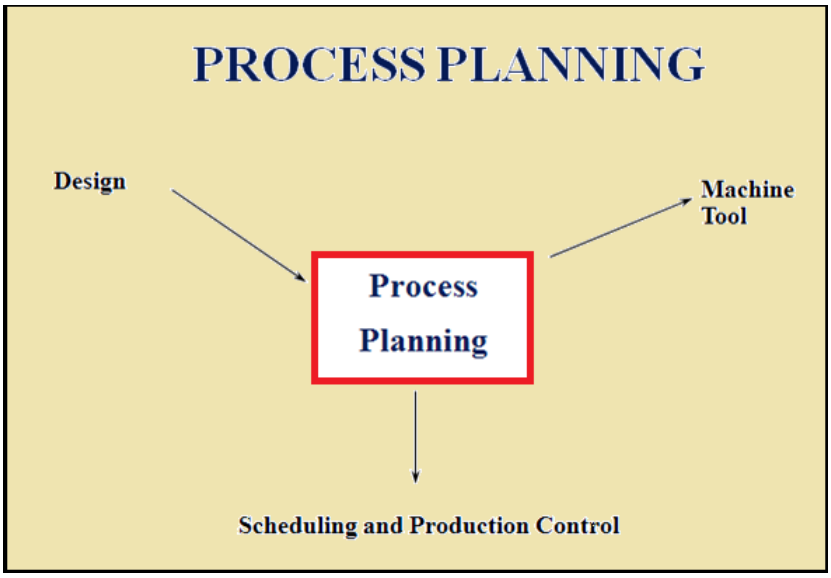
Test marketing is a stage where the new product is tested with a particular target market, to find out whether it is acceptable to the consumers or not. The expectation of the consumers from the product is tested here. Any improvement or modification required can be taken care of. Test marketing, thus, help in pretesting of the product and the marketing plan, before it is launched in the market.

8. Commercialization:

Successful test marketing gives way to actual introduction of the product in the market place. Here the company has to consider certain factors like when to launch the product, where and how the product will be launched, which market and which consumers to target etc. Market entry timing is also very important.

PROCESS PLANNING

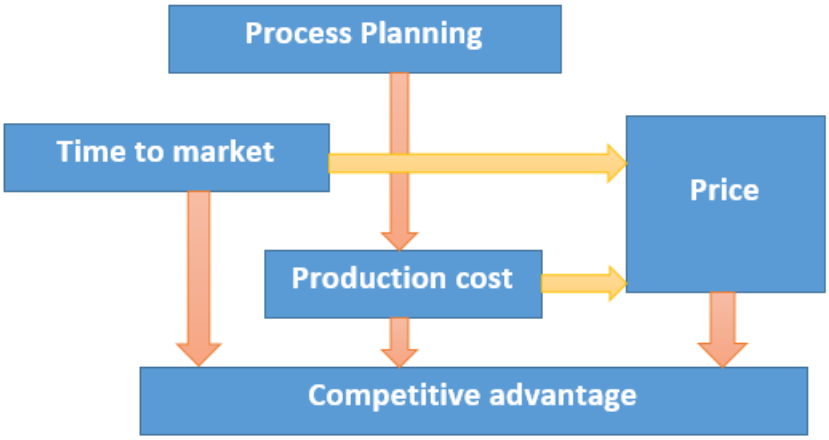
In companies, planning processes can result in increased output, higher precision, and faster turnaround for vital business tasks. A process is described as a set of steps that result in a specific outcome. It converts input into output. Process planning is also called manufacturing planning, material processing, process engineering, and machine routing. It is the act of preparing detailed work instructions to produce a part. It is a complete description of specific stages in the production process. Process planning determines how the product will be produced or service will be provided. Process planning converts design information into the process steps and instructions to powerfully and effectively manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to make simpler and improve process planning and realize more effectual use of manufacturing resources.



It has been documented that process planning is required for new product and services. It is the base for designing factory buildings, facility layout and selecting production equipment. It also affects the job design and quality control.

Objective of Process Planning: The chief of process planning is to augment and modernize the business methods of a company. Process planning is planned to renovate design specification into manufacturing instructions and to make products within the function and quality specification at the least possible costs. This will result in reduced costs, due to fewer staff required to complete the same process, higher competence, by eradicating process steps such as loops and bottlenecks, greater precision, by including checkpoints and success measures to make sure process steps are completed precisely, better understanding by all employees to fulfil their department objectives. Process planning deals with the selection of the processes and the determination of conditions of the processes. The particular operations and conditions have to be realised in order to change raw material into a specified shape. All the specifications and conditions of operations are included in the process plan. The process plan is a certificate such as engineering drawing. Both the engineering drawing and the process plan present the fundamental document for the manufacturing of products. Process planning influences time to market and productions cost. Consequently the planning activities have immense importance for competitive advantage.

Effect of process planning on competitive advantage:



Principles of Process Planning

General principles for evaluating or enhancing processes are as follows:

1. First define the outputs, and then look toward the inputs needed to achieve those outputs.
2. Describe the goals of the process, and assess them frequently to make sure they are still appropriate. This would include specific measures like quality scores and turnaround times.
3. When mapped, the process should appear as a logical flow, without loops back to earlier steps or departments.
4. Any step executed needs to be included in the documentation. If not, it should be eliminated or documented, depending on whether or not it's necessary to the process.
5. People involved in the process should be consulted, as they often have the most current information.

Process planning includes the activities and functions to develop a comprehensive plans and instructions to produce a part. The planning starts with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are routings which specify operations, operation sequences, work centres, standards, tooling and fixtures. This routing becomes a major input to the manufacturing resource planning system to define operations for production activity control purposes and define required resources for capacity requirements planning purposes.

Process plans which characteristically offer more detailed, step-by-step work instructions including dimensions linked to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints. Process plans results in fabrication and assembly drawings to support manufacture and annual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. But process planning is very lengthy and the results differ based on the person doing the planning.

Major steps in process planning: Process planning has numerous steps to complete the project that include the definition, documentation, review and improvement of steps in business processes used in a company.

Definition: The first step is to describe what the process should accomplish. It includes queries like, what is the output of this process? Who receives the output, and how do they define success?, What are the inputs for the process?, Are there defined success measures in place -

such as turnaround time or quality scores? And Are there specific checkpoints in the process that need to be addressed?

Documentation: During the documentation stage, interviews are conducted with company personnel to determine the steps and actions they take as part of a specific business process. The results of these interviews is written down, generally in the form of a flow chart, with copies of any forms used or attached. These flow charts are given to the involved departments to review, to make sure information has been correctly captured in the chart.

Process planning in manufacturing may include the following activities:

1. Selection of raw-stock,
2. Determination of machining methods,
3. Selection of machine tools,
4. Selection of cutting tools,
5. Selection or design of fixtures and jigs,
6. Determination of set-up,
7. Determination of machining sequences,
8. Calculations or determination of cutting conditions,
9. Calculation and planning of tool paths,
10. Processing the process plan

VALUE ANALYSIS

INTRODUCTION:

Value Analysis is one of the major techniques of cost reduction and control. It is a disciplined approach which ensures the necessary functions for the minimum cost without diminishing quality, reliability, performance and appearance.

It is a creative approach to eliminate the unnecessary costs which add neither to quality nor to the appearance of the product. It is a systematic application of techniques to identify the functions of a product or a component and to provide the desired function at the lowest total cost.

These are the days of providing the customer with really best quality products at least cost which is possible through value analysis which proves wrong rightly "Best and Cheap" or "Best is never cheap" or "Cheap is Costly".

WHAT IS VALUE ANALYSIS?

Before understanding the meaning of phrase "value analysis" or "value engineering", let us know about value. 'Value' is one of those terms having good many connotations and even contradictory definitions.

'Value' is a word that is very often used by individuals without being clearly understood. Forget about common people. Even different departments of the same organisation have different opinions of the 'value' of the product that the company manufactures.

The designer equates value with reliability; purchase people with price paid for them; production personnel with that of cost from the angle of manufacture; sales people with what customer is willing to pay.

In the field of value investigation, value refers to economic value, which itself can be sub-divided into four types as cost value, exchange value, use value and esteem value.

"Cost Value" is the measure of sum of all costs incurred in producing the product. The 'cost value', therefore is the sum of raw-material cost, labour cost, tool cost and overheads expended to produce the product.
"Exchange Value" is the measure of all the properties, qualities and features of the product which make the product possible of being traded for another product or for money. In a conventional sense, 'exchange value' refers to the price that a purchaser will offer for the product, the price being dependent upon the satisfaction value which derives from the product.
Value derived from the product consists of two components namely (a) value due to reliability of performance of the product and the value which the possession bestows upon the buyer. These are often referred to as "value in value" and "esteem in value".
"Use Value" is the measure of properties, qualities and features which make the product accomplish a use, work or service. Use value, therefore, is the price paid by the buyer or the cost incurred by the manufacturer in order to ensure that the product performs its intended function efficiently.

Use value in the fundamental form of economic value. An item without use value can have neither exchange value nor esteem value. "Esteem Value" is the measure of properties, features, attractiveness graphic packaging and the like which increases sales appeal or which attracts customers and create in them a strong desire to own the product.
"Esteem value", therefore, is the price paid by the buyer or the cost incurred by the manufacturer beyond the use value. It is the perception value.

Value Analysis Proper:
Value analysis is an organised approach to identify unnecessary costs associated with any product, material, part, component, system or service by analysis of function and efficiently eliminating them without impairing the quality functional reliability or its capacity to give service.
According to Society of American Value Engineers (SAVE) "Value analysis is the systematic application of recognised techniques which identify the function of a product or services establish a monetary value for the function and provide the necessary function reliability at that lowest overall cost."

Mr. Lorry D. Miles production engineer working at General Electricals of USA defined it as "Value analysis is the study of the relationship of design, function and cost of any material or service with an object of reducing its cost through modification of design or material specifications, manufacture by more efficient process, changes in sources of supply, elimination or incorporation into another item."
Thus, value analysis is a systematic application of established techniques to identify the functions of a product or component and to provide the desired functions at the lowest total cost. It is a creative approach to eliminate unnecessary costs which add neither to quality no to the appearance of the product.
It is a rational and structured process consisting of:
(a) Functional analysis to define the reason for the existence of a product or its components,
(b) Creatively analysis for generating new and better alternatives and
(c) Measurement for evaluating the value of present and future concepts.

The phrase value analysis can be defined as a technique which examines the facts of a function and cost of a product in order to determine whether the cost can be reduced or altogether eliminated, while retaining all the features of performance and quality of a product or both.
Therefore, logically, VA is an organised approach of exposing and eliminating unnecessary costs. The method has logical foundation in its fundamental approach to cost reduction and profit improvement and in this objective approach, the VA techniques has to analyse the functional cost of an item and recommend a change.
Put alternatively, VA is a team approach to think functionally about a component as to "what it does" rather than "what it is". This approach is the real test of understanding problems under study.

VALUE ANALYSIS AND VALUE ENGINEERING:
'VA' and 'VE' are closely related terms so much so that many people use them interchangeably. Though the philosophy understanding the two is the same the identification of unnecessary costs yet they are different. The difference lies in the time and stage at which the technique is applied.
"Value Analysis" is the application of a set of techniques to an existing product with a view to improve its value. Thus, it is remedial process. "Value Engineering" is the application of exactly the same set of techniques to a new product at the design stage project concept or preliminary design when no hardware exists to ensure that bad features not added. Thus, it is a 'preventive' measure. In that sense, 'VE' is fundamental and VA is collateral because 'prevention is better than cure."

VALUE ANALYSIS VERSUS OTHER CONVENTIONAL APPROACHES:
Speaking in terms of "cost reduction" value analysis is an effective tool of cost reduction which differs from established conventional approaches such as industrial engineering, production engineering, methods engineering and the like.
The "traditional" or "conventional" approaches differ from this non- conventional or modern technique of VA as under:
First:
Traditional approaches concern "post-production" stage but V.A. can be the 'pre-production' as well as "post production stage" technique.
Second:
Traditional approaches are "methods concerned". They accept the drawing of the part "as is" and, therefore, set to improve the part through analysis of manufacturing methods, machines, materials, tools, jigs and fixtures and the like.
On the other hand, 'VA' does not accept the designed product and its components "as is" but advocates cost reduction through identification of the function and subsequent redesign of the product so as to make it perform its functions at the lowest possible cost.
'VA', therefore, challenges the very design specifications, design requirements and the design itself.
Third:
Traditional methods are mere "cost centered" while VA, in addition to cost improvement, usually seeks to improve quality, reliability, maintainability, safety, performance and alluring features.
Fourth:

VA is more potent than traditional cost reduction techniques. Instances can be brought to surface to demonstrate that VA can remove ten to twenty percent of cost after the traditional methods of cost reduction have applied.

Award of warning is essential at this stage, lnspite of VA's better potential and greater effectiveness, it is not a substitute nor is it intended to replace effective cost reduction techniques which have been in use for many years and have proved effective and valuable in their areas of application. What can be said is that VA can augment or strengthen the process of cost reduction and quality improvement.

PHASES OF VALUE ANALYSIS:

As an exercise, the phases of value analysis are:

1. Phase of Origination:

In the first phase, a value analysis study team is constituted. The project is selected and clearly defined. The team examines in detail the product and its components to understand thoroughly their nature.

2. Phase of Information:

After familiarisation, a functional analysis is carried out to determine the functions and uses of the product and its components. The cost and importance of each function are identified. A value index is calculated on the basis of cost benefit ratio for each function. A list is being prepared in which the items of functions are arranged in decreasing order of value.

3. Phase of Innovation:

This is the creative phase concerned with the generation of new alternatives to replace or removing the existing ones.

4. Phase of Evaluation:

Each and every alternative is analysed and the most promising alternatives are selected. These alternatives are further examined for economic and technical feasibility.

The alternatives finally selected must be capable of performances the desired functions satisfactorily. These must meet the standards of accuracy, reliability, safety, maintenance and repairs, environmental effects and so on.

5. Phase of Choice:

In this phase, report is prepared. This report contains a summary of the study, conclusions and specific proposals. The decision makers choose the alternative. The programs and action places are then developed to implement the chosen alternative.

6. Phase of Implementation:

The chosen alternative is put to the actual use with the help of the programs and action plans so developed in advance.

7. Phase of Review:

The progress of analysis changes in continuously monitored and followed up in order to provide assistance, to clarify any misconceptions and to ensure that the desired results are achieved.

MERITS OF VALUE ANALYSIS:

Value analysis is really a very valuable technique of cost reduction and quality improvement. The specific merits of its are:

1. Improvement in Product Design:

It leads to improvements in the product design so that more useful products are given shape. Now in case of ball points, we do not have clogging, there is easy and even flow of ink and rubber pad is surrounding that reduces figures fatigue.

2. High Quality is maintained:

High quality implies higher value. Thus, dry cells were leaking; now they are leak proof; they are pen size with same power. Latest is that they are rechargeable.

3. Elimination of Wastage:

Value analysis improves the overall efficiency by eliminating the wastages of various types. It was a problem to correct the mistakes. It was done by pasting a paper. Now, pens are there and liquid paper is developed which dries fast and can write back.

4. Savings in Costs:

The main aim of value analysis is to cut the unwanted costs by retaining all the features of performance or even bettering the performance. Good deal of research and development has taken place. Now milk, oils, purees pulp can be packed in tetra packing presuming the qualities and the tetra pack is degradable unlike plastic packs.

5. Generation of New Ideas and Products:

In case of took brushes, those in 1930's were flat and hard, over 60 to 70 years brushes have come making brushing teeth easy, cosy and dosy as it glides and massages gums.

6. Encourages Team-Spirit and Morale:

Value analysis is a tool which is not handled by one, but groups or teams and an organisation itself is a team of personnel having specification. A product is the product of all team efforts. Therefore, it fosters team spirit and manures employee morale as they are pulling together for greater success.

