PRODUCTION PLANNING AND CONTROL

(As per New Syllabus of Leading Universities)

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IE6605 PRODUCTION PLANNING AND CONTROL

UNIT I: INTRODUCTION

UNIT II: WORK STUDY

UNIT III: PRODUCT PLANNING AND PROCESS PLANNING

UNIT IV: PRODUCTION SCHEDULING

UNIT V: INVENTORY CONTROL AND RECENT TRENDS IN PPC
Inventory control – Purpose of holding stock – Effect of demand on inventories – Ordering procedures. Two bin system – Ordering cycle system – Determination of Economic order quantity and economic lot size – ABC analysis – Recorder procedure – Introduction to computer integrated production planning systems – elements of JUST IN TIME SYSTEMS Fundamentals of MRP II and ERP.

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IV Year – II SEMESTER

PRODUCTION PLANNING AND CONTROL

UNIT I:

UNIT II:
Forecasting – importance of forecasting – types of forecasting, their uses – general principles of forecasting – forecasting techniques – qualitative methods and quantitative methods

UNIT III:
Introduction to MRP I, MRP II, ERP, LOB (Line of Balance), JIT and KANBAN system.

UNIT IV:

UNIT V:
Scheduling policies – techniques, standard scheduling methods. Line balancing, aggregate planning, chase planning, expediting, controlling aspects.

UNIT VI:
Despatching – activities of dispatcher – dispatching procedure – follow up – definition – reason for existence of functions – types of follow up, applications of computer in production planning and control.

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INTRODUCTION TO PRODUCTION PLANNING AND CONTROL


1.1. INTRODUCTION

Production is a process or procedure developed to transform a set of inputs like men, materials, capital, information and energy into a specified set of outputs like finished products and services in proper quantity and quality. It consists of series of sequential operations to produce a desirable product acceptable to customer and meet the customer demand with respect to quality and intended function.

Planning and control are the two important components of the management process. Production planning and control is a tool which
coordinates all the manufacturing activities in a production system. 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 firm’s resources like machines, men and materials are worked out to obtain the target in the economical way.

Once the plan is prepared, then the operations are 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 [if any deviation] is taken so as to achieve the targets as per the plan by using control techniques.

Definition:

According to Charles A. Koepke “Production Planning and Control is defined as the coordination of the series of functions according to a plan which will economically utilize the plant facilities and regulate the orderly movement of goods during the entire manufacturing cycle from the procurement of all materials to the shipping of finished goods at a predetermined rate”.

Production planning and control is a way of regulating as well as directing the movement of goods to whole of the production cycle, right from raw materials to the final delivery of the products so that the objective like maximum production, minimum inventory as well as customer service are fully satisfied.

![Fig. 1.1: PPC factory's nervous system](image-url)
According to Franklin G. Moore “Production planning and control is compared to the nervous system in the human body. This is because just as the nervous system regulates muscular movements in the human body; in the same way PPC coordinates all the activities of the plant”.

1.1.1. Objectives of production planning and control

1. To deliver quality goods in required quantities to the customer in the required delivery schedule in order to achieve maximum customer satisfaction.

2. To ensure optimum utilization of resources/materials.

3. To minimize the production/manufacturing cycle time.

4. To maintain optimum inventory levels.

5. To schedule production facilities in optimum manner.

6. To coordinate the activities of different departments relating to production to achieve regular, steady and balanced flow of production.

7. To ensure confirmation of delivery commitments.

8. To ensure production of quality products.

9. To keep the plant free from production bottleneck.

10. To ensure effective cost reduction and cost control.

11. To evaluate the performance of various shops & individuals.

12. To develop alternative plans inorder to meet any emergency or contingency.

13. To maintain spare capacity to deal with rush orders.
1.1.2. Factors affecting PPC

The various factors which affects the production planning and control are listed below

1. The interdependence of various operations involved in the transformation process.
2. The nature of product and quantity of product.
3. The nature and availability of various equipments and materials required for manufacturing process.
4. The size of orders and the production run.
5. The nature and type of manufacturing system.
6. The nature and type of manufacturing method adopted.
1.1.3. Planning and control process

The planning and control process consists of following steps:

1. Analysing past performance
2. Examining the future environment and develop the environment in which the company will be operating.
3. Developing objectives.
4. Formulating strategy to achieve objectives
5. Translating the strategy into operating plans
6. Motivating people to achieve those plans and budgets
7. Continuous comparison of actual with planned one.

1.1.4. Need for production planning and control

In order to withstand in the competition, industries have to arrange the production activities and attain maximum utilization of firm’s 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.

*Production planning and control is needed*

1. To achieve effective utilization of firms resources.
2. To achieve the production objectives with respect to quality, quantity, costs and timeliness of delivery.
3. To reduce storage cost
4. To obtain the continuous production flow in order to meet customers varying demand with respect to quality and committed delivery schedule.
5. To help the company to supply a good quality products to the customers on the continuous basis at competitive rates.
6. To minimize idleness of men and machines.

*1.1.5. Benefits of production planning and control*

1. It maintains good coordination between the departments.
2. It reduces the employee and plant idle time.
3. It ensures the optimum utilization of resources.
4. It helps in achieving the quality standards so that the quality of output is ensured.
5. It minimise the wastes, scrap, rework and also the rectification hour.
6. It also helps in utilizing idle time of the machine.
7. It make sures the availability of right supplies at right time [inventory control].
8. It avoids bottlenecks in the production process.
9. It ensures better services to customers by delivering quality goods within the specified time period.
1.2. PRODUCTION PLANNING

Production planning is a pre-production activity. It is a plan in which the facilities needed for production are determined and arranged.

It deals with basic concepts of what to produce, when to produce, where to produce, how much to produce. It takes a long term view at the overall production.

According to Raywild “production planning is the determination, acquisition and arrangement of all facilities necessary for future production of products.”

1.2.1. Objectives of Production Planning

1. To ensure the availability of raw materials, equipments etc. in right quantity and quality during the time of production.

2. To ensure all preparations for manufacturing, in order to reach the production goals established in the production budget and master production schedule (MPS) for the production process.

3. To ensure capacity utilization in tune with forecast demand at all times.

1.2.2. Planning Horizon

Production planning is made periodically for a specific time period, called the planning horizon.

Planning may be for

(a) Long term – one year or more

(b) Intermediate term – one month to a year

(c) Short term – A day or a month.
1.2.3. Production Planning Procedure

Production planning procedure generally varies from one company to the another.

The variation in planning procedure is because of difference in the economic and technological condition under which the firms operate.

There are 3 factors which determine the production planning procedures:

- Volume of production.
- Nature of production processes
- Nature of operations

1.3. PRODUCTION CONTROL

If there is any deviation between actual production and planned production, the production control function comes into action.

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

Production control tries to take corrective action to match the planned and actual deviation through control mechanism like Gantt charts, line of balance, PERT/CPM etc. Thus production control reviews the progress of the
work and takes corrective steps in order to ensure that programmed production takes place.

Production control includes.

(a) A complete plan

(b) A follow up procedure for determining how closely the plan is followed.

(c) Regulating and executing the plan to meet the production requirement.