7. Neglected Areas are brought under Focus:

The organisational areas which need attention and improvement are brought under the spot-light and even the weakest gets a chance of getting stronger and more useful finally join's the main strain.

8. Qualification of Intangibles:

The whole process of value analysis is an exercise of converting the intangibles to tangible for decision making purpose. It is really difficult to make decisions on the issues where the things are (variables) not quantifiable.

However, value analysis does it. The decision makers are provided with qualified data and on the basis of decisions are made. Such decisions are bound to be sound.

9. Wide Spectrum of Application:

The principles and techniques of value analysis can be applied to all areas-man be purchasing, hardware, products, systems, procedures and so on.

10. Building and Improving Company Image:

The company's status or image or personality is built up or improved to a great extent. Improvement in quality and reduction in cost means competitive product and good name in product market; it is a good pay master as sales and profits higher and labour market it enjoys reputation; it capital market, nobody hesitates to invest as it is a quality company.

LIMITATIONS:

Like any other cost reduction technique, value analysis has its own limitations. The most common limitations are that the man made excuses are the blocks in implementing these plans of value analysis.

The most common excuses given are:
(a) Lack of motivation
(b) Resistive to change
(c) Inertia
(d) Lack of knowledge and patience
(e) Attitude of 'It will not work in India
(f) We are very small or very big
(g) This has been tried earlier and failed
(h) The change is too big
(i) 'Let competitors try before we try'
(j) Difficulty of teams meeting or team meeting for getting consensus.

CAPACITY PLANNING

What is Capacity Planning?

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

Capacity Planning – Meaning, Importance, Determinants, Procedure

There are four major considerations in capacity planning:

1. Level of demand
2. Cost of production
3. Availability of funds
4. Management policy.

Production has no meaning unless its products can be sold at a remunerative price. Generally, the capacity of plant is limited by the level of current demand. Stable demand makes the task of capacity planning simple while fluctuations in demand create problems concerning the acquisition of resources and matching them up with demand levels. Estimation of demand is, therefore, the first step in capacity planning. Size of the market depends upon the sales potential rather than on the geographical areas.

Demand Forecasts

Demand forecasting is fundamental to effective capacity and sales planning. A demand forecast establishes link between the internal management of the firm and its external environment. Before making a demand forecast, the period of forecast should be decided and an appropriate method of forecasting should be selected.

The nature of product to be sold, the size and characteristics of population, the disposable income, degree of competition, fashion, trends, political conditions, import, export policy of Government, etc., should be taken into consideration. In case of multiple products, product line forecast is useful in deciding the priority of different products in the allocation of limited resources. For example, Delhi Cotton Mills Ltd., may like to know whether to produce more of sugar or textiles.

The demand for new product can be forecast by making consumer surveys, test marketing, product life cycle analysis etc. The annual demand forecast is broken into monthly or weekly forecasts for production scheduling.

Capacity planning is an integral part of the overall production planning for an enterprise. Capacity planning and control is the process of establishing, measuring, monitoring and

adjusting the levels of capacity in order to execute all manufacturing plans and schedules in the best possible manner.

Capacity planning involves the following questions.

1. What type of capacity is required?
2. How much capacity is required?
3. When the capacity is required?

The type of capacity required depends upon the products and services which the enterprise intends to produce or provide. The quantity and timing of capacity is related to the quantity and timing of demand for the product or service. The nature of demand (stable or fluctuating) is another important consideration.

Capacity planning is an important element of production management. Decision concerning capacity is one of the most basics decisions of production. Location, layout, and production technology can be determined only after the capacity is decided. For example, Western Electronics Ltd., can decide the number and type of machines, workers, materials and other inputs only after deciding the number of TV sets to be manufactured by it.

Importance of Capacity Planning

Capacity planning is important due to the following reasons:

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

2. 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.

3. Capacity decisions leave a direct impact on the amount of fixed investment made initially.

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

The following concepts of capacity are involved in capacity planning:

a. Design Capacity: It refers to the maximum output that can possibly be produced in a given period of time. It is the ideal situation.

b. Effective Capacity: Refers to the maximum possible output, given the changes in product mix, machine maintenance, scheduling and operating problems, labour problems, etc. It is usually less than the design capacity.

c. Actual Output: It is the rate of output actually achieved. It cannot exceed effective capacity due to machine breakdowns, labour absenteeism, irregular supply of raw materials, unusual delay in supply of equipment, power breakdown, etc.

The effectiveness of a production system (system effectiveness) can be measured in two ways:

1. Efficiency which is the rate of actual output to effective output, and
2. Utilization which implies the rate of actual output to the design capacity.

Symbolically:

Efficiency = Actual Output / Effective Capacity

Utilization = Actual Output / Design Capacity

Every operating manager should try to increase capacity utilization by increasing effective capacity.

Procedure for Capacity Planning

1. 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), brewery (barrels of bear), cannery (tons of food), Power Company, (megawatts of electricity), etc. Service concerns like hospitals (number of beds), airlines (number of seats), theatres (number of seats), restaurants (number of tables), university (number of students), warehouse (cubic feet of space), etc., can measure capacity in terms of inputs.

2. 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. For example, a company engaged in manufacturing two products may find that one product has a low demand in summer (e.g. coffee or tea) while another product has low demand in winter (e.g. cold drink).

3. 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.

4. 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.

5. 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.

Determinants of Effective Capacity

1. Facilities

The design of production facilities is the most important determinant of effective capacity. Design includes the size and also the provision for expansion of the facilities. Design facilities should be such that the employees should feel comfortable at their work place. Location factors such as distance from the market, supply of labour, transport costs, energy sources are also important. Layout of the work area determines how smoothly the work can be performed. Environmental factors such as lighting, ventilation, etc., influence the effectiveness with which employees can perform the assigned work.

2. Products or Services

Design of the company's products or services exerts a significant influence on capacity utilization. When more uniform is the output, greater can be the standardization of materials and methods and greater can be the utilization of capacity. For instance, a restaurant that offers a

limited menu can prepare and serve meals at a faster rate. Product mix should also be considered because different products have different rates of output.

3. Process

Quantity capacity of a process is the obvious determinant of effective capacity. But if quantity of output does not meet the quality standards, the rate of output is reduced due to the need for inspection and rework activities.

4. Human factors

Job design (tasks that comprise a job), nature of the job (variety of activities involved), training and experience required to perform the job, employee motivation, manager's leadership style, rate of absenteeism and labour turnover are the main human factors influencing the rate of output.

5. Operational Factors

Materials management, scheduling, quality assurance, maintenance policies and equipment breakdowns are important determinants of effective capacity. Late delivery and low acceptability of materials will reduce effective capacity. Inventory problems are a major hurdle in capacity utilization. Similarly, when the alternative equipment has different capabilities there may be scheduling problems.

6. External Factors

Product standards (minimum quality and performance standards), pollution control regulations, safety requirements and trade union attributes exercise tremendous influence on effective capacity. Generally, the external factors act as constraints in capacity utilization.

Unit – III

Plant location – factors influencing plant location, Plant layout- classification of layout with advantages, layout design procedures, Production planning and control – aggregate planning-nature, Strategies, methods, Master production Plan.

PLANT LOCATION AND LAYOUT

INTRODUCTION

Plant location or the facilities location problem is an important strategic level decision making for an organization. One of the key features of a conversion process (manufacturing system) is the efficiency with which the products (services) are transferred to the customers. This fact will include the determination of where to place the plant or facility.

The selection of location is a key-decision as large investment is made in building plant and machinery. It is not advisable or not possible to change the location very often. So an improper location of plant may lead to waste of all the investments made in building and machinery, equipment.

Before a location for a plant is selected, long range forecasts should be made anticipating future needs of the company. The plant location should be based on the company's expansion plan and policy, diversification plan for the products, changing market conditions, the changing sources of raw materials and many other factors that influence the choice of the location decision. The purpose of the location study is to find an optimum location one that will result in the greatest advantage to the organization.

NEED FOR SELECTING A SUITABLE LOCATION

The need for selecting a suitable location arises because of three situations.

I. When starting a new organization, i.e., location choice for the first time.
II. In case of existing organization.
III. In case of Global Location.

I. **In Case of Location Choice for the First Time or New Organizations:**

Cost economies are always important while selecting a location for the first time, but should keep in mind the cost of long-term business/ organizational objectives. The following are the factors to be considered while selecting the location for the new organizations:

1. **Identification of region:**

   The organizational objectives along with the various long-term considerations about marketing, technology, internal organizational strengths and weaknesses, region-specific resources and business environment, legal-governmental environment, social environment and geographical environment suggest a suitable region for locating the operations facility.

2. **Choice of a site within a region:**

   Once the suitable region is identified, the next step is choosing the best site from an available set. Choice of a site is less dependent on the organization's long-term strategies. Evaluation of alternative sites for their tangible and intangible costs will resolve facilities-location problem. The problem of location of a site within the region can be approached with the following cost-oriented non-interactive model, i.e., dimensional analysis.

3. **Dimensional analysis:**
   If all the costs were tangible and quantifiable, the comparison and selection of a site is easy. The location with the least cost is selected. In most of the cases intangible costs which are expressed in relative terms than in absolute terms. Their relative merits and demerits of sites can also be compared easily. Since both tangible and intangible costs need to be considered for a selection of a site, dimensional analysis is used.

Need For Plant Location

The plant Location of warehouses and other facilities are also having direct bearing on the operational performance of organizations.

The existing firms will seek new locations in order to expand the capacity or to place the existing facilities. When the demand for product increases, it will give rise to following decisions:

- Whether to expand the existing capacity and facilities.
- Whether to look for new locations for additional facilities.
- Whether to close down existing facilities to take advantage of some new locations.

II. **In Case of Location Choice for Existing Organization**:

In this case a manufacturing plant has to fit into a multi-plant operations strategy. That is, additional plant location in the same premises and elsewhere under following circumstances:

1. Plant manufacturing distinct products.
2. Manufacturing plant supplying to specific market area.
3. Plant divided on the basis of the process or stages in manufacturing.
4. Plants emphasizing flexibility.

The different operations strategies under the above circumstances could be:

1. **Plants manufacturing distinct products:**

Each plant services the entire market area for the organization. This strategy is necessary where the needs of technological and resource inputs are specialized or distinctively different for the different product-lines. For example, a high quality precision product-line should not be located along with other product-line requiring little emphasis on precision. It may not be proper to have too many contradictions such as sophisticated and old equipment, highly skilled and semi-skilled personnel, delicates processes and those that could permit rough handlings, all under one roof and one set of managers. Such a setting leads to much confusion regarding the required emphasis and the management policies.

Product specialization may be necessary in a highly competitive market. It may be necessary to exploit the special resources of a particular geographical area. The more decentralized these pairs are in terms of the management and in terms of their physical location, the better would be the planning and control and the utilization of the resources.

2. **Manufacturing plants supplying to a specific market area:**

Here, each plant manufactures almost all of the company's products. This type of strategy is useful where market proximity consideration dominates the resources and technology considerations. This strategy requires great deal of coordination from the corporate office. An extreme example of this strategy is that of soft drinks bottling plants.

3. **Plants divided on the basis of the process or stages in manufacturing:**

Each production process or stage of manufacturing may require distinctively different equipment capabilities, labor skills, technologies, and managerial policies and emphasis. Since the products

of one plant feed into the other plant, this strategy requires much centralized coordination of the manufacturing activities from the corporate office that are expected to understand the various technological aspects of all the plants.

4. **Plants emphasizing flexibility:**

This requires much coordination between plants to meet the changing needs and at the same time ensure efficient use of the facilities and resources. Frequent changes in the long-term strategy in order to improve be efficiently temporarily, are not healthy for the organization. In any facility location problem the central question is: 'Is this a location at which the company can remain competitive for a long time?'

For an established organization in order to add on to the capacity, following are the ways:

- Expansion of the facilities at the existing site: This is acceptable when it does not violate the basic business and managerial outlines, i.e ., philosophies, purposes, strategies and capabilities. For example, expansion should not compromise quality, delivery, or customer service.
- Relocation of the facilities (closing down the existing ones): This is a drastic step which can be called as 'Uprooting and Transplanting'. Unless there are very compelling reasons, relocation is not done. The reasons will be either bringing radical changes in technology, resource availability or other destabilization.

All these factors are applicable to service organizations, whose objectives, priorities and strategies may differ from those of hardcore manufacturing organizations.

III. **In Case of Global Location**:

Because of globalization, multinational corporations are setting up their organizations in India and Indian companies are extending their operations in other countries. In case of global locations there is scope for virtual proximity and virtual factory.

VIRTUAL PROXIMITY: With the advance in telecommunications technology, a firm can be in virtual proximity to its customers. For a software services firm much of its logistics is through the information/ communication pathway. Many firms use the communications highway for conducting a large portion of their business transactions. Logistics is certainly an important factor in deciding on a location whether in the home country or abroad. Markets have to be reached. Customers have to be contacted. Hence, a market presence in the country of the customers is quite necessary.

VIRTUAL FACTORY: Many firms based in USA and UK in the service sector and in the manufacturing sector often out sources part of their business processes to foreign locations such as India. Thus, instead of one's own operations, a firm could use its business associates' operations facilities. The Indian BPO firm is a foreign-based company's 'virtual service factory'. So a location could be one's own or one's business associates. The location decision need not always necessarily pertain to own operations.

REASONS FOR GALOBAL/FOREIGN LOCATION

A. **Tangible Reasons**:

The tangible reasons for setting up an operations facility abroad could be as follows:
Reaching the customer: One obvious reason for locating a facility abroad is that of capturing a share of the market expanding worldwide. The phenomenal growth of the GDP of India is a big

reason for the multinationals to have their operations facilities in our country. An important reason is that of providing service to the customer promptly and economically which is logistics-dependent. Therefore, cost and case of logistics is a reason for setting up manufacturing facilities abroad. By logistics set of activities closes the gap between productions of goods/services and reaching of these intended goods/services to the customer to his satisfaction. Reaching the customer is thus the main objective. The tangible and intangible gains and costs depend upon the company defining for itself as to what that 'reaching' means. The tangible costs could be the logistics related costs; the intangible costs may be the risk of operating is a foreign country. The tangible gains are the immediate gains; the intangible gains are an outcome of what the company defines the concepts of reaching and customer for itself.

The other tangible reasons could be as follows:

a. The host country may offer substantial tax advantages compared to the home country.
b. The costs of manufacturing and running operations may be substantially less in that foreign country. This may be due to lower labor costs, lower raw material cost, better availability of the inputs like materials, energy, water, ores, metals, key personnel etc.
c. The company may overcome the tariff barriers by setting up a manufacturing plant in a foreign country rather than exporting the items to that country.

B. **Intangible Reasons**:

The intangible reasons for considering setting up an operations facility abroad could be as follows:

1. **Customer-related Reasons**:
   a. With an operations facility in the foreign country, the firm's customers may feel secure that the firm is more accessible. Accessibility is an important 'service quality' determinant.
   b. The firm may be able to give a personal tough.
   c. The firm may interact more intimately with its customers and may thus understand their requirements better.
   d. It may also discover other potential customers in the foreign location.
2. **Organizational Learning-related Reasons**:
   a. The firm can learn advanced technology. For example, it is possible that cutting-edge technologies can be learnt by having operations in a technologically more advanced country. The firm can learn from advanced research laboratories/universities in that country. Such learning may help the entire product-line of the company.
   b. The firm can learn from its customers abroad. A physical location there may be essential towards this goal.
   c. It can also learn from its competitors operating in that country. For this reason, it may have to be physically present where the action is.
   d. The firm may also learn from its suppliers abroad. If the firm has a manufacturing plant there, it will have intensive interaction with the suppliers in that country from whom there may be much to learn in terms of modern and appropriate technology, modern management methods, and new trends in business worldwide.
3. **Other Strategic Reasons**:
   a. The firm by being physically present in the host country may gain some 'local boy' kind of psychological advantage. The firm is no more a 'foreign' company just sending its products across international borders. This may help the firm in lobbying with the government of that country and with the business associations in that country.

b. The firm may avoid 'political risk' by having operations in multiple countries.
c. By being in the foreign country, the firm can build alternative sources of supply. The firm could, thus, reduce its supply risks.
d. The firm could hunt for human capital in different countries by having operations in those countries. Thus, the firm can gather the best of people from across the globe.
e. Foreign locations in addition to the domestic locations would lower the market risks for the firm. If one market goes slow the other may be doing well, thus lowering the overall risk.