Production control is dependent upon the following factors:

1. Nature of production
2. Nature of operation
3. Size of operation.

1.3.1. Objectives of production control

1. To minimize the production cost and to maintain delivery date with an effective utilization of resources.

2. To avoid delays in production by ensuring/providing regular and timely supply of raw materials at right place and of right quality and quantity.

3. To utilize quality control system to discover that the produced goods are on needed specifications.

4. To coordinate, monitor and giving feedback to production management in order to take corrective action if necessary.

1.3.2. Scope of production control

Production control rests on mechanisms by means of which, observations of current happenings are recorded and continuously compared with the planned production programme.
Deviations from the established plan are recognized and reported to the authority in order to take the corrective action. The factors in the practice of production control include:

1. Control of activities
2. Control of material movement
3. Control of tool availability
4. Control of due dates
5. Control of quantity produced
6. Control of replacement
7. Control of labour efficiency
8. Control of progress of orders.

**Activities of Production Control**

The following four categories are the activities over which the production control department has major responsibility.

1. Routing.
2. Scheduling.
3. Dispatching.
4. Follow up
### 1.4. DIFFERENCE BETWEEN PRODUCTION PLANNING AND PRODUCTION CONTROL

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<td>Production planning is a pre-production activity.</td>
<td>Production control will be in action when production activity begins.</td>
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<td>2.</td>
<td>Planning involves the collection, maintenance and analysis of data with respect to time standards, materials and their specification, machines and their process capabilities.</td>
<td>Control is concerned with communication of their information and producing reports like output reports, productivity, rejection rate etc.</td>
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<td>3.</td>
<td>Planning is useful to anticipate the problems and devising remedial measure incase the problem arises.</td>
<td>Control involves in taking corrective steps incase of error to match actual performance against the planned performance.</td>
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<td>4.</td>
<td>Planning is a centralised activity and includes functions like materials control, tool control, process planning &amp; control.</td>
<td>Control is a widespread activity. Includes functions such as dispatching, programming, inspection etc.</td>
</tr>
<tr>
<td>5.</td>
<td>Planning sees that all the necessary resources are available to make the production at right quantity, quality and time.</td>
<td>Control keeps track of the activities and sees whether everything is going as per schedule or not.</td>
</tr>
</tbody>
</table>
1.5. STAGES IN PRODUCTION PLANNING AND CONTROL

Production planning and control consists of three different stages as shown in Fig. 1.4.

![Fig. 1.4](image)

1. **Planning Stage**

   Planning stage includes activities such as planning the resources, facilities etc. It can be further divided into following two stages.

   (i) **Preplanning Stage**

   This stage deals with the activities such as product planning, forecasting of the demand on the basis of past trend, inputs planning, plant and facility planning related to location and layout.

   (ii) **Active-Planning Stage**

   After the preplanning stage the quantity, level of quality, process, capacity, production planning like routing, scheduling, materials and tools planning etc. are carried out in the active-planning stage.
2. Action Stage

It is concerned with the real implementation of the plan. It usually begins with the dispatching function, which deals with the progress of the work.

3. Monitoring Stage

In monitoring stage, the planned activities are controlled and monitored by using various techniques such as inventory control, cost control, quality control etc.

1.6. FUNCTIONS OF PRODUCTION PLANNING AND CONTROL

The main functions of PPC can be classified into different categories.

![Fig. 1.5: Functions of production planning and control]

1. Materials

The purpose of this function is to ensure correct start and end of each operation by providing raw materials, finished parts and semifinished components at required quantities and at required time for uninterrupted production process.
This function includes the specification of materials, delivery dates, variety reduction (standardisation) procurement and make or buy decision.

2. Methods

The purpose of this function is to find the best method of processing from the several alternatives. It also includes determining the best sequence of operations and planning of tools, jigs and fixtures etc.

3. Machines and equipment

This function is related with the detailed analysis of available production facilities, equipment downtime, maintenance policy procedure and schedule. It is also concerned with economy of Jigs & Fixture, equipment availability. Thus the duties include the analysis of facilities and making their availability with minimum downtime because of breakdowns.

4. Routing (Process Planning)

Routing means determination of path or route on which manufacturing operations will travel. It also establishes the sequence of operation to be followed in manufacturing a particular product. Generally route path is determined in advance.

The several activities in routing/process planning includes

1. Fixation of path of travel.
2. Breaking down of operations to define each operation.
3. Deciding the setup time and process time for each operation.

5. Estimating

This function is concerned with estimation of operation time. The operation time can be worked out, once the overall method and sequence of operation is fixed and process sheet for each operation is available.
6. Loading and Scheduling

Allocating the jobs to the individual machine is known as machine loading. The purpose of this function is to load the machine according to their capability of performing the given task and according to their capacity.

Scheduling is concerned with preparation of machine loads and assigning starting and due dates for each of the operation.

Here, the duties include:

1. Loading the machines as per their capability and capacity.
2. Determining the start and completion time for each operation.
3. Coordinating with sales department regarding delivery schedules.

7. Dispatching

Dispatching is the part of production control that translates the paper work into actual production. This is concerned with the execution of the planning functions.

Dispatching is the release of orders and instructions for the starting of production in accordance with the route sheets and schedule charts.

Here, the activities include:

1. Assigning definite work to definite machines, work centres and men.
2. Supplying required materials from store.
3. Providing jigs, fixture and making them available at correct point of use.
4. Releasing necessary work orders, time tickets etc. to authorise timely start of operation.
5. Recording start and finish time of each job on each machine (or) by each man.
8. Expediting (or) Follow up (or) Progressing

Follow up is the very important function for any production system. This is generally done after the dispatching function.

Expediting is the control tool that keeps a close observation on the progress of the work. It identifies the deviation from the actual production plan, then all deviations are investigated and suitable remedial measures are taken in order to complete the work by the planned date.

Here, the activities include:

1. Identification of bottlenecks, delays and interruption.
2. Devise action plans (remedies) for correcting the errors.
3. Following up and monitoring progress of work through all stages of production.

9. Inspection

Inspection is the quality control aspect of production planning and control.

This function is related to maintenance of quality in production and of evaluating the efficiency of the processes, methods and labours so that improvements can be made to achieve the quality standard set by product design.

10. Evaluation

The main objective of this function is to improve performance.

The evaluating function is concerned with providing a feedback mechanism on a long-term basis so that the past experience can be used to improve upon the use of methods, facilities and resources in future period.
1.7. PRODUCTION SYSTEM

Production implies the creation of goods/services to satisfy human needs.

Production is the process of transformation of inputs (resources), into outputs (good/services) using physical resources.

According to Cart Heyle, production is the process of transforming raw materials or purchased components/semi finished products into finished products for sale.

![Fig. 1.6: Model of Production System](image)

Production system consists of three main processes

1. Inputs
2. Conversion process
3. Outputs

**Inputs**: It includes raw materials, machines, drawings etc.

**Conversion process**: Conversion process includes welding, forging, machining, modeling, assembling etc.

Conversion process adds value to raw materials by changing its shape, size or weight.

**Outputs**: It includes finished products, finished goods and services.
1.7.1. Types of Production System

According to the volume of production (quantity) and product standardization, the production systems are classified as

1. Job shop production
2. Batch production
3. Continuous production
4. Mass production

1.7.1.1. Job Shop Production

In Job shop production system, products are manufactured to meet the requirements of a specific order.