FACTORS AFFECTING IN FACILITY LOCATION:

Facility location is the process of determining a geographic site for a firm's operations. Managers of both service and manufacturing organizations must weigh many factors when assessing the desirability of a particular site, including proximity to customers and suppliers, labor costs, and transportation costs.

Location conditions are complex and each comprises a different Characteristic of a tangible (i.e. Freight rates, production costs) and non-tangible (i.e. reliability, frequency security, quality) nature.

Location conditions are hard to measure. Tangible cost based factors such as wages and products costs can be quantified precisely into what makes locations better to compare. On the other hand non-tangible features, which refer to such characteristics as reliability, availability and security, can only be measured along an ordinal or even nominal scale. Other non-tangible features like the percentage of employees that are unionized can be measured as well. To sum this up non-tangible features are very important for business location decisions.

It is appropriate to divide the factors, which influence the plant location or facility location on the basis of the nature of the organization as

1. **General location factors**, which include controllable and uncontrollable factors for all type of organizations.
2. **Specific location factors** specifically required for manufacturing and service organizations.

Location factors can be further divided into two categories: Dominant factors are those derived from competitive priorities (cost, quality, time, and flexibility) and have a particularly strong impact on sales or costs. Secondary factors also are important, but management may downplay or even ignore some of them if other factors are more important.

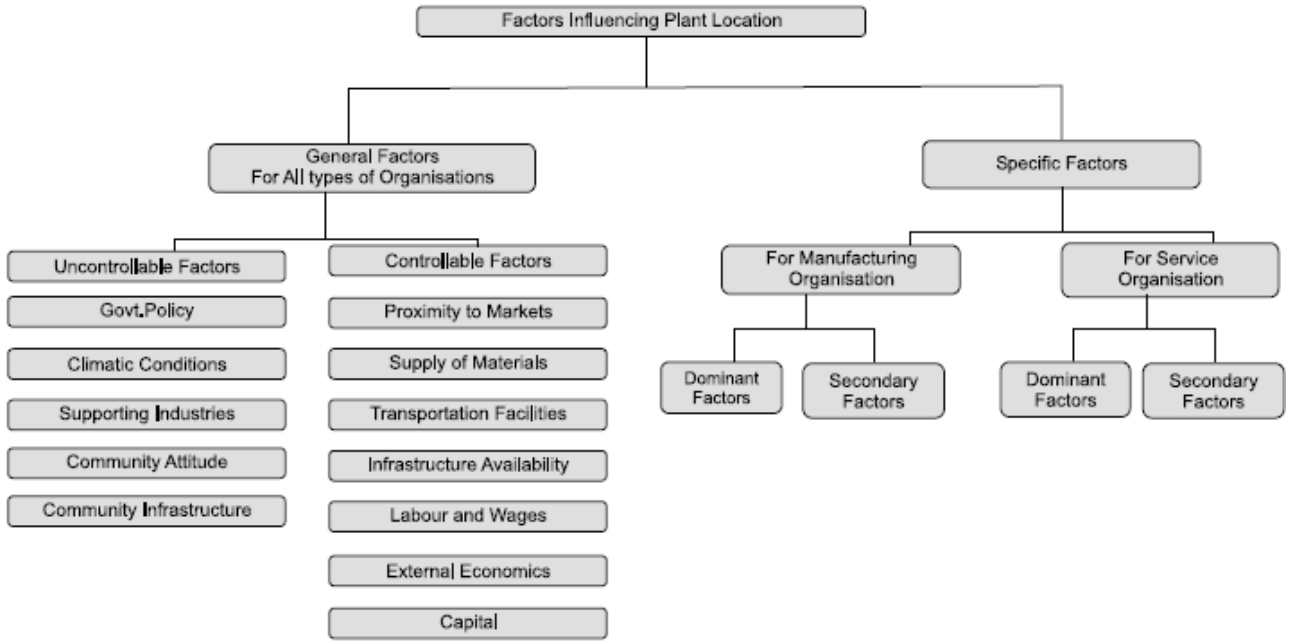
FACTORS INFLUENCING PLANT LOCATION

General Location Factors:

Following are the general factors required for location of plant in case of all types of organisations.

CONTROLLABLE FACTORS

1. Proximity to markets.
2. Supply of materials
3. Transportation facilities
4. Infrastructure availability
5. Labour and wages



6. External economies
7. Capital

UNCONTROLLABLE FACTORS

8. Government policy
9. Climate conditions
10. Supporting industries and services
11. Community and labor attitudes
12. Community Infrastructure

CONTROLLABLE FACTORS

1. **Proximity to markets:**

Every company is expected to serve its customers by providing goods and services at the time needed and at reasonable price organizations may choose to locate facilities close to the market or away from the market depending upon the product. When the buyers for the product are concentrated, it is advisable to locate the facilities close to the market. Locating nearer to the market is preferred if,

- The products are delicate and susceptible to spoilage.
- After sales services are promptly required very often.
- Transportation cost is high and increase the cost significantly.
- Shelf life of the product is low.

Nearness to the market ensures a consistent supply of goods to customers and reduces the cost of transportation.

2. **Supply of raw material:**

It is essential for the organization to get raw material in right qualities and time in order to have an uninterrupted production. This factor becomes very important if the materials are perishable and cost of transportation is very high. General guidelines suggested by Yaseen regarding effects of raw materials on plant location are:

- When a single raw material is used without loss of weight, locate the plant at the raw material source, at the market or at any point in between.

- When weight loosing raw material is demanded, locate the plant at the raw material source.
- When raw material is universally available, locate close to the market area.
- If the raw materials are processed from variety of locations, the plant may be situated so as to minimize total transportation costs.

Nearness to raw material is important in case of industries such as sugar, cement, jute and cotton textiles.

3. **Transportation facilities:**

Speedy transport facilities ensure timely supply of raw materials to the company and finished goods to the customers. The transport facility is a prerequisite for the location of the plant. There are five basic modes of physical transportation, air, road, rail, water and pipeline. Goods that are mainly intended for exports demand a location near to the port or large airport. The choice of transport method and hence the location will depend on relative costs, convenience, and suitability. Thus transportation cost to value added is one of the criteria for plant location.

4. **Infrastructure availability:**

The basic infrastructure facilities like power, water and waste disposal, etc., become the prominent factors in deciding the location. Certain types of industries are power hungry e.g., aluminum and steel and they should be located close to the power station or location where uninterrupted power supply is assured throughout the year. The non-availability of power may become a survival problem for such industries. Process industries like paper, chemical, cement, etc., require continuous. Supply of water in large amount and good quality, and mineral content of water becomes an important factor. A waste disposal facility for process industries is an important factor, which influences the plant location.

5. **Labor and wages:**

The problem of securing adequate number of labor and with skills specific is a factor to be considered both at territorial as well as at community level during plant location. Importing labor is usually costly and involve administrative problem. The history of labor relations in a prospective community is to be studied. Prospective community is to be studied. Productivity of labor is also an important factor to be considered. Prevailing wage pattern, cost of living and industrial relation and bargaining power of the unions' forms in important considerations.

6. **External economies of scale:**

External economies of scale can be described as urbanization and locational economies of scale. It refers to advantages of a company by setting up operations in a large city while the second one refers to the "settling down" among other companies of related Industries. In the case of urbanization economies, firms derive from locating in larger cities rather than in smaller ones in a search of having access to a large pool of labor, transport facilities, and as well to increase their markets for selling their products and have access to a much wider range of business services.

Location economies of scale in the manufacturing sector have evolved over time and have mainly increased competition due to production facilities and lower production costs as a result of lower transportation and logistical costs. This led to manufacturing districts where many companies of related industries are located more or less in the same area. As large corporations have realized that inventories and warehouses have become a major cost factor, they have tried reducing inventory costs by launching "Just in Time" production system (the so called Kanban System). This high efficient production system was one main factor in the Japanese car industry for being so successful. Just in time ensures to get spare parts from suppliers within just a few hours after ordering. To fulfill these criteria corporations have to be located in the same area increasing their market and service for large corporations.

7. **Capital:**

By looking at capital as a location condition, it is important to distinguish the physiology of fixed capital in buildings and equipment from financial capital. Fixed capital costs as building and construction costs vary from region to region. But on the other hand buildings can also be rented and existing plants can be expanded. Financial capital is highly mobile and does not very much influence decisions. For example, large Multinational Corporations such as Coca- Cola operate in many different countries and can raise capital where interest rates are lowest and conditions are most suitable.Capital becomes a main factor when it comes to venture capital. In that case young, fast growing (or not) high tech firms are concerned which usually have not many fixed assets. These firms particularly need access to financial capital and also skilled educated employees.

UNCONTROLLABLE FACTORS

8. **Government policy:**

The policies of the state governments and local bodies concerning labor laws, building codes, safety, etc., are the factors that demand attention. In order to have a balanced regional growth of industries, both central and state governments in our country offer the package of incentives to entrepreneurs in particular locations. The incentive package may be in the form of exemption from a safes tax and excise duties for a specific period, soft loan from financial institutions, subsidy in electricity charges and investment subsidy. Some of these incentives may tempt to locate the plant to avail these facilities offered.

9. **Climatic conditions:**

The geology of the area needs to be considered together with climatic conditions (humidity, temperature). Climates greatly influence human efficiency and behavior. Some industries require specific climatic conditions e.g., textile mill will require humidity.

10. **Supporting industries and services:**

Now a day the manufacturing organization will not make all the components and parts by itself and it subcontracts the work to vendors. So, the source of supply of component parts will be the one of the factors that influences the location.The various services like communications, banking services professional consultancy services and other civil amenities services will play a vital role in selection of a location.

11. **community and labor attitudes:**

Community attitude towards their work and towards the prospective industries can make or mar the industry. Community attitudes towards supporting trade union activities are important criteria. Facility location in specific location is not desirable even though all factors are favoring because of labor attitude towards management, which brings very often the strikes and lockouts.

12. **Community infrastructure and amenity:**

All manufacturing activities require access to a community infrastructure, most notably economic overhead capital, such as roads, railways, port facilities, power lines and service facilities and social overhead capital like schools, universities and hospitals.

These factors are also needed to be considered by location decisions as infrastructure is enormously expensive to build and for most manufacturing activities the existing stock of infrastructure provides physical restrictions on location possibilities.

SPECIFIC LOCATION FACTORS FOR MANUFACTURING ORGANIZATION

DOMINANT FACTORS

Factors dominating location decisions for new manufacturing plants can be broadly classified in six groups. They are listed in the order of their importance as follows.

1. Favorable labor climate
2. Proximity to markets
3. Quality of life
4. Proximity to suppliers and resources
5. Utilities, taxes, and real estate costs

1. **Favorable labor climate:**

A favorable labor climate may be the most important factor in location decisions for labour-intensive firms in industries such as textiles, furniture, and consumer electronics. Labor climate includes wage rates, training requirements, attitudes toward work, worker productivity, and union strength. Many executives consider weak unions or al low probability of union organizing efforts as a distinct advantage.

2. **Proximity to markets:**

After determining where the demand for goods and services is greatest, management must select a location for the facility that will supply that demand. Locating near markets is particularly important when the final goods are bulky or heavy and outbound transportation rates are high. For example, manufacturers of products such as plastic pipe and heavy metals all emphasize proximity to their markets.

3. **Quality of life:**

Good schools, recreational facilities, cultural events, and an attractive lifestyle contribute to quality of life. This factor is relatively unimportant on its own, but it can make the difference in location decisions.

4. **Proximity to suppliers and resources:**

In many companies, plants supply parts to other facilities or rely on other facilities for management and staff support. These require frequent coordination and communication, which can become more difficult as distance increases?

5. **Utilities, taxes, and real estate costs:**

Other important factors that may emerge include utility costs (telephone, energy, and water), local and state taxes, financing incentives offered by local or state governments, relocation costs, and land costs.

SECONDARY FACTORS:

There are some other factors needed to be considered, including room for expansion, construction costs, accessibility to multiple modes of transportation, the cost of shuffling people and materials between plants, competition from other firms for the workforce, community attitudes, and many others. For global operations, firms are emphasizing local employee skills and education and the local infrastructure.

Specific Location Factors for Service Organization

DOMINANT FACTORS:

The factors considered for manufacturers are also applied to service providers, with one important addition the 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.

PROXIMITY TO CUSTOMERS:
Location is a key factor in determining how conveniently customers can carry on business with a firm. For example, few people would like to go to remotely located dry cleaner or supermarket if another is more convenient. Thus the influence of location on revenues tends to be the dominant factor.

TRANSPORTATION COSTS AND PROXIMITY TO MARKETS:
For warehousing and distribution operations, transportation costs and proximity to markets are extremely important. With a warehouse nearby, many firms can hold inventory closer to the customer, thus reducing delivery time and promoting sales.

LOCATION OF COMPETITORS:
One complication in estimating the sales potential at different location is the impact of competitors. Management must not only consider the current location of competitors but also try to anticipate their reaction to the firm's new location. Avoiding areas where competitors are already well established often pays. However, in some industries, such as new-car sales showrooms and fast- food chains, locating near competitors is actually advantageous. The strategy is to create a critical mass, whereby several competing firms clustered in one location attract more customers than the total number who would shop at the same stores at scattered locations. Recognizing this effect, some firms use a follow –the leader strategy when selecting new sites.

SECONDARY FACTORS:
Retailers also must consider the level of retail activity, residential density, traffic flow, and site visibility. Retail activity in the area is important, as shoppers often decide on impulse to go shopping or to eat in a restaurant. Traffic flows and visibility are important because businesses' customers arrive in cars. Visibility involves distance from the street and size of nearby buildings and signs. High residential density ensures nighttime and weekend business when the population in the area fits the firm's competitive priorities and target market segment.

Plant Layout in Operation Management

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work centers 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".

Plant Location and Plant Layout in Production Management

The Plant location and Plant layout in production management are

PLANT LAYOUT

DEFINITION OF PLANT LAYOUT

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work centers 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".

OBJECTIVES OF PLANT LAYOUT:

The primary goal of the plant layout is to maximize 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. Minimize materials handling and cost.
5. Effective utilization of men, equipment and space.
6. Make effective utilization 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 utilization 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 utilization:** The good layout is one that utilizes both horizontal and vertical space. It is not only enough if only the floor space is utilized optimally but the third dimension, i.e., the height is also to be utilized 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

CLASSIFICATION AND ADVANTAGES OF PLANT LAYOUT

Layouts can be classified into the following five categories:

1. Process layout.
2. Product layout
3. Combination layout
4. Fixed position layout
5. Group layout

Process Layout:

Process layout is recommended for batch production. All machines performing similar type of operations are grouped at one location in the process layout e.g., all lathes, milling machines, etc. are grouped in the shop will be clustered in like groups. Thus, in process layout the arrangement of facilities are grouped together according to their functions. A typical process layout is shown in the following figure. The flow paths of material through the facilities from one functional area to another vary from product to product. Usually the paths are long and there will be possibility of backtracking.

Process layout is normally used when the production volume is not sufficient to justify a product layout. Typically, job shops employ process layouts due to the variety of products manufactured and their low production volumes.

Process layout

Advantages

1. In process layout machines are better utilized and fewer machines are required.
2. Flexibility of equipment and personnel is possible in process layout.
3. Lower investment on account of comparatively less number of machines and lower cost of general purpose machines.
4. Higher utilization of production facilities.
5. A high degree of flexibility with regards to work distribution to machineries and workers.
6. The diversity of tasks and variety of job makes the job challenging and interesting.
7. Supervisors will become highly knowledgeable about the functions under their department.