The quantity involved is small and the manufacturing of the product will take place as per the specification given by the customer.

The distinguishing feature of job shop production system is low volume and high variety of products.

Examples: Space vehicles, aircraft, machine tools, special purpose machines etc.

According to the regularity of manufacturing, Job shop production is further classified into three types

1. A small number of pieces produced only once.
2. A small number of pieces produced intermittently when the need arises.
3. A small number of pieces produced periodically at known time interval.
Characteristics of Job shop production

1. General purpose machines and equipments are used to perform wide range of operations.

2. Highly skilled operators and supervisors are employed.

3. Flexible planning and control system to deal with the frequent changes in product requirements.

Merits

1. Due to the use of general purpose machines, it is suitable for producing variety of products.

2. The potential and skill of operators can be fully utilized.

Demerits

1. Production planning is complicated.

2. Higher setup and tooling cost due to frequent setup changes.

3. Higher inventory cost due to higher level of inventory at all levels.

1.7.1.2. Batch Production

In batch production system, the products are made in small batches and in large variety. Each batch contains identical items but every batch is different from the others.

Batch production plant includes machine shops, foundries, plastic moulding units, press shops, chemical and pharmaceutical units.

It is characterized by the manufacture of limited number of products produced at regular interval and stocked awaiting sales.
This type of production system is further divided into three different categories.

1. A batch produced only once
2. A batch produced at irregular intervals
3. A batch produced at known intervals.

**Characteristics of batch production**

1. A large variety of products are manufactured in lots or batches.
2. Higher level of work-in-process inventory.
3. Amount of supervision required is less compared to job shop production.

**Merits**

1. Cost per unit is lower as compared to job production system.
2. Investment is lower in plant & machinery.
3. Better utilization of plant & machinery compared to job shop production.

**Demerits**

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.
3. Higher setup costs due to frequent changes in setup.
1.7.1.3. Continuous Production

Production facilities for continuous production are arranged as per a predetermined sequence of production operations from the first operation to the finished product.

The items are made to flow in a sequence of operations through material handling devices such as conveyers, transfer devices etc.

A highly rigid type of machine layout is used for continuous production.

Characteristics of Continuous Production

1. Material handling is fully automated.
2. Persons with limited skills can be used in the production line.
3. Process follows a predetermined sequence of operation.

Merits

1. Due to high volume of production the unit cost is low.
2. Products and process sequences are highly standardized.
Demerits

Very high investment is required for setting flow lines.

1.7.1.4. Mass Production

Mass production refers to the process of creating large number of similar products efficiently

Standardisation of products, process, materials, machines and uninterrupted flow of materials are the basic features of this system.

Automobile assembly line is a typical example of mass production.

Characteristics of mass production

1. Special purpose machines having higher production rate is used.

2. Production volume is large.

3. Flow of materials, components and parts are continuous without any back tracking.

Merits

1. Higher rate of production with reduced cycle time.

2. Low in-process inventory.

3. Production cost per unit is low

4. Less skilled operators may be employed.

Demerits

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

2. High investment in production facilities.
1.8. PRODUCT DEVELOPMENT

Product development is an activity which involves in creating a new product or modifying the existing product in order to meet the changing customer requirements.

Generally industries have to continuously upgrade their products as well as to introduce new products in the market in order to retain as well as to increase their market share.

In a manufacturing company product development is done by research and development department.

The two main activities of product development are

1. Improving the existing product.
2. Introducing the new product to the market.

1.9. PRODUCT DESIGN

Designing is very important before actual transformation of raw materials (Input) into finished products (Output).

Product design is a critical function in the production system.

The quality of the product design (i.e. how well the design department does its job) is probably the most important factor in determining the commercial success and societal value of a product.

The products has to be designed in order to satisfy the customer’s desire.

If the product design is good, then the product will contribute to the company’s profit and success.
If the product design is poor then the revenues and well being of the firm is affected.

1.9.1. Different Stages in Product Design

The stages in the product design process are listed below

```
Conception  I
Acceptance   II
Execution    III
Translation  IV
Pre - Production V
```

**Fig. 1.8**

**State I: Conception**

In this stage, incorporating the user requirements the draft specifications for the product are laid down.

On design specification, the following information should be furnished.

1. Performance requirements.
2. Appearance (or) supplying requirements.
3. Estimated quantity which will be sold.
4. Maximum price within which the product should be offered.
5. Probable date of introduction of the product into the market.
Stage II: Acceptance

This is a stage where the design activity of the product begins after the feasibility analysis and model making and calculations of the product is accepted.

Stage III: Execution

Based on general design considerations, a model is prepared as per the acceptance of specification in stage II.

Rapid prototyping technique (RPT) and experimental stress analysis techniques are used for prototype, modelling and testing.

Stage IV: Translation

At this stage, the production engineering department is involved in design work.

The manufacturing feasibility is tested at this stage.

The final manufacturing drawings are also prepared in this stage.

Stage V: Pre-production

Before starting the production on commercial basis, it is recommended to carry out a pilot run under production conditions. The pre-production run will ensure the quality, and reliability of the product as per the specification. Thus the pre-production stage will check

1. Drawings.

2. Final tools.

3. Production techniques & estimates.

4. Specifications.
1.10. PRODUCT LIFE CYCLE

Every product goes through a cycle from birth, followed by a growth stage, a relatively stable matured period, and finally into a declining stage that eventually ends in the death of the product as shown schematically in Fig. 1.9.

1. **Introduction stage:** In this stage the product is new and the customer acceptance is low and hence the sales are low.

2. **Growth stage:** Knowledge of the product and its capabilities reaches to a growing number of customers.

3. **Maturity stage:** The product is widely acceptable and sales are now stable, and it grows with the same rate as the economy as a whole grows.

4. **Decline Stage:** At some point of time the product enters the decline stage. Its sales start decreasing because of a new and a better product has entered the market to fulfill the same customer requirements.

![Fig. 1.9: Schematic outline of a product life cycle](Image)

1.11. PRODUCT ANALYSIS

Before selection and conversion of a product idea into reality, management should carryout the detailed analysis of the product with respect to various factors that influence the product design.
Product analysis is performed before starting the actual design.

It is based on the information collected about the customer’s requirements and level of competition.

**Why product analysis is so important?**

(i) At later stage of product life, design modification are more expensive.

(ii) Once the product is launched, design modifications are not desirable.

(iii) At later stage of product life, design modification delays the launch of new product.

Various factors that influences the product design are listed below:

1. Marketing aspects
2. Product characteristics
   * Functional aspects
   * Operational aspects
   * Durability & reliability.
   * Aesthetic aspects.
3. Economic analysis
4. Production aspects.

1.1.1. Marketing Aspects

It is very important to know whether the planned product can satisfy a demand in the market and that it would be acceptable by customers.

It there is no potential market, then it is wasteful exercise to design and manufacture the product.

Therefore before going for the product design and other activities, the marketability of the product should be carefully examined.
The marketing analysis for the proposed product seeks to give answers to the following questions.

![Diagram showing the relationship between product design, characteristics, and aspects like marketing, economic, and production.]

**Fig. 1.10**

1. Does the product match the consumer needs, like shape, size and colour etc.?
2. Is it within the buying power of the consumers?
3. Whether the product functions are desirable and acceptable to the customers?
4. What will be the expected short term and long term demand for the product?
5. Who are the competitors and what are the distinguishing features offered by them?