Limitations

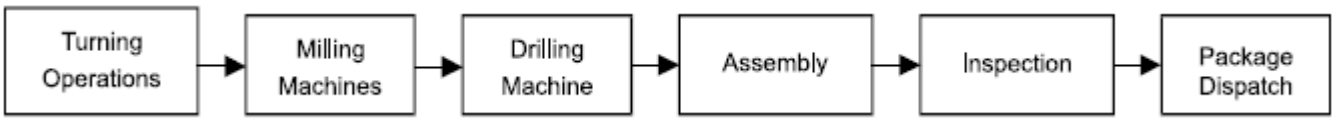
1. Backtracking and long movements may occur in the handling of materials thus, reducing material handling efficiency.
2. Material handling cannot be mechanized which adds to cost.
3. Process time is prolonged which reduce the inventory turnover and increases the in- process inventory.
4. Lowered productivity due to number of set-ups.
5. Throughput (time gap between in and out in the process) time is longer.
6. Space and capital are tied up by work-in-process.

Product Layout:

In this type of layout, machines and auxiliary services are located according to the processing sequence of the product. If the volume of production of one or more products is large, the facilities can be arranged to achieve efficient flow of materials and lower cost per unit. Special purpose machines are used which perform the required function quickly and reliably.

The product layout is selected when the volume of production of a product is high such that a separate production line to manufacture it can be justified. In a strict product layout, machines are not shared by different products. Therefore, the production volume must be sufficient to achieve satisfactory utilization of the equipment. A typical product layout is shown in the following figure.

Product layout



Advantages

1. The flow of product will be smooth and logical in flow lines.
2. In-process inventory is less.
3. Throughput time is less.
4. Minimum material handling cost.
5. Simplified production, planning and control systems are possible.
6. Less space is occupied by work transit and for temporary storage.
7. Reduced material handling cost due to mechanised handling systems and straight flow.
8. Perfect line balancing which eliminates bottlenecks and idle capacity.
9. Manufacturing cycle is short due to uninterrupted flow of materials.
10. Small amount of work-in-process inventory.
11. Unskilled workers can learn and manage the production.

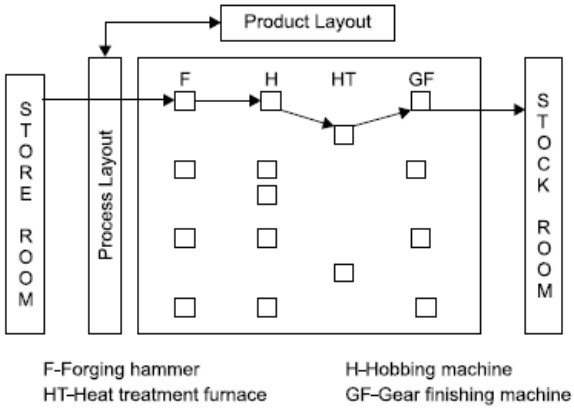
Limitations

1. A breakdown of one machine in a product line may cause stoppages of machines in the downstream of the line.
2. A change in product design may require major alterations in the layout.
3. The line output is decided by the bottleneck machine.
4. Comparatively high investment in equipments is required.
5. Lack of flexibility. A change in product may require the facility modification.

Combination 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. The following figure shows a combination type of layout for manufacturing different sized gears.

Combination layout for making different types and sizes of gears

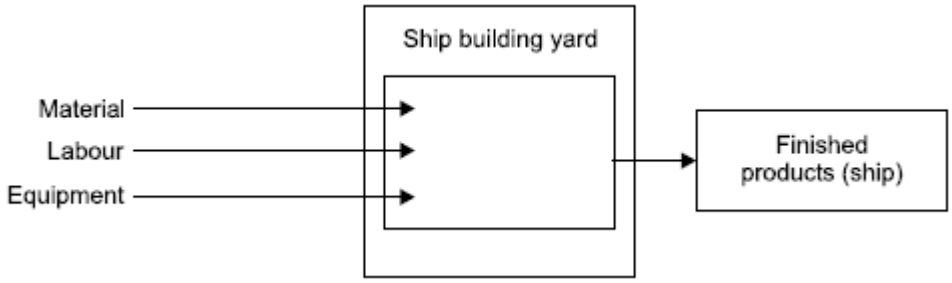


Fixed Position Layout:

This is also called the **project type** of layout. In this type of layout, the material, or major components remain in a fixed location and tools, machinery, men and other materials are brought

to this location. This type of layout is suitable when one or a few pieces of identical heavy products are to be manufactured and when the assembly consists of large number of heavy parts, the cost of transportation of these parts is very high.

Fixed position layout



Advantages

The major advantages of this type of layout are:

1. Helps in job enlargement and upgrades the skills of the operators.
2. The workers identify themselves with a product in which they take interest and pride in doing the job.
3. Greater flexibility with this type of layout.
4. Layout capital investment is lower.

Group Layout (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.

Group technology layout in Operation Management

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.

The application of group technology involves two basic steps; first step is to determine component families or groups. The second step in applying group technology is to arrange the plants equipment used to process a particular family of components. This represents small plants within the plants. The group technology reduces production planning time for jobs. It reduces the set-up time.

Thus **group layout** is a combination of the product layout and process layout. It combines the advantages of both layout systems. If there are m-machines and n-components, in a group layout (Group-Technology Layout), the M -machines and n -components will be divided into number of machine-component cells (group) such that all the components assigned to a cell are almost processed within that cell itself. Here, the objective is to minimize the intercell movements.

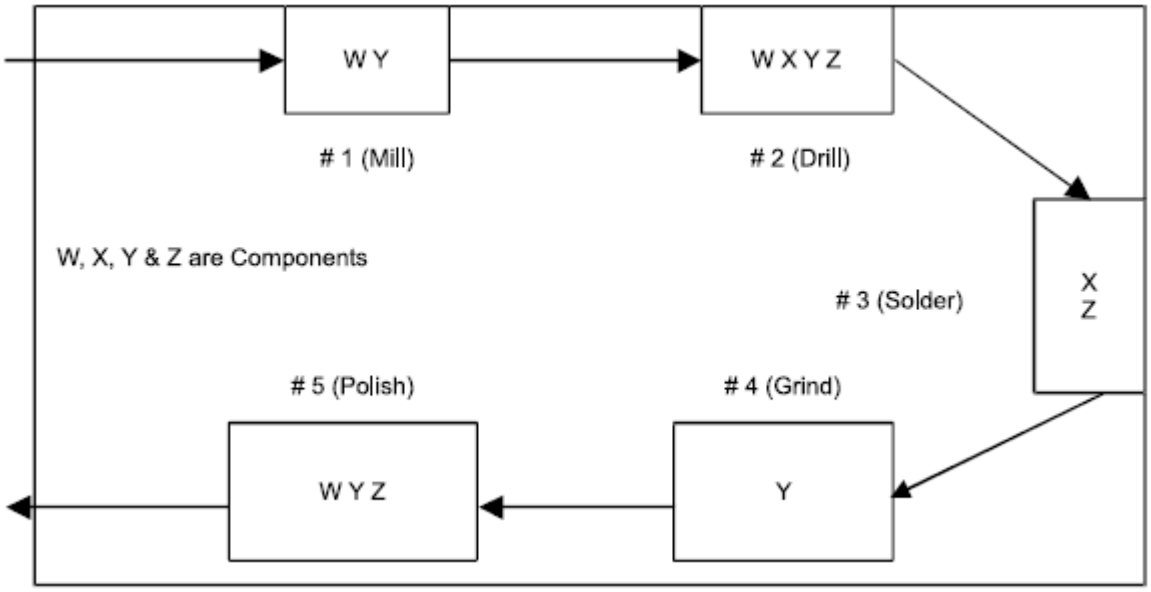
The basic aim of a group technology layout is to identify families of components that require similar of satisfying all the requirements of the machines are grouped into cells. Each cell is capable of satisfying all the requirements of the component family assigned to it.

The layout design process considers mostly a single objective while designing layouts. In process layout, the objective is to minimize the total cost of materials handling. Because of the nature of the layout, the cost of equipments will be the minimum in this type of layout. In product layout,

the cost of materials handling will be at the absolute minimum. But the cost of equipments would not be at the minimum if the equipments are not fully utilized.

In-group technology layout, the objective is to minimize the sum of the cost of transportation and the cost of equipments. So, this is called as multi-objective layout. A typical process layout is shown .

Group layout or Cellular layout



Advantages of Group Technology Layout:

Group Technology layout can increase

1. Component standardization and rationalization.
2. Reliability of estimates.
3. Effective machine operation and productivity.
4. Customer service.

It can decrease the

1. Paper work and overall production time.
2. Work-in-progress and work movement.
3. Overall cost.

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.

INTRODUCTION OF PRODUCTION PLANNING AND CONTROL:

Production planning and control is a tool available to the management to achieve the stated objectives. Thus, a production system is encompassed by the four factors. *i.e*., quantity, quality, cost and time.

Production planning starts with the analysis of the given data, *i.e*., demand for products, delivery schedule etc., and on the basis of the information available, a scheme of utilization of firms resources like machines, materials and men are worked out to obtain the target in the most economical way.

Once the plan is prepared, then execution of plan is performed in line with the details given in the plan. Production control comes into action if there is any deviation between the actual and planned. The corrective action is taken so as to achieve the targets set as per plan by using control techniques.

Definition of Production Planning & Control (PPC)

Thus production planning and control can be defined as the "*direction and coordination of firms' resources towards attaining the prefixed goals*." Production planning and control helps to achieve uninterrupted flow of materials through production line by making available the materials at right time and required quantity.

What is Production Planning & Control (PPC)?

Production planning and control is a predetermined process which includes the use of human resource, raw materials, machines etc. PPC is the technique to plan each and every step in a long series of separate operation. It helps to take the right decision at the right time and at the right place to achieve maximum efficiency.

NEED FOR PRODUCTION PLANNING AND CONTROL

The present techno-economic scenario of India emphasize on competitiveness in manufacturing. Indian industries have to streamline the production activities and attain the maximum utilization of firms' resources to enhance the productivity. Production planning and control serves as a useful tool to coordinate the activities of the production system by proper planning and control system. Production system can be compared to the nervous system with PPC as a brain.

Production planning and control is needed to achieve:

1. Effective utilization of firms' resources.
2. To achieve the production objectives with respect to quality, quantity, cost and timeliness of delivery.
3. To obtain the uninterrupted production flow in order to meet customers varied demand with respect to quality and committed delivery schedule.
4. To help the company to supply good quality products to the customer on the continuous basis at competitive rates.

Need of Production Planning and Control

Production planning is a pre-production activity. It is the pre-determination of manufacturing requirements such as manpower, materials, machines and manufacturing process. Ray wild defines "*Production planning is the determination, acquisition and arrangement of all facilities necessary for future production of products."*

It represents the design of production system. Apart from planning the resources, it is going to organize the production. Based on the estimated demand for company's products, it is going to establish the production programme to meet the targets set using the various resources.

Production Control:

Inspite of planning to the minute details, most of the time it is not possible to achieve production 100 per cent as per the plan. There may be innumerable factors which affect the production

system and because of which there is a deviation from the actual plan. Some of the factors that affect are:

1. Non-availability of materials (due to shortage, etc.);
2. Plant, equipment and machine breakdown;
3. Changes in demand and rush orders;
4. Absenteeism of workers; and
5. Lack of coordination and communication between various functional areas of business.

Thus, if there is a deviation between actual production and planned production, the control function comes into action. Production control through control mechanism tries to take corrective action to match the planned and actual production. Thus, production control reviews the progress of the work, and takes corrective steps in order to ensure that programmed production takes place. The essential steps in control activity are:

1. Initiating the production,
2. Progressing, and
3. Corrective action based upon the feedback and reporting back to the production planning.

OBJECTIVES OF PRODUCTION PLANNING AND CONTROL

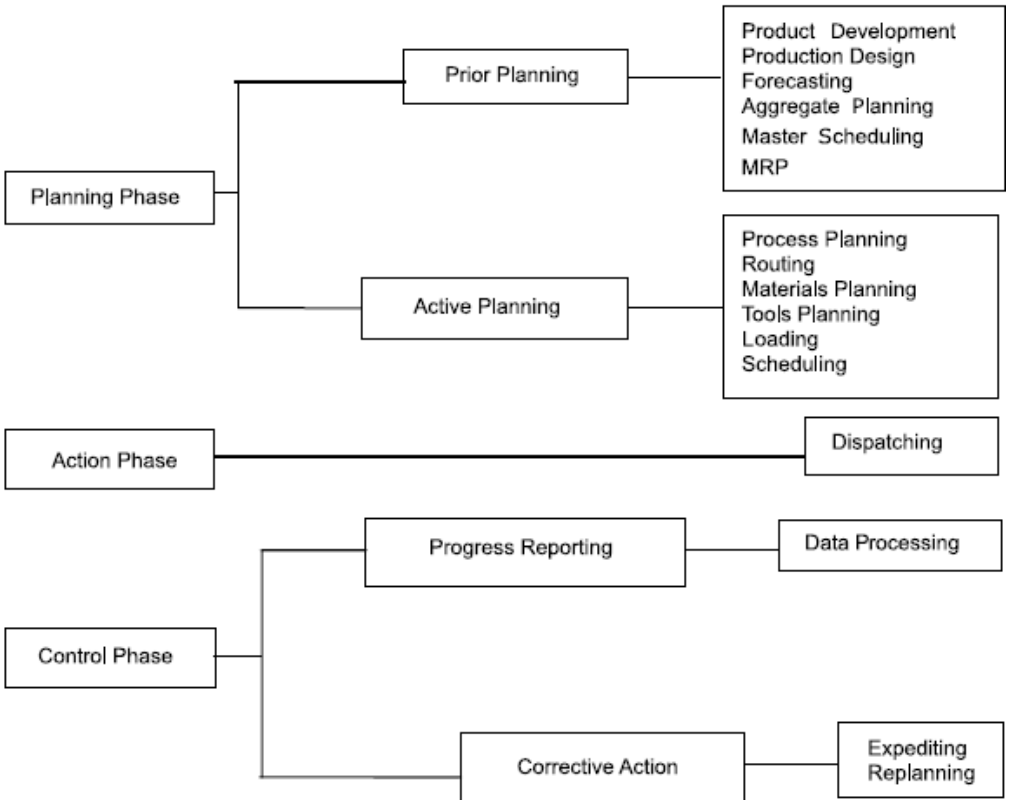
1. Systematic planning of production activities to achieve the highest efficiency in production of goods/services.
2. To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
3. Optimum scheduling of resources.
4. Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
5. To conform to delivery commitments.
6. Materials planning and control.
7. To be able to make adjustments due to changes in demand and rush orders.

ELEMENTS OR STAGES OF PRODUCTION PLANNING AND CONTROL

The stages of Production planning and control has three phases namely:

A. Planning Phase
B. Action Phase
C. Control Phase

Phases of production planning and control



I. PLANNING PHASE:

Planning is an exercise of intelligent anticipation in order to establish how an objective can be achieved or a need fulfilled in circumstances, which are invariably restrictive. Production planning determines the optimal schedule and sequence of operations economic batch quantity, machine assignment and dispatching priorities for sequencing. It has two categories of planning namely

1. Prior planning
2. Active planning.

PRIOR PLANNING:

Prior planning means pre-production planning. This includes all the planning efforts, which are taking place prior to the active planning.

Modules of pre-planning:

The modules of prior planning are as follows:

1. ***Product development and design*** is the process of developing a new product with all the features, which are essential for effective use in the field, and designing it accordingly. At the design stage, one has to take several aspects of design like, design for selling, design for manufacturing and design for usage.
2. ***Forecasting*** is an estimate of demand, which will happen in future. Since, it is only an estimate based on the past demand, proper care must be taken while estimating it. Given the sales forecast, the factory capacity, the aggregate inventory levels and size of the work force,

the manager must decide at what rate of production to operate the plant over an intermediate planning horizon.