The demand for the existing product can be easily estimated. But if the product is entirely new to the market, a detailed market survey is to be carried out to estimate the demand for the product.
Sometimes marketing division has to make special efforts to create demand and make product acceptable to the customers through sales promotion schemes like advertising.

Generally, the main objective of advertising is to expand the market this being achieved by

1. Providing general information about the existence of the product.
2. Drawing attention of the customers to special features.
3. Providing technical information about the product functional characteristics (or) utility.

It is understood clearly that the input from marketing aspects is important in deciding the products to make, how many to make and when to make them.

Marketing aspects analyse the factors that influence the demand of the product. Therefore it is a crucial step in product analysis.

1.11.2. Product Characteristics

The following aspects are the essential inputs to the product development process.

1.11.2.1. Functional aspects

When the marketing possibilities have been explored, the functional scope of the product has to be carefully analysed and properly defined. The functional objectives are to be fixed with respect to the product as given here.

1. What are the functions the product is expected to perform?
2. Whether single function or multiple functions are to be incorporated in the product?
3. Cost considerations due to offering multiple functions.
The functional analysis analyses the importance and worth of each function to be built in the product. It also analyses the effect of each function on the design of the product.

In recent times, the trend is towards offering a functional versatility of the product, thereby increasing the range of applications of product to the customer.

Versatility in the products will create a psychological satisfaction to the customer of owning more than one product.

**Example**

Mobile phones, vacuum cleaner and many others perform versatile functions with the use of additional attachments.

**1.11.2.2. Durability and dependability aspects:**

Durability and dependability are the two important aspects that often determine quality and reliability of the product.

Durability can be defined as active life of a product under given working conditions.

Reliability is probability that a particular product would perform satisfactorily for the period intended under a given operating conditions.

Dependability is the capability of the product to function when called upon to do the job.

**1.11.2.3. Operational aspects**

Once the functional aspects of the proposed product are determined, then operational aspects of the product has to be carefully analysed and properly defined.

The product produced should be easy to handle and simple to operate at the customers end.

The product may be used in different operational conditions and the customers vary with respect to skill and knowledge.
Thus the designer has to consider the various operational conditions, situation, environments and the logistic supports before designing the product.

1.11.2.4. Aesthetic aspect

Aesthetic aspect refers to the “external look good” aspect of the product.

It makes the product attractive to the customers and creates good impression about the product.

For many consumer goods like automobiles, household equipment etc aesthetics is the dominant factor in creating demand for the product.

The following factors are usually utilised by the designer to bring out aesthetic characteristics:

(a) Use of special materials
(b) Use of colours and colour combinations
(c) Surface finish and textures
(d) Shape by contours.

1.11.3. Economic analysis

An economic analysis is the key to management decision in product design policy.

Once the sufficient information on the marketability of the product is obtained and various aspects like functional, operational, and aesthetics are studied about the proposed product, then the next step is the economic analysis which seeks to answer the following questions.

1. What will be the amount of investment needed to manufacture the new product?
2. What is the estimated production cost per piece?
3. What is the reasonable margin of profit that can be expected?
4. Whether the prices (cost + profit) proposed to be offered by the company are competitive?

5. What is the expected volume of sales?

Here, again, the interdependence of variable like investment profit margin etc., should be strongly emphasized. Not one single question in this list can be isolated and solved independently of the others. The economic analysis is in fact a cycle and repetitive procedure. Each question is weighted in the light of the answer and the data provided by the previous question, and all the answers are checked when their turn comes again to be re-evaluated, until a state of equilibrium is reached and no further modifications to these answers are required.

1.11.4. Production aspects of product design

The design will be converted into reality in the production shop where it will be transformed into a physical product to be offered to the customer. So successful conversion of design into a saleable product is a challenge to every organisation. This needs a close coordination of production and design department at all stages of manufacturing the product. Thus, a designer cannot design the product in isolation and more interaction is needed by production and other departments to produce design that works and that can be manufactured without any defects.

Thus the concept of “DESIGN FOR MANUFACTURING” is used for evaluating the production aspects of product design.

Effective implementation of design for manufacturing requires that the designer to have fundamental understanding of the characteristics, capabilities and limitation of materials, manufacturing process etc.

The following aspects of production should be evaluated for effective implementation of DFM,
(A) Selection of Suitable Process

1. Production quantity (volume of production).

2. Information regarding utilisation of equipment, capacity of equipment, accuracy etc.

3. Selection of tooling such as jigs and fixtures.

4. Sequence of operations and methods of assembly.

5. Possibility of applications of new techniques, processes.

(B) Utilisation of Materials and Components with a view of

(i) Selecting the materials conforming to specifications.

(ii) Selection of method to reduce waste and scrap.

(iii) Usage of standard components and parts.

(iv) Interchangebility of components and assemblies within the product.

(C) Selecting the proper tolerances and work method

To achieve the specified quality standard through available processes and equipment. The specification of quality is going to influence the selection of a process.

To achieve a successful transformation of the design, a design engineer should work in close coordination with production and methods engineer to specify the best available process of transformation, keeping in mind the limitations of the production.
1.11.4.1. Design for Manufacturing (DFM)

Design for manufacturing (DFM) means the design of the product for ease of manufacturing.

The heart at any design for manufacturing system is a set of design principles (or) guidelines that are structured to help the designer in order to reduce the cost and difficulty of manufacturing an item.

DFM Guidelines

1. Design parts with tolerances that are within process capability.
2. Design parts for multiuse.
3. Design for ease of assembly.
4. Design for ease of manufacturing
5. Shape parts & products for case of packaging.
7. Minimize the number of components.
8. Use standard commercially available components.
9. Use common parts across product lines.
10. Minimize handling.
11. Use modular design.

1.11.4.2. Design for Assembly (DFA)

Design for assembly means the design of the product for ease of assembly.

The purpose of DFA is to minimize assembly cost by optimizing the assembly process and reducing the number of parts.
Guidelines for DFA

1. Minimize assembly surfaces.
2. Simplify design and reduce number of parts.
3. Use standard components/parts.
4. Design for automated production.
5. Design for ease of fabrication.
6. Minimize flexible parts and interconnections.
7. Eliminate adjustments as much as possible.

1.12. PROFIT CONSIDERATION

Profit making is the ultimate goal for any organization. So a thorough analysis of various expenditures incurred for manufacturing with reasonable profit margin is necessary for the survival of companies. If an organization wants to increase the total profit percentage, then it has to follow any one of the methods described below:

(a) by increasing profit margin
(b) by implementing effective marketing strategy
(c) by reducing production cost

\[ \text{Profit} = \text{Sales price} - \text{Total cost} \]

Fig. 1.11: Profit = Sales price – Total cost
(a) **By Increasing Profit Margin**: A margin is the difference between the sales price of a good or service and the price the business owner pays to attain that product or service.
In order to increase the total profit percentage, increase the profit margin per unit and hence the sales price but leave the total production cost unchanged.

If the sales volume remains same, the total profit would be proportional to the raise in the profit margin per unit.

Such an increase, affects the market equilibrium unfavorably and in that case the ratio of customers value of the product to its price will decline and the products of competitors will become more attractive.

In extreme cases, the market may shrink, and the total profit may fall below its original level.