3. ***Aggregate planning*** aims to find out a product wise planning over the intermediate planning horizon.
4. ***Material requirement planning*** is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy the master production schedule.

ACTIVE PLANNING:

The modules of active planning are: Process planning and routing, Materials planning. Tools planning, Loading, Scheduling etc.

1. ***Process planning and routing*** is a complete determination of the specific technological process steps and their sequence to produce products at the desired quality, quantity and cost. It determines the method of manufacturing a product selects the tools and equipments, analyses how the manufacturing of the product will fit into the facilities. Routing in particular prescribes the flow of work in the plant and it is related to the considerations of layout, temporary locations for raw materials and components and materials handling systems.
2. A ***material planning*** is a process which determines the requirements of various raw materials/subassemblies by considering the trade-off between various cost components like, carrying cost, ordering cost, shortage cost, and so forth.
3. ***Tools' planning*** determines the requirements of various tools by taking process specification (surface finish, length of the job, overall depth of cut etc.), material specifications (type of material used, hardness of the material, shape and size of the material etc.) and equipment specifications (speed range, feed range, depth of cut range etc.).
4. ***Loading*** is the process of assigning jobs to several machines such that there is a load balance among the machines. This is relatively a complex task, which can be managed with the help of efficient heuristic procedures.
5. ***Scheduling*** is the time phase of loading and determines when and in what sequence the work will be carried out. This fixes the starting as well as the finishing time for each job.

II. ACTION PHASE:

Action phase has the major step of **dispatching.** Dispatching is the transition from planning phase to action phase. In this phase, the worker is ordered to start manufacturing the product. The tasks which are included in dispatching are job order, store issue order, tool order, time ticket, inspection order, move order etc.

The **job order** number is the key item which is to be mentioned in all other reports/orders.

Stores issue order gives instruction to stores to issue materials for manufacturing the product as per product specifications. As per tooling requirements for manufacturing the product, the **tool Order** instruct the tool room to issue necessary tools.

Time ticket is nothing but a card which is designed to note down the actual time taken at various processes. This information is used for deciding the costs for future jobs of similar nature and also for performing variance analysis, which helps to exercise control.

Job order is the official authorization to the shop floor to start manufacturing the product. Generally, the process sequence will contain some testing and inspection. So, these are to be instructed to inspection wing in the form of inspection order for timely testing and inspection so that the amount of rework is minimized. The manufacture of product involves moving raw materials/subassemblies to the main line. This is done by a well-designed materials handling

system. So, proper instruction is given to the materials handling facilities for major movements of materials/subassemblies in the form of a move order. Movements which involve less distance and fewer loads are managed at the shop floor level based on requests from operators.

III. CONTROL PHASE:

The control phase has the following two major modules:

1. Progress reporting, and
2. Corrective action.

1. ***PROGRESS REPORTING***:

   In progress reporting, the data regarding what is happening with the job is collected. Also, it helps to make comparison with the present level of performance. The various data pertaining to materials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analyzed for the purpose of progress reporting. These data are used for performing variance analysis, which would help us to identify critical areas that deserve immediate attention for corrective actions.

2. ***CORRECTIVE ACTION***:

   The tasks under corrective action primarily make provisions for an unexpected event. Some examples of corrective actions are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decisions, expediting the work, pre-planning, and so on. Due to unforeseen reasons such as, machine breakdown, labor absenteeism, too much rejection due to poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear picture of the situation to progress further. Under such situation, it is to be re-examined for selecting appropriate course of action. Expediting means taking action if the progress reporting indicates deviations from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.

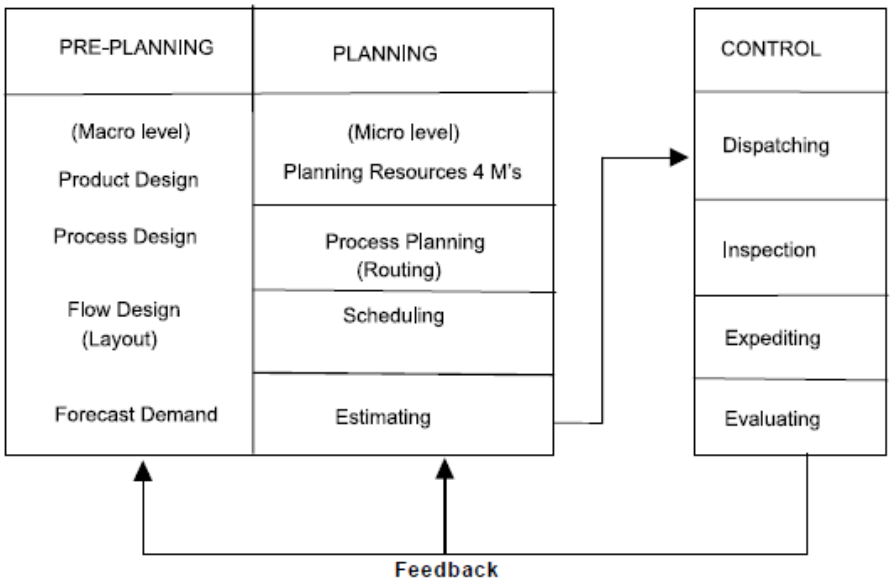
PRODUCTION PLANNING AND CONTROL FUNCTIONS

Functions of production planning and controlling is classified into:

1. Pre-planning function
2. Planning function
3. Control function

1. ***PRE-PLANNING FUNCTION***:

   Pre-planning is a macro level planning and deals with analysis of data and is an outline of the planning policy based upon the forecasted demand, market analysis and product design and development. This stage is concerned with process design (new processes and developments, equipment policy and replacement and work flow (Plant layout). The pre-planning function of PPC is concerned with decision-making with respect to methods, machines and work flow with respect to availability, scope and capacity.



2. ***PLANNING FUNCTION:***
   The planning function starts once the task to be accomplished is specified, with the analysis of **four M's**, *i.e*., Machines, Methods, Materials and Manpower. This is followed by process planning (routing). Both short-term (near future) and long-term planning are considered. Standardization, simplification of products and processes are given due consideration.
3. **CONTROL FUNCTION**:
   Control phase is effected by dispatching, inspection and expediting materials control, analysis of work-in-process. Finally, evaluation makes the PPC cycle complete and corrective actions are taken through a feedback from analysis. A good communication, and feedback system is essential to enhance and ensure effectiveness of PPC.

PARAMETERS FOR PPC:

The functions of PPC can be explained with the following parameters:

1. ***Materials*:** Raw materials, finished parts and bought out components should be made available in required quantities and at required time to ensure the correct start and end for each operation resulting in uninterrupted production. The function includes the specification of materials (quality and quantity) delivery dates, variety reduction (standardization) procurement and make or buy decisions.
2. ***Machines and equipment:*** This function is related with the detailed analysis of available production facilities, equipment down time, maintenance policy procedure and schedules. Concerned with economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time because of breakdowns.
3. ***Methods*:**
   This function is concerned with the analysis of alternatives and selection of the best method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.
4. ***Process planning (Routing):***
   It is concerned with selection of path or route which the raw material should follow to get transformed into finished product. The duties include:

a. Fixation of path of travel giving due consideration to layout.
b. Breaking down of operations to define each operation in detail.
c. Deciding the set up time and process time for each operation.

5. ***Estimating:***
   Once the overall method and sequence of operations is fixed and process sheet for each operation is available, then the operations times are estimated. This function is carried out using extensive analysis of operations along with methods and routing and a standard time for operation are established using work measurement techniques.
6. ***Loading and scheduling:***
   Scheduling is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations. Machines have to be loaded according to their capability of performing the given task and according to their capacity. Thus the duties include:
   a. Loading, the machines as per their capability and capacity.
   b. Determining the start and completion times for each operation.
   c. To coordinate with sales department regarding delivery schedules.
7. ***Dispatching:***
   This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions. It authorizes the start of production activities by releasing materials, components, tools, fixtures and instruction sheets to the operator. The activities involved are:
   a. To assign definite work to definite machines, work centers and men.
   b. To issue required materials from stores.
   c. To issue jigs, fixtures and make them available at correct point of use.
   d. Release necessary work orders, time tickets, etc., to authorize timely start of operations.
   e. To record start and finish time of each job on each machine or by each man.
8. ***Expediting****:*
   This is the control tool that keeps a close observation on the progress of the work. It is logical step after dispatching which is called 'follow-up'. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts, *i.e.*, follow up of materials, follow up of work-in-process and follow up of assembly. The duties include:
   a. Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.
   b. To devise action plans (remedies) for correcting the errors.
   c. To see that production rate is in line with schedule.
9. ***Inspection:***
   It is a major control tool. Though the aspects of quality control are the separate function, this is of very much important to PPC both for the execution of the current plans and its scope for future planning. This forms the basis for knowing the limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.
10. ***Evaluation:***
    This stage though neglected is a crucial to the improvement of productive efficiency. A thorough analysis of all the factors influencing the production planning and control helps to identify the weak spots and the corrective action with respect to pre-planning and planning will be effected by a feedback. The success of this step depends on the communication, data and information gathering and analysis.

AGGREGATE PLANNING:-

Aggregate planning meaning

Aggregate planning is an intermediate term planning decision. It is the process of planning the quantity and timing of output over the intermediate time horizon (3 months to one year). Within this range, the physical facilities are assumed to –10 be fixed for the planning period. Therefore, fluctuations in demand must be met by varying labor and inventory schedule. Aggregate planning seeks the best combination to minimize costs.

Aggregate Planning importance

- 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

Nature or Characteristics of the Aggregate Planning:

- A planning horizon is considered from about 3 to 18 months, with the periodic updating.
- Aggregate product demand, stated in the common terms is observed.
- Aggregate resource quantities, stated in the common terms are observed.
- Influence both the supply and the demand by adjusting the production rates, workforce levels, the inventory levels etc., but the facilities cannot be expanded.

Aggregate Planning Strategies:

The variables of the production system are labor, materials and capital. More labor effort is required to generate higher volume of output. Hence, the employment and use of overtime (OT) are the two relevant variables. Materials help to regulate output. The alternatives available to the company are inventories, back ordering or subcontracting of items. These controllable variables constitute pure strategies by which fluctuations in demand and uncertainties in production activities can be accommodated by using the following steps:

1. **Vary the size or the workforce:** Output is controlled by hiring or laying off workers in proportion to changes in demand.
2. **Vary the hours worked:** Maintain the stable workforce, but permit idle time when there is a slack and permit overtime (OT) when demand is peak.
3. **Vary inventory levels:** Demand fluctuations can be met by large amount of inventory.
4. **Subcontract:** Upward shift in demand from low level. Constant production rates can be met by using subcontractors to provide extra capacity.

Methods and Guidelines of Aggregate Planning

The following are the guidelines for aggregate planning:

1. Determine corporate policy regarding controllable variables.
2. Use a good forecast as a basis for planning.
3. Plan in proper units of capacity.
4. Maintain the stable workforce.
5. Maintain needed control over inventories.
6. Maintain flexibility to change.

7. Respond to demand in a controlled manner.
8. Evaluate planning on a regular base.

MASTER PRODUCTION PLAN OR MASTER PRODUCTION SCHEDULE

INTRODUCTION:

Master scheduling follows aggregate planning. It expresses the overall plans in terms of specific end items or models that can be assigned priorities. It is useful to plan for the material and capacity requirements.

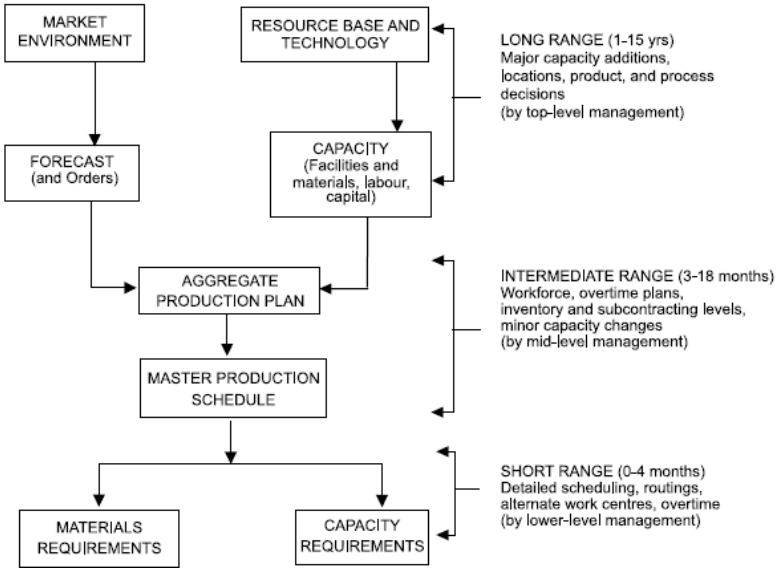
Flowchart of aggregate plan and master production schedule is shown in the following figure. Time interval used in master scheduling depends upon the type, volume, and component lead times of the products being produced. Normally weekly time intervals are used. The time horizon covered by the master schedule also depends upon product characteristics and lead times. Some master schedules cover a period as short as few weeks and for some products it is more than a year.

FUNCTIONS OF MASTER PRODUCTION SCHEDULE

Master Production Schedule (MPS) gives a formal detail of the production plan and converts this plan into specific material and capacity requirements. The requirements with respect to labor, material and equipment are then assessed. The main functions of MPS are:

1. **To translate aggregate plans into specific end items:** Aggregate plan determines level of operations that tentatively balances the market demands with the material, labor and equipment capabilities of the company. A master schedule translates this plan into specific number of end items to be produced in specific time period.

Flowchart of aggregate plan and master schedule



2. **Evaluate alternative schedules:** Master schedule is prepared by trial and error. Many computer simulation models are available to evaluate the alternate schedules.
3. **Generate material requirement:** It forms the basic input for material requirement planning (MRP).
4. **Generate capacity requirements:** Capacity requirements are directly derived from MPS. Master scheduling is thus a prerequisite for capacity planning.

5. **Facilitate information processing:** By controlling the load on the plant. Master schedule determines when the delivery should be made. It coordinates with other management information systems such as, marketing, finance and personnel.
6. **Effective utilization of capacity:** By specifying end item requirements schedule establishes the load and utilization requirements for machines and equipment.

Unit – IV

Quality control-Definition, need, Quality control techniques, control charts, acceptance sampling, six sigma, quality circles. TQM-scope, benefits. JIT.

Quality and Quality Control:

What is Quality?

Quality is the degree of excellence a product possesses with respect to design of product and conformity with certain prescribed standards and specifications; so as to meet customers' expectations most satisfactorily.

John D. Mclellan defines quality as follows:

"Quality is the degree to which a product conforms to specifications and workmanship standards."

What is Quality Control?

Quality control may be defined as follows:

Quality control involves establishment of quality standards and installation of systems to ensure that these standards are maintained and practiced.

DEFINITIONS OF QUALITY CONTROL:

(1) "Quality control is systematic control of management of the variables in the manufacturing process that affects goodness of the end product." —H.N. Broom.

(2) "Quality control means the recognition and removal of identifiable causes of defects and variations from the set standards." —J. A. Shubin

(3) "Quality control is that industrial management technique or group of techniques by means of which products of uniform acceptable quality are manufactured." —Alford and Beaty.

STEPS IN THE PROCESS OF QUALITY CONTROL:

1. Formulate quality policy.
2. Set the standards or specifications on the basis of customer's preference, cost and profit.
3. Select inspection plan and set up procedure for checking.
4. Detect deviations from set standards of specifications.
5. Take corrective actions or necessary changes to achieve standards.
6. Decide on salvage method *i.e.*, to decide how the defective parts are disposed of, entire scrap or rework.
7. Coordination of quality problems.
8. Developing quality consciousness both within and outside the organization.
9. Developing procedures for good vendor-vendee relations.

SIGNIFICANCE OF QUALITY CONTROL:

Quality control is significant for the following reasons:

(i) Cost Reduction and Profit Maximization:

Quality control helps in better utilisation of productive resources; and in elimination of all sort of wastes. Thus it leads to cost reduction and profit maximisation for the enterprise.

(ii) Increase in Operational Efficiency:

Quality control implies control over quality of raw-materials, performance of men and machines etc. Thus it brings about more operational efficiency of the organisation.

(iii) Maximum Customer Satisfaction:

Quality control minimizes complaints from customers and results in maximum customer satisfaction. It is quality that brings customers back for a second time, third time and so on. Thus quality control leads to sales maximisation; and consequently profit maximisation.

(iv) Good-Will and Image of the Enterprise:

Quality control builds goodwill of the enterprise in society. It makes for an image of the enterprise in the eyes of the public, due to the quality products offered by the enterprise.

(v) Insurance against Heavy Losses:

Quality control protects the manufacturer against heavy losses which may be caused due to rejection of large quantity of sub-standard products.

(vi) Promotes Employees' Productivity:

Quality control inculcates a feeling of quality consciousness among employees; and promotes their productivity.

(vii) Morale of Employees:

Quality control heightens morale of employees; as they feel that they are working for an enterprise producing goods of superior quality.

Significance of quality control – at a glance

1. Cost reduction and profit maximisation
2. Increase in operational efficiency
3. Maximum customer satisfaction
4. Goodwill and image of the enterprise
5. Insurance against heavy losses
6. Promotes employees' productivity
7. Morale of employees

Objectives of Quality Control:

To improve the companies income by making the production more acceptable to the customers, *i.e.*, by providing long life, greater usefulness, maintainability etc.

1. To reduce companies cost through reduction of losses due to defects.
2. To achieve interchangeability of manufacture in large scale production.
3. To produce optimal quality at reduced price.
4. To ensure satisfaction of customers with productions or services or high quality level, to build customer goodwill, confidence and reputation of manufacturer.
5. To make inspection prompt to ensure quality control.
6. To check the variation during manufacturing.

The broad areas of application of quality control are incoming material control, process control and product control.

Benefits of Quality Control

- Improving the quality of products and services.
- Increasing the productivity of manufacturing processes, commercial business, and corporations.
- Reducing manufacturing and corporate costs.
- Determining and improving the marketability of products and services.
- Reducing consumer prices of products and services.
- Improving and/or assuring on time deliveries and availability.

- Assisting in the management of an enterprise.

Techniques of Quality Control:
(I) Inspection
(II) Statistical quality control (SQC)
Let us describe both these techniques.

(I) Inspection:
Inspection is that component of quality control programme which is concerned with checking on the performance of items to the specifications set for it. It involves periodic checking and measuring – before, during and after the production process. Because of the numerous variables that enter into manufacturing, inspection is a never ending process.
Inspection may be 'Centralised' or 'Floor Inspection.'
Under centralized inspection, all the work from a department is sent to the Inspection Department, before passing on to the next operation. Floor inspection, on the other hand, follows the practice of sending inspectors to the floor and inspects work at the machines of operatives. It is also called patrolling or travelling inspection.

Advantages of centralized inspection:
(i) Centralised inspection ensures impartial supervision; because the inspector is not under the strain of not rejecting the work of a person with him he has good personal relations.
(ii) Under centralized inspection, it is easier to keep records of items/parts which are approved or rejected.
(iii) Production work is liable to less interruption, under centralized inspection.

Advantages of floor inspection:
(i) Since work is inspected on the floor; delay in sending work to next station is avoided.
(ii) Inspector can immediately locate the fault and suggest rectification.
(iii) It involves minimum material handling.

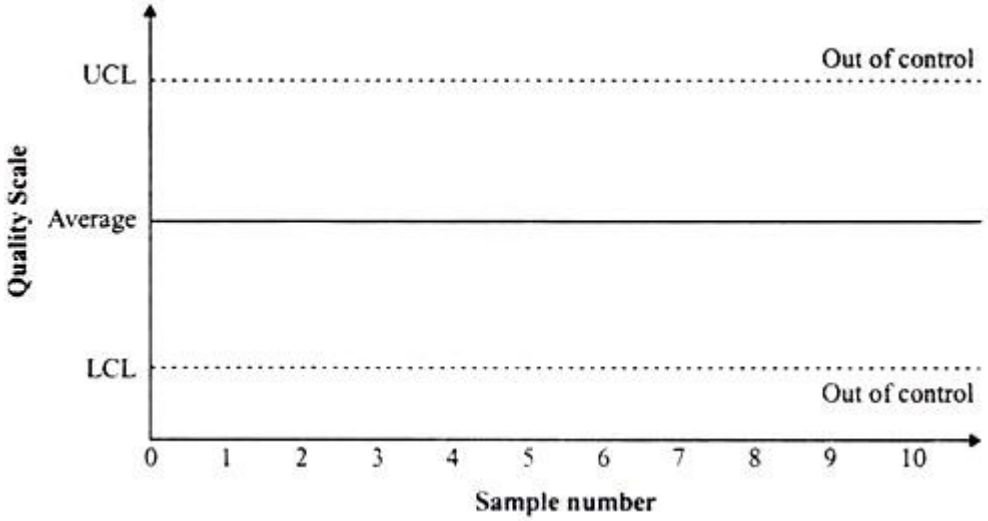
(II) Statistical Quality Control (SQC):
SQC is based upon the laws of probability. It is a system for controlling the quality of production within specified limits (tolerance limits) by means of a sample procedure and continuing analysis of inspection results.

Grant defines SQC as follows:
"SQC is a simple statistic method for determining the extent to which quality goods are being met without necessarily checking every item produced and for indicating whether or not the variations which occur are exceeding normal expectations. It enables us to decide whether to reject or accept a particular product."

Point of Comment:
SQC does not produce a quality product. It merely informs management that things are not going as they should. Management must take necessary action to remove the causes of variations and ensure production of quality products.

Inspections vs. SQC:
It is an interesting academic exercise to compare inspection and SQC.
The two techniques of quality control may be compared as follows:
(i) The result of inspection is acceptance or rejection of production; while SQC enables management to take action so that products will meet specifications. As such inspection enables one "to be wiser after the event" whereas SQC enables one **"to get wiser before the event."**
(ii) Inspection can be cent per cent; while SQC always involves sampling.

Techniques of SQC:
Techniques of SQC can be divided into two parts:
(1) Process control
(2) Acceptance sampling
Following is a brief account of these techniques of SQC:
(1) Process Control:
The checking up of quality characteristics under process control is done with the help of charts. There may be many types of charts like 'X-Chart', 'R-Chart', 'C-Chart' and 'P-Chart'. All types of charts are similar in composition and structure. All of them represent how quality-characteristic is changing from one sample to another.
A control chart when prepared would appear as follows:



Note: UCL = Upper Control Limit
LCL = lower control Limit
A process is considered out of control and an action to check and correct the process is taken; when a plotted point falls outside the control limits.

Advantages of control charts:
1. They provide visual aids
2. They are easy to prepare.
3. They give early warning of trouble

(2) Acceptance Sampling:

Control charts are useful for process control. In case of receipt of materials and dispatch of finished goods; a different method is used, that of acceptance sampling. Acceptance sampling plans are of utmost value when the nature of the process used to manufacture products remains unchanged.

In acceptance sampling, decisions [e.g. whether acceptable/not acceptable (rejection)] about the quality of batches or lots are made after inspection of only a portion i.e. a sample. If the sample of items conforms to requisite quality levels; then the whole batch from which the sample is taken is accepted. If the sample does not conform to the requisite quality level; then the whole batch is rejected.

An acceptance sampling is defined as:

Lot size (N)

Sample size (n)

Acceptance number (C)

Suppose N = 9000; n = 300 and C = 7; then this sampling plan means that a lot of 9000 items has 300 units (sample size) inspected. If seven or less defectives are found in 300 units' sample; the lot is accepted. If eight or more defectives are found in the sample; the lot is rejected.

A close study of acceptance sampling technique would reveal that there is likelihood that a lot of satisfactory quality is rejected on the basis of sample result. This is technically called producer's risk. Similarly, the consumer (or buyer) has the risk of accepting a lot of unsatisfactory quality, on the basis of sample results. This risk is called consumer's risk.

Advantages of acceptance sampling:

(i) Less expensive than 100% inspection

(ii) Used where 100% inspection is not possible.

(iii) Useful when inspection may cause damage or complete destruction.

Advantages of SQC:

(i) Reduced Cost:

Since only a fraction of output is inspected; costs of inspection are greatly reduced.

(ii) Early Warning of Defects:

SQC gives an early warning of defects in the production process; so that these defects can be detected and corrected at inception.

(iii) Simple Technique:

SQC techniques are simple and can be operated by semi-skilled operators.

(iv) Continuous Inspection:

SQC is a technique which provides a continuous inspection of the product at various stages of the manufacturing process.

(v) Adherence to Specifications:

SQC enables a process to be held in a state of statistical control i.e. a state in which variability is the result of chance causes alone.

Advantages of SQC – at a glance

1. Reduced cost
2. Early warning of defects
3. Simple technique
4. Continuous inspection
5. Adherence to specifications.

Seven Tools for Quality Control:

To make rational decisions using data obtained on the product, or process, or from the consumer, organizations use certain graphical tools. These methods help us learn about the characteristics of a process, its operating state of affairs and the kind of output we may expect from it. Graphical methods are easy to understand and provide comprehensive information; they are a viable tool for the analysis of product and process data. These tools are effect on quality improvement. The seven quality control tools are:

1. Pareto charts
2. Check sheets
3. Cause and effect diagram
4. Scatter diagrams
5. Histogram
6. Graphs or flow charts
7. Control charts

1. **PARETO CHARTS**:

   Pareto charts help prioritize by arranging them in decreasing order of importance. In an environment of limited resources these diagrams help companies to decide on the order in which they should address problems. The Pareto analysis can be used to identify the problem in a number of forms.

   a. Analysis of losses by material (number or past number).
   b. Analysis of losses by process *i.e.*, classification of defects or lot rejections in terms of the process.
   c. Analysis of losses by product family.
   d. Analysis by supplier across the entire spectrum of purchases.
   e. Analysis by cost of the parts.
   f. Analysis by failure mode.

   Example:

   A Pareto chart of reasons for poor quality. Poor design will be the major reason, as indicated by 64%. Thus, this is the problem that the manufacturing unit should address first.

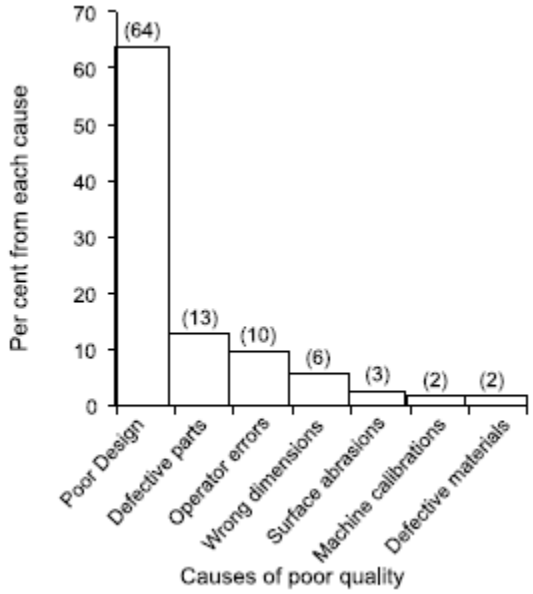
   G. Poor Design
   H. Defective Parts
   I. Operator Error
   J. Wrong Dimensions
   K. Surface Abrasion

L. Machine Calibrations
M. Defective Material

CHECK SHEETS:

Check sheets facilitate systematic record keeping or data collection observations are recorded as they happen which reveals patterns or trends. Data collection through the use of a checklist is often the first step in analysis of quality problem. A checklist is a form used to record the frequency of occurrence of certain product or service characteristics related to quality. The characteristics may be measurable on a continuous scale such as weight, diameter, time or length.

Pareto chart



Example:

The table is a check sheet for an organization's computer related problems.

Checklist

COMPONENTS REPLACED BY LAB
TIME PERIOD: 22 Feb. to 27 Feb. 2005
REPAIR TECHNICIAN: XYZ

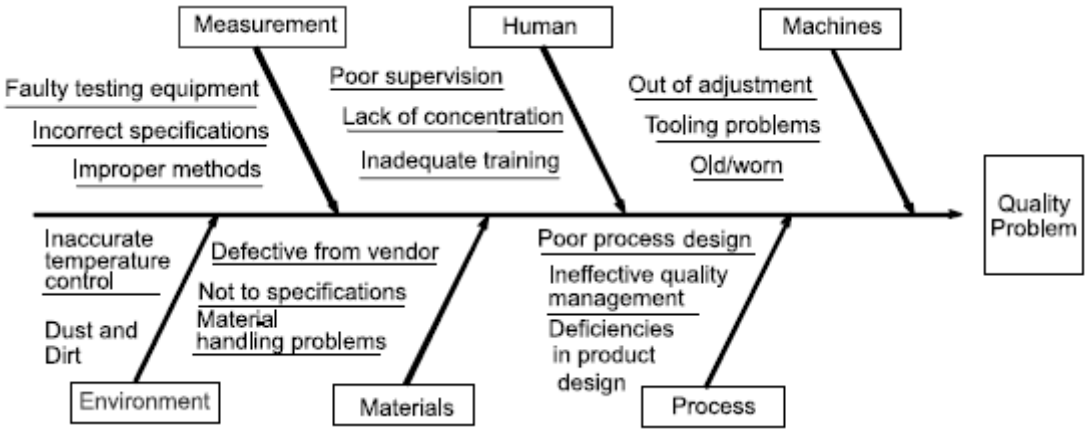
TV SET MODEL 1013	
Integrated Circuits	||||
Capacitors	|||| |||| |||| |||| |||| ||
Resistors	||
Transformers	||||
Commands	
CRT		

CAUSE AND EFFECT DIAGRAM:

It is sometimes called as Fish-bone diagram. It is first developed by Kaorv Ishikawa in 1943 and is sometimes called as Ishikawa diagram. The diameter helps the management trace

customer complaints directly to the operations involved. The main quality problem is referred to Fish-head; the major categories of potential cause structural bones and the likely specific causes to ribs. It explores possible causes of problems, with the intention being to discover the root causes. This diagram helps identify possible reasons for a process to go out of control as well as possible effects on the process.

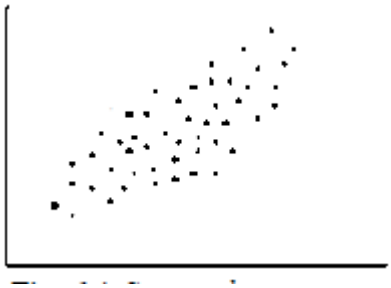
Fishbone diagram



SCATTER DIAGRAM (SCATTER PLOTS)

It often indicates the relationship between two variables. They are often used as follow-ups to a cause and effect analysis to determine whether a stated cause truly does impact the quality characteristics.

Scatter diagram



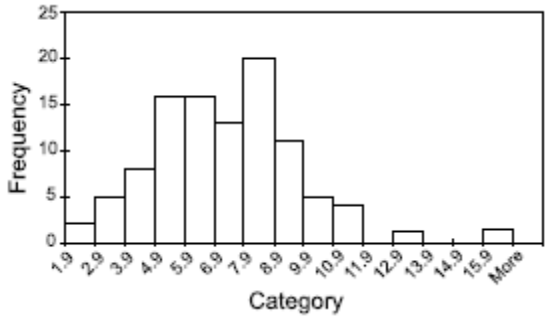
Example:

The plots advertising expenditure against company sales and indicates a strong positive relationship between the two variables. As the level of advertising expenditure increases sales tend to increase.