(b) By Implementing Effective Marketing Strategy: In order to increase the total profit percentage, leave the total costs unchanged, but improve the ratio of value to price and thus widen the market.

This can be achieved by the following ways

1. by producing a better or more attractive product at the same cost.

2. by launching an intense advertising campaign in order to improve the customer’s assessment of the product value.

3. by reducing the sales price at the expense of the margin of profit per unit, in the hope that the market will expand enough to increase total profit.

(c) By Reducing Production Cost: In order to increase the total profit percentage, reduce the total production costs and give some of the benefits to the customers in the form of reduced sales prices

If both the profit per piece and the size of the market increase, a considerable improvement in total profits will be achieved.

This method depends on continuous search for better process, better materials, better methods and better management in order to reduce overheads.
1.13. EFFECTS OF STANDARDIZATION, SIMPLIFICATION AND SPECIALIZATION

Standardization, simplification and specialization are the important tools for product development and help in economic analysis of product design.

1.13.1. Standardization

A standard is a document that defines the characteristics of a product or service such as dimensions, safety aspects and performance requirements.

To make life much easier and simpler, standardization of products, methods, processes, activities etc. is very much necessary. Simple examples taken from daily life are standard sizes of garments and shoes, standard sizes of books and magazines, standard traffic signals and road signs, standard forms used by business organizations.

*Standardization is applied to two distinct areas in industry:*

1. Standardisation of products – their shape, dimensions, colour, physical and chemical properties etc. This is industrial standardization.

2. Standardization of business practices – of forms, procedure, systems, operating practices etc. This is managerial standardization.

**Definition:**

Standardization means producing maximum variety of products from the minimum variety of materials, parts, tools and processes. It is the process of establishing standards (or) units of measure by which extent, quality, quantity, value, performance etc. may be compared and measured.

The concept of standardization is applicable to all factors of production namely men, machines, materials and finished goods. These standards can become the basis to evaluate the performance of various components of production in a manufacturing process.
1.13.2. Role of standards

Standards play a critical role in

1. Ensuring the safety, quality and reliability of products, processes and services.
2. Efficient production.
3. Cost reduction through competition.
4. Supporting regulation.

1.13.3. Types of Standard

There are 3 types of documentary standards

1. **Formal standards**

   Formal standards are published by

   **National Standards Bodies (NSB)** – like AFNOR (France), BSI (UK), DIN (Germany), BSC (Japan), etc. A list of the approximately 160 national standards bodies that are members of ISO (the international organization for standardization), together with links to each of them.

   **Regional standards bodies** – like Pacific Area Standards Congress (PASC), The Pan American Standards Commission (COPANT), the African Organization for Standardization (ARSO), the Arabic industrial Development and Mining Organization (AIDMO).

   **International Standards Bodies** – like ISO, IEC, ITU

2. **Informal Standards**

   Informal standards are published by SDOS (Standards Development Organisations), like ASTM, IEEE, SAE, SEMI, VDI, etc.

3. **Private Standards**

   Private standards are developed by a company or by a trade association.
1.13.4. Goals of standardization

1. To maximize the use of common parts in different products.
2. To minimize the number of different types of parts, components, assemblies and other items.
3. To achieve maximum overall economy in terms of
   (a) Cost
   (b) human effort
   (b) Conservation of essential materials as opposed to more readily available materials.
4. To ensure maximum convenience in use. This objective of standardization leads to simplification, rationalization, interchangeability of parts and freezing of dimensions of components.
5. To control and simplify inventory and maintenance.
6. To adopt the best possible solutions to recurring problems.

1.13.5. Classifications of standardization

1. **Dimensional standardization**: It deals with the standardization of various engineering components such as rivets, bearings, nuts and bolts etc.
2. **Materials standardization**: It deals with the standardization of raw materials, tools, lubricants etc.
3. **Process standardization**: It deals with the standardization of process in order to get maximum benefit of ease and cheapness in production.
4. **Safety measures standardization**: It deals with the standardization of rules and regulations in order to assure safety to men and machines in the factory.
5. **Administrative standardization**: This standardization refers to office methods and procedures to assure a most efficient working.
1.13.6. Levels of standard

There are 5 different levels of standards. The level is determined by the group of interests creating and using the standard in its day-to-day operations.

(i) Individual Standard: An individual standard, specially laid down by an individual user, builder, a government department or a corporate body to suit his or its specific needs, such as specification for a price of furniture, a design for building, a house, a dam or for constructing a bridge or creating a factory.

(ii) Company Standard: A company standard or in plant standard, prepared by common agreement between various departments of a concern for guiding its design, purchase, manufacture and other operations.

(iii) Industry Standard: An industry or trade standard prepared by an organised group of related interests in a given industry or within a given trade or profession (sometimes this level is called association level because the activity originates with associations of trade or industry or other professional bodies).

(iv) National Standard: A national standard established after continuing all interests concerned within a country through a national standards organisation which may be a government department, a nongovernment unit or a quasi-government body.

(v) International Standard: An international standard or an international recommendation for standardisation resulting from agreement between independent sovereign nations having common interest.

Important foreign standards used in India

- BSS – BRITISH STANDARD SPECIFICATION
- ASTM – AMERICAN SOCIETY FOR TEST MATERIALS
- SAE – SOCIETY OF AUTOMOBILE ENGINEER
- DIN – GERMAN STANDARD
- JIS – JAPAN STANDARD
- NF – FRENCH STANDARD
Advantages of standardization

1. It reduces material waste and obsolescence.
2. It reduces stock and inventory of materials, parts and end products.
3. It enables the procurement of raw materials without any loss of time.
4. It enables uniform quality of product.
5. It reduces maintenance, servicing and replacement of equipment and parts.
6. It reduces the manufacturing cost per unit and hence the price of the product.

Limitations

1. Reduced choice for customers because of reduced variety.
2. Too much standardization of operations and procedure will reduce the interest of workers (loss of motivation).

1.13.7. Preferred Numbers

Standardization reduces number of sizes and variety of items, to reduce cost and to improve quality. These sizes are expressed numerically and are called preferred numbers (also called preferred values or preferred series).

Regard suggested the use of a geometrical progression as a guide for selection and this system can be adopted in standardization to cover the given ranges satisfactorily.

In the series each term is larger than the proceeding by fixed percentage.

The preferred numbers, suitably rounded off for practical convenience, are classified into five principal series, namely, R5, R10, R20, R40 and R80, where the number indicates the particular root of 10 on which the series is based. (The letter R stands as a tribute to Col. Regard who first proposed this system.)
The basic series is derived by the use of integral powers of 5th root of 10, viz., for R₅ series the formula to be used

\[ R_n = \sqrt[5]{10^n} \]

where, \( n = 0, 1, 2, 3, 4 \) and 5

Accordingly, the R₅ series is given below

1, 1.58, 2.51, 3.98, 6.31 and 10

Here geometrical increment is increased by approximately 60%. In the same manner, the increments in the other series are given below

R₁₀ series – increment by 26%  
R₂₀ series – increment by 12% and  
R₄₀ series – increment by 6%

The rating of electric bulbs follows R₅ series, viz. 15, 25, 40, 60, 100 and 150 Watts after rounding off 16, 63 and 160 to 15, 60 and 150 respectively.