HISTOGRAM (OR) BAR CHARTS:

It displays the large amounts of data that are difficult to interpret in their raw form. A histogram summarizes data measured on a continuous scale showing the frequency distribution of some quality characteristics (in statistical terms the central tendency and the dispersion of the data).

Histogram

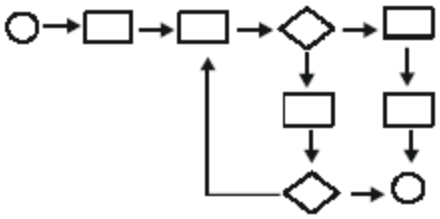


Often the mean of the data is indicated on the histogram. A bar chart is a series of bare representing the frequency of occurrence of data characteristics, the bar height indicates the number of times a particular quality characteristic was observed.

FLOW CHARTS (OR) GRAPHS:

It shows the sequence of events in a process. They are used for manufacturing and service operations. Flow charts are often used to diagram operational procedures to simplify the system. They can identify bottlenecks, redundant steps and non-value added activities. A realistic flow chart can be constructed by using the knowledge of the person who are directly involved in the particular process. The flow chart can be identifies where delays can occur.

Flowchart



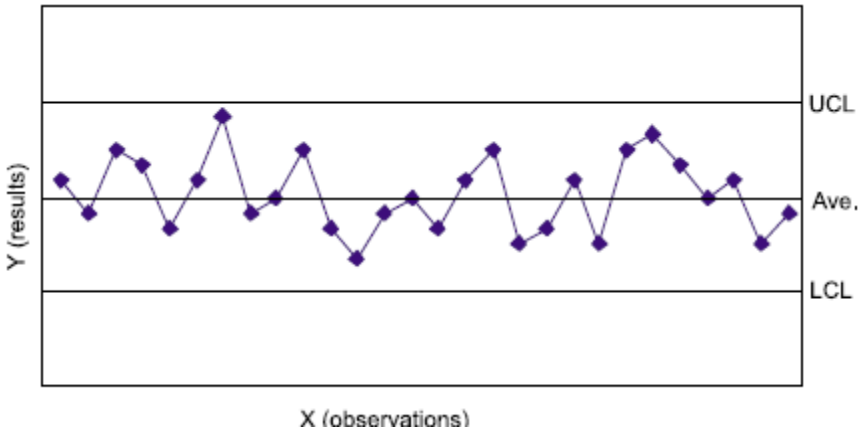
CONTROL CHARTS:

It distinguishes special causes of variations from common causes of variation. They are used to monitor and control process on an ongoing basis. A typical control chart plots a selected quality characteristic found from sub-group of observations as a function of sample number. Characteristics such as sample average, sample range and sample proportion of non-conforming units are plotted. The centre line on a control chart represents the average value of characteristics being plotted. Two limits know as the upper control limit (UCL) and lower control limit (LCL) are also shown on control charts. These limits are constructed so that if the process is operating under a stable system of chance causes, the problem of an observation falling outside these limits is quite small. The following figure shows a generalized representation of a control chart. Control chart shows the performance of a process from two points of view.

First, they show a snapshot of the process at the moment the data are collected.

Second, they show the process trend as time progresses. Process trends are important because they help in identifying the out-of-control status if it actually exists. Also, they help to detect variations outside the normal operational limits, and to identify the cause of variations. Fig. shows a generalized representation of a control chart.

Control charts



Causes of Variation in Quality:

The variation in the quality of product in any manufacturing process is broadly classified as:

A. Chance causes
B. Assignable causes.

A. **CHANCE CAUSES**:

The chance causes are those causes which are inherit in manufacturing process by virtue of operational and constructional features of the equipments involved in a manufacturing process.

This is because of

1. Machine vibrations
2. Voltage variations
3. Composition variation of material, etc.

They are difficult to trace and difficult to control, even under best condition of production. Even though, it is possible to trace out, it is not economical to eliminate. The chance causes results in only a minute amount of variation in process. Variation in chance causes is due to internal factors only the general pattern of variation under chance causes will follow a stable statistical distribution (normal distribution). Variation within the control limits means only random causes are present.

B. **ASSIGNABLE CAUSES**:

These are the causes which creates ordinary variation in the production quality. Assignable cause's variation can always be traced to a specific quality. They occur due to

1. Lack of skill in operation
2. Wrong maintenance practice
3. New vendors
4. Error in setting jigs and fixtures
5. Raw material defects

Variation due to these causes can be controlled before the defective items are produced. Any one assignable cause can result in a large amount of variation in process. If the assignable causes are present, the system will not follow a stable statistical distribution. When the actual variation

exceeds the control limits, it is a signal that assignable causes extend the process and process should be investigated.

SIX SIGMA

Introduction to Six Sigma:

In today's competitive world – there is no room for any type of error, everyone wants quick and efficient access to information, products and services – so it has become very important and mandatory to bring some critical changes, in the ways by which a company conducts or carries its various business activities. The company should make it a point to delight their customers by fulfilling their expectations. To help this cause, six sigma plays a very critical role as it lays a lot of emphasis on "Quality must become a part of the culture"

Objectives of six sigma:

- To give good performance and reliability
- To provide value to the end customer
- Reducing or minimizing defects in any type of process (reducing defects to less
- than 3.4 million operations).
- To eliminate wasteful practices i.e. the practices which do not provide any value to the process, should be eliminated.
- Providing after sales service quality
- Improving the quality of the product
- Satisfying both internal and external customers

Benefits of Six sigma:

- Transaction involving six sigma provides services and products, free from defects.
- Lower production, inspection and warranty costs, with tension free conditions for working.
- Greater satisfaction of the customer, resulting in better place and better reputation in the market.
- Moving from % defect AQL PPM (parts per million) to PPB (parts per billion) to zero defect (Zero variation), which automatically results in achievement of excellence in the process.
-

Principles of six sigma:

- The use of pro active thinking to achieve perfection.
- Top priority should always be service towards customer, stress towards understanding their needs and expectations and trying to fulfill them.
- Boundary less collaboration, supported by data and fact driven management.
- Failure is allowed but through risk management techniques.

The Six Sigma Methodology

The two main Six Sigma methodologies are DMAIC and DMADV. Each has its own set of recommended procedures to be implemented for business transformation.

DMAIC is a data-driven method used to improve existing products or services for better customer satisfaction. It is the acronym for the five phases: D – Define, M – Measure, A –

Analyse, I – Improve, C – Control. DMAIC is applied in the manufacturing of a product or delivery of a service.
DMADV is a part of the Design for Six Sigma (DFSS) process used to design or re-design different processes of product manufacturing or service delivery. The five phases of DMADV are: D – Define, M – Measure, A – Analyse, D – Design, V – Validate. DMADV is employed when existing processes do not meet customer conditions, even after optimization, or when it is required to develop new methods. It is executed by Six Sigma Green Belts and Six Sigma Black Belts and under the supervision of Six Sigma Master Black Belts. We'll get to the belts later.
The two methodologies are used in different business settings, and professionals seeking to master these methods and application scenarios would do well to take an online certificate program taught by industry experts.

The Six Sigma Process
Although Six Sigma uses various methods to discover deviations and solve problems, the DMAIC is the standard methodology used by Six Sigma practitioners. Six Sigma uses a data-driven management process used for optimizing and improving business processes. The underlying framework is a strong customer focus and robust use of data and statistics to conclude.
The Six Sigma Process of the DMAIC method has five phases:

Each of the above phases of business transformation has several steps:

1. DEFINE
   The Six Sigma process begins with a customer-centric approach.
   - The business problem is defined from the customer perspective.
   - Goals are set. What do you want to achieve? What are the resources you will use to achieve the goals?
   - Map the process. Verify with the stakeholders that you are on the right track.
2. MEASURE

The second phase is focused on the metrics of the project and the tools used in the measurement. How can you improve? How can you quantify this?

- Measure your problem in numbers or with supporting data.
- Define performance yardstick. Fix the limits for "Y."
- Evaluate the measurement system to be used. Can it help you achieve your outcome?

3. ANALYZE
   The third phase analyzes the process to discover the influencing variables.
   - Determine if your process is efficient and effective. Does the process help achieve what you need?
   - Quantify your goals in numbers. For instance, reduce defective goods by 20%.

- Identify variations using historical data.

4. IMPROVE

This process investigates how the changes in "X" impacts "Y." This phase is where you identify how you can improve the process implementation.

- Identify possible reasons. Test to identify which of the "X" variables identified in Process III influence "Y."
- Discover relationships between the variables.
- Establish process tolerance, defined as the precise values that certain variables can have, and still fall within acceptable boundaries, for instance, the quality of any given product. Which boundaries need X to hold Y within specifications? What operating conditions can impact the outcome? Process tolerances can be achieved by using tools like robust optimization and validation set.

5. CONTROL

In this final phase, you determine that the performance objective identified in the previous phase is well implemented and that the designed improvements are sustainable.

- Validate the measurement system to be used.
- Establish process capability. Is the goal being met? For instance, will the goal of reducing defective goods by 20 percent be achieved?
- Once the previous step is satisfied, implement the process.

SIX SIGMA TECHNIQUES

The Six Sigma methodology also uses a mix of statistical and data analysis tools such as process mapping and design and proven qualitative and quantitative techniques, to achieve the desired outcome.

Brainstorming

Brainstorming is the key process of any problem-solving method and is often utilized in the "improve" phase of the DMAIC methodology. It is a necessary process before anyone starts using any tools. Brainstorming involves bouncing ideas and generating creative ways to approach a problem through intensive freewheeling group discussions. A facilitator, who is typically the lead Black Belt or Green Belt, moderates the open session among a group of participants.

Root Cause Analysis/The 5 Whys

This technique helps to get to the root cause of the problems under consideration and is used in the "analyze" phase of the DMAIC cycle.

In the 5 Whys technique, the question "why" is asked, again and again, finally leading up to the core issue. Although "five" is a rule of thumb, the actual number of questions can be greater or fewer, whatever it takes to gain clarity.

Voice of the Customer

This is the process used to capture the "voice of the customer" or customer feedback by either internal or external means. The technique is aimed at giving the customer the best products and services. It captures the changing needs of the customer through direct and indirect methods. The voice of the customer technique is used in the "define' phase of the DMAIC method, usually to further define the problem to be addressed.

The 5S System

This technique has its roots in the Japanese principle of workplace energies. The 5S System is aimed at removing waste and eliminating bottlenecks from inefficient tools, equipment, or resources in the workplace. The five steps used are Seiri (Sort), Seiton (Set In Order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain).

Kaizen (Continuous Improvement)

The Kaizen technique is a powerful strategy that powers a continuous engine for business improvement. It is the practice continuously monitoring, identifying, and executing improvements. This is a particularly useful practice for the manufacturing sector. Collective and ongoing improvements ensure a reduction in waste, as well as immediate change whenever the smallest inefficiency is observed.

Benchmarking

Benchmarking is the technique that employs a set standard of measurement. It involves making comparisons with other businesses to gain an independent appraisal of the given situation. Benchmarking may involve comparing important processes or departments within a business (internal benchmarking), comparing similar work areas or functions with industry leaders (functional benchmarking), or comparing similar products and services with that of competitors (competitive benchmarking).

Poka-yoke (Mistake Proofing)
This technique's name comes from the Japanese phrase meaning "to avoid errors," and entails preventing the chance of mistakes from occurring. In the poka-yoke technique, employees spot and remove inefficiencies and human errors during the manufacturing process.

Value Stream Mapping
The value stream mapping technique charts the current flow of materials and information to design a future project. The objective is to remove waste and inefficiencies in the value stream and create leaner operations. It identifies seven different types of waste and three types of waste removal operations.

THE SIX SIGMA TOOLS
1. Cause and Effect Analysis
2. Flow Chart
3. Pareto Chart
4. Histogram
5. Check Sheet
6. Scatter Plot
7. Control Chart

SIX SIGMA LEVELS
The Six Sigma training levels conform to specified training requirements, education criteria, job standards, and eligibility.

White Belt
- This is the simplest stage, where:
- Any newcomer can join.
- People work with teams on problem-solving projects.
- The participant is required to understand the basic Six Sigma concepts.

Yellow Belt
Here, the participant:
- Takes part as a project team member.
- Reviews process improvements.
- Gains understanding of the various methodologies, and DMAIC

Green level
This level of expertise requires the following criteria:
- Minimum of three years of full-time employment
- Understand the tools and methodologies used for problem-solving.
- Hands-on experience on projects involving some level of business transformation.
- Guidance for Black Belt projects in data collection and analysis.
- Lead Green Belt projects or teams.

Black Level
This level includes the following:
- Minimum of three years of full-time employment
- Work experience in a core knowledge area
- Proof of completion of a minimum of two Six Sigma projects

- Demonstration of expertise at applying multivariate metrics to diverse business change settings
- Leading diverse teams in problem-solving projects
- Training and coaching project teams

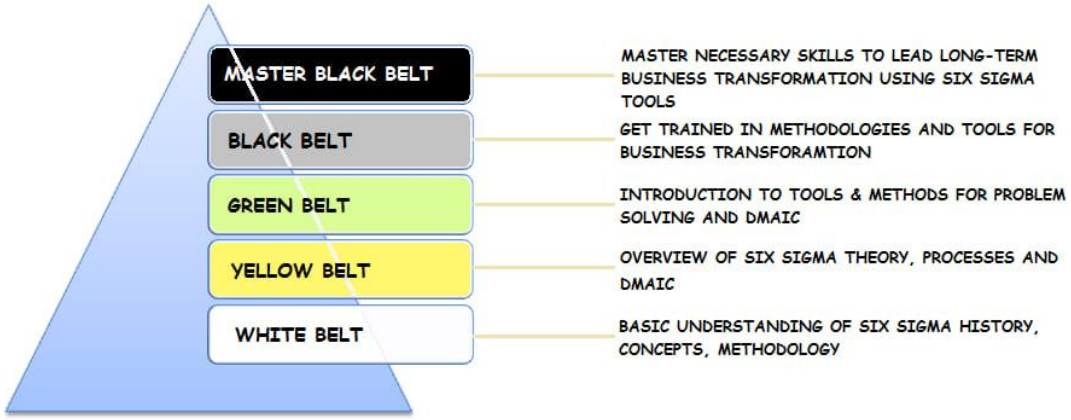
Master Black Belt

To reach this level, a candidate must:

- Be in possession of a Black Belt certification
- Have a minimum of five years of full-time employment, or Proof of completion of a minimum of 10 Six Sigma projects
- A proven work portfolio, with individual specific requirements, as given here, for instance.
- Have coached and trained Green Belts and Black Belts.
- Develop key metrics and strategies.
- Have worked as an organization's Six Sigma technologist and internal business transformation advisor.

THE SIX SIGMA CERTIFICATION LEVELS

Six Sigma certification is much like the certification system followed in martial arts, where a wannabe Six Sigma professional begins with the White Belt and upskills his way up to become the master of the pack with the Master Black Belt; or take an integrated certification offered by some institutes.



QUALITY CIRCLES (QC)

DEFINITION:

Perhaps the most widely discussed and undertaken intervention of employee involvement is the quality circle (QC). The concept of QC originally began in the United States and was exported to Japan in the 1950s. It is mentioned that it is the concept of QC that enabled Japanese firms to make high quality products at low costs.

What is quality circle?

It is a work group of employees who meet regularly to discuss their quality problems, investigate causes, recommend solutions, and take corrective actions. Generally, QC is a small group of employees belonging to the same similar work area.

This is so because the employees doing the similar type of work are well familiar to problems faced by them. The size of the QC should not be too big so as to prevent some members from participating meaningfully in its meetings. Generally, six to eight members are considered the ideal size of the QC.

OBJECTIVES OF QC:

1. Improvement in quality of product manufactured by the organisation.
2. Improvement in methods of production.
3. Development of employees participating in QC.
4. Promoting morale of employees.
5. Respect humanity and create a happy work place worthwhile to work.