Typical application of use of preferred numbers series is gear ratios in speed boxes of metal-cutting machine tools.

1.13.8. Simplification

Simplification means making improvement in methods by eliminating unnecessary parts of the job combining and rearranging other elements of the job and making them easier and safer to perform. It refers to the elimination of unnecessary varieties and size etc. In simplification superfluous and loss important varieties and types are cut down. Thus simplification reduces range of products, their types, sizes, shapes, styles and also reduces their complexity of manufacturing procedure. Thus it is helpful in eliminating wastage by avoiding unnecessary variety and unimportant difference in products of daily use.
The simplification of product generally involves in the reduction of number of varieties of products.

**Considerations in simplifying item**

1. Can simplification be effectively achieved depending open the nature of item?
2. How simplification will affect customer demand and volume of sale?
3. Does market competition permit simplification or it encourages product diversification?

**Note:**

*Diversification.* Diversification is just contrary to simplification. *Diversification means:*

(i) *addition of new products*

(ii) *introduction of established products into new market.*

This tends to increase complexity of the methods of manufacturing, because sometimes consumers like to have variety in type, size, colour, and quality of products being manufactured. This adds to the cost characteristic of the production which is of varied nature.

**Advantages of simplification**

1. It reduces inventories of material and component parts.
2. It leads to reduce investment in plant and machinery
3. It simplifies inspection and control.
4. Planning and control becomes easier.
5. It makes possible the effective utilization of special purpose and automatic machines.
Disadvantages

1. It cannot meet the needs of wide range of customer preferences.

2. Because of simplification there is a chance of losing customers to the competitors.

3. It creates a constant source of conflict between marketing and production.

1.13.9. Specialization

Specialization is concentration of effort in a particular area or occupation. It is the natural outcome of simplification and standardization. For example: Electricians, doctors, and lawyers specialize in their chosen fields. In product specialization, a firm may produce and market only one or a limited range of similar products. This leads to process and labor specialization, which increases productivity and decreases costs.

With a limited range of products, productivity can be increased and costs reduced by:

- Allowing the development of machinery and equipment specially designed to make the limited range of products quickly and cheaply.

- Reducing the number of setups because of fewer task changes.

- Allowing labor to develop speed and dexterity because of fewer task changes.

Specialization builds experience and makes it possible to produce a product or provide a service better at lower cost than if it were done by unspecialized individual effort.

Advantages of specialization

1. Productivity is high

2. Reduced production cost and hence lower unit price
3. Efficiency is high
4. Time required to complete the activity is less.

Disadvantages
1. Loss of flexibility. If workers specialize too much, it may be difficult for them to performing other tasks.
2. Monotony. Workers can get bored performing the same tasks everyday.

1.14. BREAK EVEN ANALYSIS

The Break Even Analysis is used to analyses the relationship between cost, volume and profit. It is also called as CVP (Cost, Volume, and Profit) analysis. Break even analysis is used to find the level at which the total cost and total revenue becomes equal. It is foolishness on the part of management to run a business without break even analysis.

![Fig. 1.13: Break Even Point](chart)

Fig. 1.13: Break Even Point
1.14.1. **Significance of BEA**

1. It gives, the **minimum number of units** to be produced so that there is no loss.

2. It indicates when the profit is attained.

3. To fix the bonus for employees and other wage calculations, this analysis is used.

The break even point can be obtained by graph. In this graph when total sales line intersects the total cost line, the **BEP** is obtained.

**B.E.P can be obtained in terms of**

(a) Number of units (How much minimum number of units should be produced to avoid loss)

(b) Sales Volume (or) Total Revenue (How much sales volume should be achieved to avoid loss)

(c) % of estimated capacity (What is the % of estimated capacity should be attained to avoid loss).

1.14.2. **Break Even Point (BEP)**

'BEP' is the production/sales level at which the total revenue equals total expenses. It is the point at which a product, project or a business becomes commercially viable. Operating beyond the BEP results in profits and operating below the BEP results in losses. Also **BEP** is a measure of how long it takes to recover ones investments. Many companies prefer a BEP of 18 months or less.

Now if  \( P = \) Salting price (Rs./unit)

\( F = \) Fixed cost (Rs.)

\( V = \) Variable cost (Rs./unit)

\( Q = \) Production volume (units)
We have

\[ Z = PQ - (QV + F) \]

At break even point, the gross profit is zero. So the production volume at BEP is given by,

\[ Q_{\text{BEP}} = \frac{F}{P - V} \]

1.14.3. Concept of Break Even Point

The concept of break even point is illustrated by using the problem given below.

**Problem 1.1**

The following data refers to the business concern
AIR WALK Publications.
Fixed cost per annum \( F = \text{Rs. 1,00,000} \)
Variable Cost per unit \( V = \text{Rs. 6} \)
Sales price per unit \( S = \text{Rs. 10} \)
Annual Production capacity is 50,000 units.
From above data

1. Fixed cost Rs. 1,00,000 is constant for any no. of units produced.

2. Total variable cost = \( \frac{\text{Variable Cost}}{\text{Unit}} \times \text{No. of units produced.} \)

3. Total Sales (or) Total Revenue = \( \frac{\text{Price}}{\text{Unit}} \times \text{No. of units sold.} \)

4. Total cost = \( F + V \).

5. Profit = Total Sales − Total cost.
The total cost, sales and profit can be worked out for different production levels as given in the table.

<table>
<thead>
<tr>
<th>Production Level (units)</th>
<th>Fixed Cost (FC)</th>
<th>Total Variable Cost = Rs. 6\times Q (VC)</th>
<th>Total Cost = FC + VC</th>
<th>Total Sales Rs.10\times Q</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1,00,000</td>
<td>0</td>
<td>1,00,000</td>
<td>$-1,00,000$ (Loss)</td>
</tr>
<tr>
<td>2</td>
<td>5000</td>
<td>1,00,000</td>
<td>30,000</td>
<td>1,30,000</td>
<td>$-80,000$ (Loss)</td>
</tr>
<tr>
<td>3</td>
<td>15,000</td>
<td>1,00,000</td>
<td>90,000</td>
<td>1,90,000</td>
<td>$-40,000$ (Loss)</td>
</tr>
<tr>
<td>4. BEP in units</td>
<td>25,000</td>
<td>1,00,000</td>
<td>1,50,000</td>
<td>2,50,000</td>
<td>0 (No loss &amp; No profit)</td>
</tr>
<tr>
<td>5</td>
<td>35,000</td>
<td>1,00,000</td>
<td>2,10,000</td>
<td>3,10,000</td>
<td>$+40,000$</td>
</tr>
<tr>
<td>6</td>
<td>45,000</td>
<td>1,00,000</td>
<td>2,70,000</td>
<td>3,70,000</td>
<td>$+80,000$</td>
</tr>
</tbody>
</table>

From the above table, we can understand the following points.

1. When the company does not produce anything, the loss is Rs. 1,00,000, which is equal to F (or FC).

2. When there is an increase in production, the loss goes on reducing i.e. when 5000 units are produced, the loss is Rs. 80,000. When 15,000 units are produced, the loss is further reduced to Rs. 40,000./-.
3. At a production level of 25,000 units, the unit makes no loss and no profit. The production level, which makes neither profit nor loss, is known as the BEP.

At the BEP, the total sales are just sufficient to cover the variable cost and recover fully the fixed cost.

4. At production levels beyond the BEP, the company earns profits. Higher level of production earns higher profits.

5. The calculation are valid until the maximum capacity is reached i.e. up to 50,000 units, the calculations are valid. Beyond this level, even the fixed costs will change due to additional infrastructure required and hence fresh calculations have to be made.

1.14.4. Construction and analysis of break even charts

1.14.4.1. Graphical Method

1. For drawing graph different levels of production are plotted in x axis and the cost and Revenue (F, TC and Sales) are plotted in y-axis.
2. The data from the table can be plotted in the graph.

3. When the production is 0 unit, the sales revenue is 0 (mark point 0) and at 45,000 units, it is Rs. 4,50,000 (Mark point C). The sales revenue line is drawn by joining these points 0 and C.

4. When the production is 0 unit, the total cost is Rs. 1,00,000 (Mark point A) and at production level of 45,000 units, it is Rs. 3,70,000/- (Mark Point B). The cost line is drawn to joining these two points A and B.

5. The above two lines (Total sales line and total cost line) intersect at production level of 25,000 units. This is the **Break Even Point B.E.P.**

### 1.14.4.2. Analytical method

A simple way of finding out BEP is as follows

\[
\text{BEP} = \frac{F}{S - V}
\]

where

- \( F \) = Fixed cost
- \( S \) = Sales per unit
- = Price per unit
- \( V \) = Variable cost per unit

So \( \text{BEP} = \frac{1,00,000}{10 - 6} = 25,000 \)

**Contribution**: \((S - V)\)

In the formulae \( \text{BEP} = \frac{F}{S - V} \)

\((S - V)\) represents the portion of the sales revenue, which goes to recover the fixed cost. Hence, \((S - V)\) is known as ‘contribution’ towards fixed costs (and profit). The formula can be modified as

\[
\text{BEP} = \frac{F}{C}
\]

Where \( C = S - V = \text{Contribution per unit} \).
Profit volume ratio (or) Simply P/V ratio

P/V ratio is the ratio of contribution to sales. It is generally expressed as a %. It is also called as contribution ratio.

In the above example,

The P/V ratio = \( \frac{C \times 100}{S} \)

= \( \frac{4 \times 100}{10} = 40\% \)

BEP can be calculated in terms of turnover (in Rupees) on the basis of P/V ratio. In this case, formula is modified as follows

\[ \text{BEP} = \frac{F}{\text{P/V ratio}} \]

For the above example, the BEP can be calculated by using the modified formula

\[ \text{BEP} = \frac{1,00,000}{40\%} = \frac{1,00,000}{0.4} = \text{Rs. 2,50,000} \]

When sales per unit and variable cost per unit is not given, we can use the above formula.

1.14.4.3. Margin of safety (MOS)

Margin of safety is the difference between the existing level of output and level of output at BEP.

\[ \text{Margin of safety (%) } = \frac{\text{Sales} - \text{Sales of BEP}}{\text{Sales}} \times 100 \]

If MOS is high then the firm incurs profit.

If MOS is low then the firm incurs loss.
1.14.4.4. Angle of Incidence

This is an angle at which sales revenue line cuts the total cost line.

A large angle of incidence indicates a high profit rate. Whereas narrow angle of incidence indicates low profit rate.

Problem 1.2: The following data are given for a company estimated output = 80,000 units. Fixed cost = Rs. 4,00,000 Variable cost = Rs. 10 per unit selling Price = Rs. 20 per unit. Find out the break even point analytically and Graphically.

(a) Analytically

\[
\text{BEP} = \frac{F}{S - V} = \frac{4,00,000}{20 - 10} = \frac{4,00,000}{10} = 40,000 \text{ units.}
\]

(b) Graphically

<table>
<thead>
<tr>
<th>No. of units produced (Q)</th>
<th>FC</th>
<th>Total VC = 10 × Q</th>
<th>Total Cost TC = FC + VC</th>
<th>Total Sales = Rs. 20 × Q</th>
<th>Profit = Total Sales – Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4,00,000</td>
<td>0</td>
<td>4,00,000</td>
<td>0</td>
<td>- 4,00,000</td>
</tr>
<tr>
<td>80,000</td>
<td>4,00,000</td>
<td>8,00,000</td>
<td>12,00,000</td>
<td>16,00,000</td>
<td>+ 4,00,000</td>
</tr>
</tbody>
</table>

1. Plot the no. of units in the ‘x’ axis. Plot the Rupee in lakhs in ‘y’ axis.
2. When ‘0’ units are produced, the total cost is 4 lakhs, Mark this point as A.
3. When ‘80,000’ units are produced, the total cost is 12 lakhs. Mark this as B.
4. Joint A and B. This is Total cost line.
5. When ‘0’ units are produced, the total sales is ‘0’.
6. When 80,000 units are produced and sold, the sales revenue is 16 lakhs. Mark this point as C. Now join ‘0’ and C. This is Total Sales line.

7. The total cost line and total sales line will intersect at point BEP. From BEP, draw vertical to cut ‘x’ axis. We get 40,000 units. So \( BEP = 40,000 \) units. Similarly, from BEP, draw horizontal to cut ‘y’ axis. We get 8 lakhs. So \( BEP = 8 \) lakhs. So from above graph, we found

**BEP in terms of units = 40,000 units and**

**BEP in terms of money = 8 lakhs.**

**Problem 1.3:** From the following data (a) find out the break even point. Variable cost per unit = Rs. 15/- Fixed cost = Rs. 54,000/- Selling price per unit = Rs. 20/- (b) What should be the selling price per unit if the BEP is brought down to 6,000 units.

**Solution:**

(a) \( V = \text{Rs. 15}; \ F = \text{Rs. 54,000}; \ S = \text{Rs. 20} \)

\[
\text{BEP} = \frac{F}{S-V} = \frac{54,000}{20-15} = \frac{54,000}{5} = 10,800 \text{ units}
\]
(b) \[ \text{BEP} = \frac{F}{S - V} \]

\[ 6000 = \frac{54,000}{S - 15} \]

\[ S - 15 = \frac{54,000}{6000} = 9 \]

\[ S = 15 + 9 = 24 \quad \text{So} \quad S = \text{Rs. 24} \]

So Selling Price = Rs. 24/- if the BEP is brought down to 6000 units.

**Problem 1.4:** The following data relate to a company working at 100% capacity level in manufacturing business. Fixed Overheads = Rs. 30,000/- Variable Overheads = Rs. 50,000/-, Direct wages = 40,000/- Direct materials = 1,00,000/-; Sales = 2,50,000/-. Mark the values in the break-even chart and determine BEP from the chart. Verify the result by calculations.