FEATURES OF QC

1. Voluntary Groups:

QC is a voluntary group of employees generally coming from the same work area. There is no pressure from anywhere on employees to join QC.

2. Small Size:

The size of the QC is generally small consisting of six to eight members.

3. Regular Meeting:

QC meetings are held once a week for about an hour on regular basis. The members meet during working hours usually at the end of the working day in consultation with the manager. The time of the meetings is usually fixed in advance in consultation with the manager and members.

4. Independent Agenda:

Each QC has its own agenda with its own terms of reference. Accordingly, each QC discusses its own problems and takes corrective actions.

5. Quality Focused:

As per the very nature and intent of QC, it focuses exclusively on quality issues. This is because the ultimate purpose of QC is improvement in quality of product and working life.

TECHNIQUES OF QC

The qualities circles use certain techniques to identify analyse and resolve problems; they are:

(a) Brain storming
(b) Data collection
(c) Pareto analysis
(d) Cause and affect diagram.
(e) Line graphs
(f) Frequency distribution.
(g) Scatter diagram, and
(h) Histograms.

TOTAL QUALITY MANAGEMENT

Meaning of TQM:

TQM is an enhancement to the traditional way of doing business. It is the art of managing the whole to achieve excellence. It is defined both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. It is the application of quantitative methods and human resources to improve all the processes within an organization and exceed customer needs now and in the future. It integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach.

DEFINE QUALITY:

- Predictable degree of uniformity and dependability at low cost and suited to the market – Deming
- Fitness for use-Juran
- Conformance to requirements – Crosby
- Minimum loss imparted by a product to society from the time the product is shipped – Taguchi

OBJECTIVES OF TQM

- To develop a conceptual understanding of the basic principles and methods associated with TQM;
- To develop an understanding of how these principles and methods have been put into effect in a variety of organizations;
- To develop an understanding of the relationship between TQM principles and the theories and models studied in traditional management;

SCOPE OR PRINCIPLES OF TOTAL QUALITY MANAGEMENT

Commitment from the management:

- Plan (drive, direct)
- Do (deploy, support, and participate)
- Check (review)
- Act (recognize, communicate, revise)

Employee Empowerment

- Training
- Excellence team
- Measurement and recognition
- Suggestion scheme

Continuous Improvement

- Systematic measurement
- Excellence teams
- Cross-functional process management
- Attain, maintain, improve standards

Customer Focus

- Partnership with Suppliers
- Service relationship with internal customers
- Customer-driven standards

- Never compromise quality

TQM BENEFITS AND ADVANTAGES:

- Strengthened competitive position
- Adaptability to changing or emerging market conditions and to environmental and other government regulations
- Higher productivity
- Enhanced market image
- Elimination of defects and waste
- Reduced costs and better cost management
- Higher profitability
- Improved customer focus and satisfaction
- Increased customer loyalty and retention
- Increased job security
- Improved employee morale
- Enhanced shareholder and stakeholder value
- Improved and innovative processes

JUST-IN-TIME (JIT)

INTRODUCTION

Just-In-Time (JIT) Manufacturing is a philosophy rather than a technique. By eliminating all waste and seeking continuous improvement, it aims at creating manufacturing system that is response to the market needs.

The phase just in time is used to because this system operates with low WIP (Work-In-Process) inventory and often with very low finished goods inventory. Products are assembled just before they are sold, subassemblies are made just before they are assembled and components are made and fabricated just before subassemblies are made. This leads to lower WIP and reduced lead times. To achieve this organizations have to be excellent in other areas *e.g*. quality.

DEFINITION OF JIT:

- Just-in-time is defined as the production of the minimum number of units in the smallest possible quantities at the latest possible time, which eliminates the need for inventory. It does not mean to produce on time but to produce "just in time".
- JIT is defined as an approach for providing smoother production flows and making continual improvements in processes and products. (Svensson, 2001)
- According to Voss, JIT is viewed as a "*Production methodology which aims to improve overall productivity through elimination of waste and which leads to improved quality*".

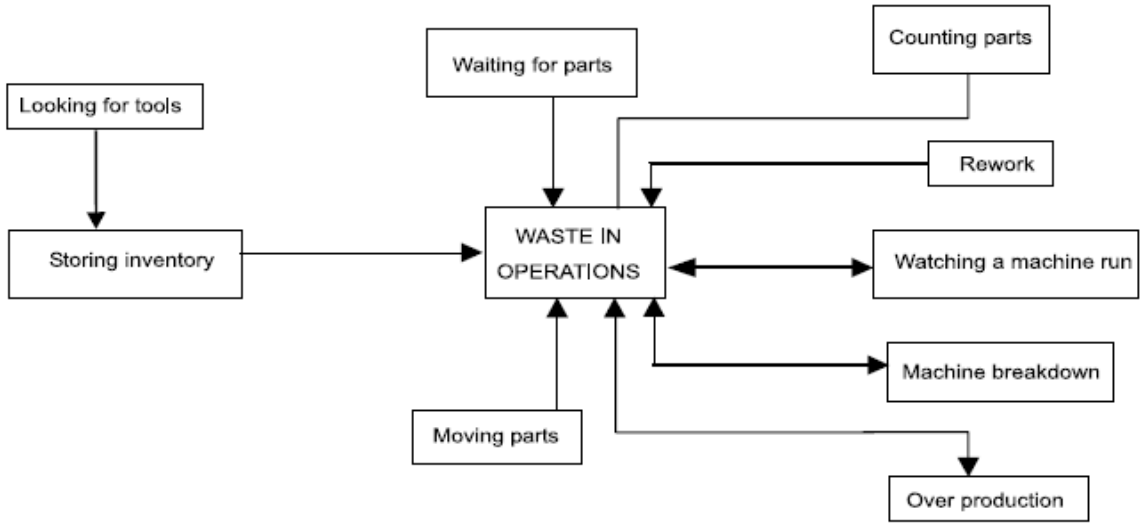
JIT IN PRODUCTION MANAGEMENT

JIT provides an efficient production in an organization and delivery of only the necessary parts in the right quantity, at the right time and place while using the minimum facilities".

SEVEN WASTES:

Shiego Shingo, a Japanese JIT authority and engineer at the Toyota Motor Company identifies seven wastes as being the targets of continuous improvement in production process. By attending to these wastes, the improvement is achieved.

1. Waste of over production eliminate by reducing set-up times, synchronizing quantities and timing between processes, layout problems. Make only what is needed now.
2. Waste of waiting eliminate bottlenecks and balance uneven loads by flexible work force and equipment.
3. Waste of transportation establishes layouts and locations to make handling and transport unnecessary if possible. Minimize transportation and handling if not possible to eliminate.
4. Waste of processing itself question regarding the reasons for existence of the product and then why each process is necessary.
5. Waste of stocks reducing all other wastes reduces stocks.



6. Waste of motion study for economy and consistency. Economy improves productivity and consistency improves quality. First improve the motions, then mechanize or automate otherwise. There is danger of automating the waste.
7. Waste of making defective products develop the production process to prevent defects from being produced, so as to eliminate inspection. At each process, do not accept defects and makes no defects. Make the process fail-safe. A quantify process always yield quality product.

BENEFITS OF JIT

The most significant benefit is to improve the responsiveness of the firm to the changes in the market place thus providing an advantage in competition. Following are the benefits of JIT:

1. ***Product cost***—is greatly reduced due to reduction of manufacturing cycle time, reduction of waste and inventories and elimination of non-value added operation.
2. ***Quality*** —is improved because of continuous quality improvement programs.
3. ***Design***—Due to fast response to engineering change, alternative designs can be quickly brought on the shop floor.
4. Productivity improvement.
5. Higher production system flexibility.
6. Administrative and ease and simplicity.

Unit – V

Flexible Manufacturing Systems. Poka yoke-Characteristics, levels, classification, principles, device. Kaizen-Elements, classification, steps in implementing kaizen.

INTRODUCTION TO FLEXIBLE MANUFACTURING SYSTEM (FMS):

Definition of FMS:

A flexible manufacturing system (FMS) is an arrangement of machines ... interconnected by aϖ transport system. The transporter carries work to the machines on pallets or other interface units so that work-machine registration is accurate, rapid and automatic. A central computer controls both machines and transport system.

Or

FMS consists of a group of processing work stations interconnected by means of anϖ automated material handling and storage system and controlled by integrated computer control system.

FMS is called flexible due to the reason that it is capable of processing a variety of differentϖ part styles simultaneously at the workstation and quantities of production can be adjusted in response to changing demand patterns.

BASIC COMPONENTS OF FMS:

The basic components of FMS are:

1. Workstations
2. Automated Material Handling and Storage system
3. Computer Control System

1. Workstations: In present day application these workstations are typically computer numerical control (CNC) machine tools that perform machining operation on families of parts. Flexible manufacturing systems are being designed with other type of processing equipment‘s including inspection stations, assembly works and sheet metal presses. The various workstations are

1. Machining centers
2. Load and unload stations
3. Assembly work stations
4. Inspection stations
5. Forging stations
6. Sheet metal processing, etc.

2. Automated Material Handling and Storage system: The various automated material handling systems are used to transport work parts and subassembly parts between the processing stations, sometimes incorporating storage into function. The various functions of automated material handling and storage system are

1. Random and independent movement of work parts between workstations
2. Handling of a variety of work part configurations
3. Temporary storage
4. Convenient access for loading and unloading of work parts
5. Compatible with computer control.

3. Computer Control System: It is used to coordinate the activities of the processing stations and the material handling system in the FMS. The various functions of computer control system are:

(i) Control of each work station
(ii) Distribution of control instruction to work station
(iii) Production control
(vi) Traffic control
(v) Shuttle control
(vi) Work handling system and monitoring
(vii) System performance monitoring and reporting

DIFFERENT TYPES OF FMS

The different types of FMS are
1. Sequential FMS
2. Random FMS
3. Dedicated FMS
4. Engineered FMS
5. Modular FMS

Sequential FMS: It manufactures one-piece part batch type and then planning and preparation is carried out for the next piece part batch type to be manufactured. It operates like a small batch flexible transfer line.

Random FMS: It manufactures any random mix of piece part types at any one time.

Dedicated FMS: It continually manufactures, for extended periods, the same but limited mix of piece part batch types.

Engineered FMS: It manufactures the same mix its lifetime.

Modular FMS: modular FMS with a sophisticated FMS host, enables and FMS user to expand their FMS capabilities in a stepwise fashion into any of the previous four types of FMS. modular FMS, with a sophisticated FMS host, enables and FMS.

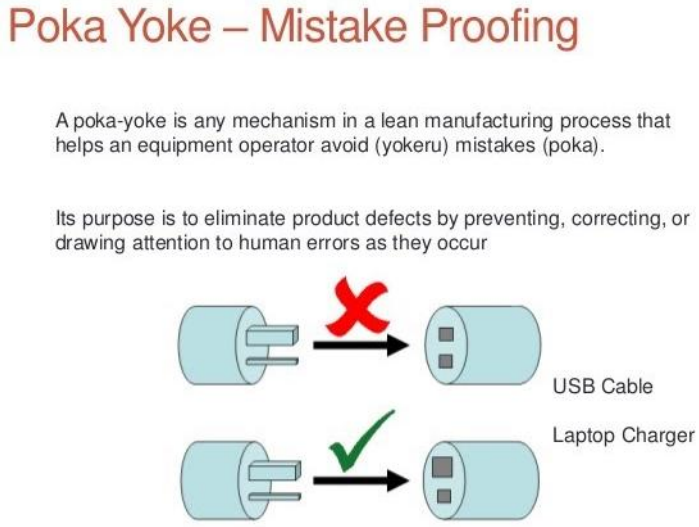
POKA-YOKE

What is Poka-yoke?

Poka-yoke [poka yoke] is a Japanese term that means "mistake-proofing". A poka-yoke is any mechanism in any process that helps an equipment operator avoid (*yokeru*) mistakes (*poka*). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur.

Poka Yoke, also known as mistake-proofing, is a technique for avoiding simple human errors at work. The idea was originally developed in the 1960s by Shigeo Shingo who was one of the IE engineers at Toyota.

EXAMPLES:



BENEFITS OF POKA-YOKE IMPLEMENTATION

A typical feature of poka-yoke solutions is that they don't let an error in a process happen. Other advantages include:

- Less time spent on training workers;
- Elimination of many operations related to quality control;
- Unburdening of operators from repetitive operations;
- Promotion of the work improvement-oriented approach and actions;
- A reduced number of rejects;
- Immediate action when a problem occurs;
- 100% built-in quality control;
- Preventing bad products from reaching customers;
- Detecting mistakes as they occur;
- Eliminating defects before they occur.

CHARACTERISTICS OF POKA YOKE

- Simple and cheap
- Part of process, permitting 100% inspection
- Placed close to where the mistakes occur, providing quick feedback.
- Designed to stop a particular mistake
- A detection device cannot provide a complete error proof solution
- Necessary and not a sufficient solution

LEVELS OF POKA YOKE

There are three levels at which your company can effect poka-yoke:

- Eliminating errors defects and losses at the source or prevention of a mistake from being committed..
- Detection of a loss or mistakes it occurs,allowing correction before it becomes a problem.
- Detection of a loss or mistakes after it has occurred,just in time before it blows up into a major issue(least effective).

CLASSIFICATION OF POKA YOKE

There are three levels at which your company can effect poka-yoke:

- Eliminating errors defects and losses at the source or prevention of a mistake from being committed..
- Detection of a loss or mistakes it occurs,allowing correction before it becomes a problem.
- Detection of a loss or mistakes after it has occurred,just in time before it blows up into a major issue(least effective).

PRINCIPLES OF POKA YOKE

There are six mistake-proofing principles or methods.

- **Elimination** seeks to eliminate the possibility of error by redesigning the product or process so that the task or part is no longer necessary.
- **Replacement** substitutes a more reliable process to improve consistency.
- **Prevention** engineers the product or process so that it is impossible to make a mistake at all.
- **Facilitation** employs techniques and combining steps to make work easier to perform.
- **Detection** involves identifying an error before further processing occurs so that the user can quickly correct the problem.
- **Mitigation** seeks to minimize the effects of errors.

DEVICES OF POKA YOKE

- Poka yoke is implemented by using simple objects like fixtures, jigs, warning devices and the like to prevent people from committing mistakes, even if they try to!.
- The main feature of poka-yoke devices is their exceptional suitability for reducing or eliminating defects through effective feedback and instantaneous corrective action.
- These devices are capable of being used all the time by all workers; simple and usually installed with low implementation cost.
- Poka-yoke devices help eliminate errors and defects by giving machines the "intelligence" to stop and signal when a error occurs.
- Poka-yoke devices stop machines and alert workers when a problem exists.

KAIZEN

MEANING OF KAIZEN

Kaizen is a Japanese term meaning "change for the better" or "continuous improvement." It is a Japanese business philosophy regarding the processes that continuously improve operations and involve all employees.

The Japanese words “kai-” which means “change” and “-zen” which means “good.” The popular meaning from Toyota is “continuous improvement” or “small incremental improvements” of all areas of a company, not just manufacturing.

ELEMENTS OF KAIZEN

Teamwork,
Personal discipline,
Improved morale,
Quality circles, and
Suggestions for improvement

CLASSIFICATION OF KAIZEN

There are actually four types of Kaizen methodologies:

1. Kaizen Teian - **Kaizen** is Japanese for “improvement” or “change for the better” while, **teian** is simply translated to “Suggestion”.
2. Kaizen Events - **Kaizen events** are short duration improvement projects with a specific aim for improvement
3. Kaikaku - **Kaikaku** is concerned with making fundamental and radical changes to a production system, unlike Kaizen which is focused on incremental changes.
4. Kakushin - **Kakushin** literally means “innovation” or reform as in the reformists in a political party.

STEPS IN IMPLEMENTING KAIZEN

- Identify an opportunity.
- Analyze the process.
- Develop an optimal solution.
- Implement the solution.
- Study the results.
- Standardize the solution.
- Plan for the future.