**Solution:**

Draw the chart for 0% and 100%
Fixed Overheads = Fixed cost = Rs. 30,000/-

Variable cost = Variable overheads + Direct wages + Direct materials

= 50,000 + 40,000 + 1,00,000 = Rs. 1,90,000/-

Total cost at 0% = 30,000 (A)

Total cost at 100% = 30,000 + 1,90,000 = 2,10,000 (B)

Join A & B get Total Cost line (TC line)

Total sales at 0% = 0

Total Sales at 100% = Rs. 2,50,000/- (C)

Join 0 & C. This is **Total Sales line**

This Total Sales line & Total cost line intersect at B.E.P. From B.E.P, draw horizontal. It cuts at Rs. 1,25,000/- So B.E.P = Rs. 1,25,000/-

**Verification**

\[ \text{B.E.P} = \frac{F}{P/V \text{ ratio}} = \frac{F}{\text{Contribution ratio}} = \frac{F}{(S - V)/S} \]

Contribution ratio = \( \frac{S - V}{S} = \frac{2,50,000 - 1,90,000}{2,50,000} = 0.24 \)

\[ \text{BEP} = \frac{F}{\text{Contribution ratio}} = \frac{30,000}{0.24} = Rs. 1,25,000/- \]

**1.14.5. Applications of Break Even Analysis**

The Break Even analysis is used by managers for decision-making in a number of areas as follows.

1. Pricing decision.
2. Make or buy decisions.
3. Products (or Sales) mix

5. Alternative methods of production.

6. Discontinuance of product line.

7. Expansion of capacity.

8. Profit planning.

1.14.6. Assumptions

The Break Even Analysis is based on the following assumptions.

1. All the expenditures can be classified into Fixed Cost and Variable Cost.

2. Fixed Cost is constant irrespective of change in level of activity.

3. Variable costs change in direct proportion with change in volume.

4. The sales price remains same irrespective of change in volume.

5. No Discount and No offer for more sales.

6. All units produced are sold.

7. Single product is considered. If there is more than one product, their product mix remains constant.

1.14.7. Limitations

1. Apart from Fixed Costs and Variable Costs, there are semi variable costs. These are not taken into account in the BEA.

2. The fact that fixed costs remain unchanged is untrue practically.

3. Selling prices will not remain constant.

4. The BEA does not take into account the capital involved. Without considering the capital cost, the decision making will be poor.
5. Only limited information can be shown on a break-even chart. A number of charts have to be drawn to show the effect of changes in variable cost, sales price, fixed cost, product mix etc.

6. In the long run, all factors including Fixed cost may change. Hence BEA is particularly for short-run technique and cannot be used for long run.

1.15. ECONOMICS OF A NEW DESIGN

In order to survive in the competitive atmosphere of industrial world, a new product (or) modification of existing product is essential. During the launch of a new model (or) design, a careful analysis of the economics of the proposed project has to be done.

The reason for introducing a new model to the market is

1. To increase the profit of the company.
2. To avoid decrease in sales of an existing product.

Samuel Eilon’s mathematical model of profit-volume analysis is the useful tool to determine whether the additional investment (I) of monetary units (due to process change, design change, material change) is desirable or not.

\[ P_1 \] is the profit obtained before investment
\[ P_2 \] is the profit obtained after investment.

By comparing \( P_1 \) & \( P_2 \), the decision is made.

Let,
- \( F \rightarrow \text{Fixed cost} \)
- \( I \rightarrow \text{Additional investment made} \)
- \( P \rightarrow \text{Profit} \)
- \( N \rightarrow \text{Quantity sold} \).

We know that the slope of break even chart

\[ \phi = \frac{\text{Profit} + \text{Fixed cost}}{\text{Quantity sold}} \]
Before Investment

The slope of break even chart is

\[ \phi_1 = \frac{P_1 + F}{N_1} \]

\[ \therefore P_1 = \phi_1 N_1 - F \] .... (1.1)

After Investment

The slope of break even chart is

\[ \phi_2 = \frac{P_2 + F + I}{N_2} \]

\[ \therefore P_2 = \phi_2 N_2 - F - I \] .... (1.2)

It has been assumed that fixed costs are mainly dependent on the existing machinery of the company and are therefore not likely to change very much.

It is desirable that the profit after investment will be larger than or at least equal to the existing one. Therefore

\[ P_2 \geq P_1 \]

(or)

\[ P_2 - P_1 \geq 0 \]

From eqn. (1.1) & (1.2)

\[ \Rightarrow \left( \phi_2 N_2 - F - I \right) - \left( \phi_1 N_1 - F \right) \]

\[ \Rightarrow \phi_2 N_2 - F - I - \phi_1 N_1 + F \]

\[ \Rightarrow \phi_2 N_2 - \phi_1 N_1 - I \geq 0 \] .... (1.3)

The above condition tells us how many units of the new design ought to be sold in order to ensure that the total profit does not decline.
For $P_2 - P_1 \geq 0$, using eqn. (1.1) & (1.2) we get

\[ N_2 \geq \frac{1}{\phi_2} + \left( \frac{\phi_1}{\phi_2} \right) N_1 \]  

\[ \ldots (1.4) \]

Dividing eqn. (1.4) by $N_1$, we get

\[ \frac{N_2}{N_1} \geq \frac{1}{\phi_2} \frac{\phi_1}{N_1} + \frac{\phi_1}{\phi_2} \left( \frac{1}{\phi_1 N_1} + 1 \right) \]  

\[ \ldots (1.5) \]

From eqn. (1.1)

\[ P_1 = \phi_1 N_1 - F \]

\[ P_1 + F = \phi_1 N_1 \]  

\[ \ldots (1.6) \]

Put (1.6) in (1.5)

\[ \therefore \frac{N_2}{N_1} \geq \frac{\phi_1}{\phi_2} \left[ \frac{1}{P_1 + F} + 1 \right] \]

\[ \frac{N_2}{N_1} \geq D \left[ \frac{1}{P_1 + F} + 1 \right] \]  

\[ \ldots (1.7) \]

Where, $D$ stands for the ratio

\[ D = \frac{\phi_1}{\phi_2} = \frac{P/V \text{ ratio of old design}}{P/V \text{ ratio of new design}} \]

When we substitute $D = 1$ in the above eqn. (1.7),

$N_2$ must be greater than $N_1$ to justify investment on design change.
Problem 1.5: The annual fixed costs of a product are known to be 4 lakh and the annual net profit Rs. 70,000, the average monthly sale being 2,000 units. A new design is contemplated, involving an expenditure for preparations amounting to Rs. 2,20,000, to be reiterated in two years. It is expected that with new production methods the P/V ratio may be increased by 5 per cent. What should the annual sales figure for the new design be

(i) so that the same net profit will be realized?

(ii) so that in addition to this profit, a yield of 10 per cent on the capital invested will be obtained?

Given Data:

\[ F = \text{Rs. 4,00,000}, \quad P_1 = \text{Rs. 70,000}; \quad N_1 = 2000 \text{ units/month} = 12 \times 2000 = 24,000 \text{ units/year}; \quad I = \text{Rs. 2,20,000}. \]

Solution: (i) We know that,

\[ \frac{D}{P/V \text{ ratio for old design}} = \frac{1.00}{1.05} = 0.95 \]

[*P/V ratio for new design is increased by 5%]*

The additional expenditure per year, \( I = \frac{2,20,000}{2} = \text{Rs. 1,10,000} \)

We know that, \( \frac{N_2}{N_1} \geq \left( 1 + \frac{I}{P_1 + F} \right) D \)

\[ = \left[ 1 + \frac{1,10,000}{70,000 + 4,00,000} \right] 0.95 = 1.17 \]

Annual sales enquired, \( N_2 \geq 1.17 N_1 = 1.17 \times 24,000 = 28,080 \text{ units Ans.} \)