ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 2 PROCESS PLANNING ACTIVITIES

ECONOMICS OF PROCESS PLANNING:

INTRODUCTION

The process planner should have the fundamental knowledge on cost estimating, cost accounting, various types of costs, and components of costs and calculation of manufacturing of a product.

The knowledge of costing will help the process planner and the management to take the following decisions:

- Type of material to be used for a product
- Type of manufacturing process to be used for a product
- Volume of product to be manufactured
- Make or buy a product
- Design of a product

The various classification of costs elements of costs and the calculation of total cost of a product with numerous numerical. In the following section, the Concept of break-even analysis with respect to process planning activities is presented.

BREAK-EVEN ANALYSIS

Break-even analysis, also known as cost-volume-profit analysis, is the study of Inter- relationships among a firm’s sales, coats and operating profit at various levels of output. It reveals the effect of fixed costs, variable costs, prices, sales mix, etc., on the profitability of a firm.

It is a simple method of presenting to management the effect of changes in volume on profit. It is concerned with finding the point at which revenues and costs are exactly equal. This point is known as break-even point.

Aims of Break-Even Analysis

The important aims and objects of break-even analysis are:

- To help in deciding profitable level of output, below which losses will occur.
- To compute costs and revenues for all possible volumes of output to fix budgeted sales.
- To take decision regarding make or buy.
- To decide the product mix and promotion mix.
- To take plant expansion decisions.
- To take equipment replacement decisions.
- To indicate margin of safety.
- To fix the price of an article to give the desired profit.
- To compare a number of business enterprises.
- To compare a number of facility locations.

Break-Even Point

Break-even point may be defined as the level of sales at which total revenues and total costs are equal. It is a point at which the profit is zero. It is also known as “no-profit no-loss point”. If a firm produces and sells above the break-even point, it makes profit. In case it produces and sells less than the break- even point, the firm would suffer losses, Management can change the break-even point by changing fixed cost, variable cost and selling price.

Determination of Break-Even Point

Two approaches used to determine break-even point are:

1. The algebraic method, and
2. The graphical method.

THE ALGEBRAIC METHOD:

(1) Break-even point in terms of Physical Units:

- FC = Fixed cost
- VC = Variable cost per unit
- TVC = Total variable cost
- TC = Total costs
- TR = Total revenue i.e., total income
- Q = Sales volume i.e., quantity sold
- SP = Selling price per unit

Total costs = Fixed cost + Variable cost TC = FC+(VC x Q)

Total revenue = Selling price / unit x Quantity sold

TR = SP X Q

At Break-Even Point,

Total costs = Total revenue

TC = TR

FC+ (VC x Q) = SP x Q

QBEP = FC / (SP –VC)

Break-even quantity = Fixed Costs / {(Selling price / unit) — (Variable cost / unit)}

(ii) Break-even point in terms of Sales Value:

This method is suitable for a multi-product firm.

Break-even sales (BEP in rupees) = Fixed costs / 1- {(Variable cost / unit) / (Selling price / Unit)}

BEP in rupees = FC / 1- (VC/SP)

Contribution

The difference between selling price and variable cost per unit is known as contribution or contribution margin.

Contribution = Selling price — Variable cost

C = SP—VC

Contribution is a companion measure of value that tells how much of the revenue from the sale of one unit of a product will contribute to cover fixed costs with the remainder going to profit.

Contribution margin divided by selling price is known as contribution ratio.

Contribution ratio = Contribution / Selling price

Contribution ratio = (Selling price — Variable cost) / Selling price

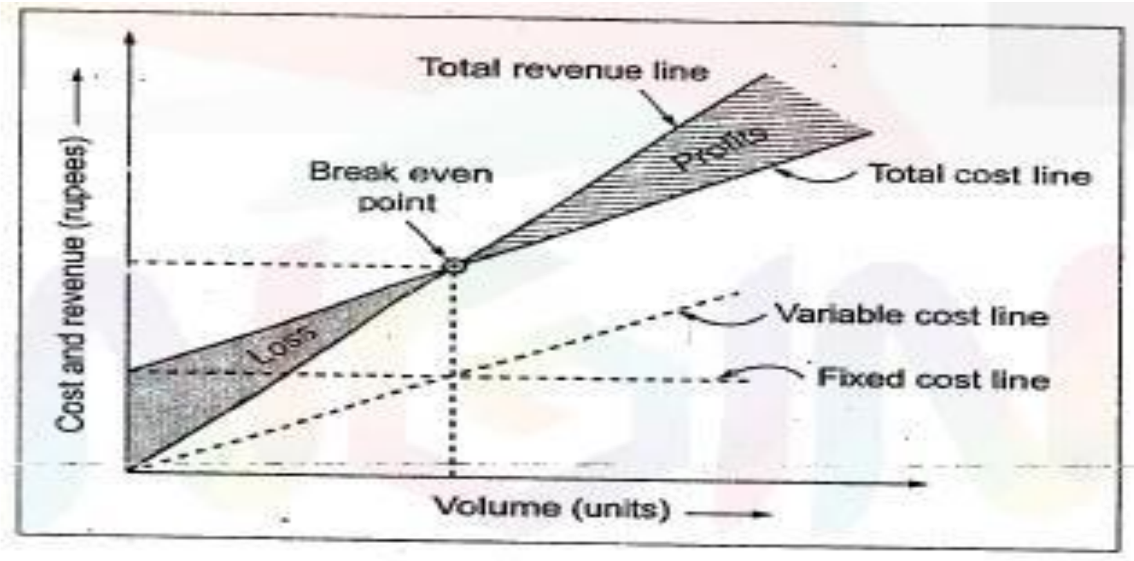
P/V RATIO (PROFIT / VOLUME RATIO)

P/V Ratio = Contribution / Sales

The Graphical Method (Break Even Chart)

- Break even chart is a graphical representation of the relationship between costs and revenue at a given time.
- It is a graphic device to determine the break-even point and amount of loss or profit under varying conditions of output and costs.
- In break-even chart, cost and revenue in rupees is represented on horizontal ax is
- The fixed cost line is horizontal and parallel to the X-axis. It indicates that fixed costs remain unchanged for any volume.
- The variable cost line is superimposed on the fixed cost line to show total costs.
- The total sales revenue line is drawn.
- This line indicates sales income at various levels of output.
- The point at which the total revenue line intersects the total cost line is the break-even point.

- The shaded area above the BEP marks profit to the firm whereas the shaded area below the BEP represents loss to the concern



MARGIN OF SAFETY

- Margin of safety is the difference between the existing level of output and the level of output at BEP.
- Greater value of margin of safety means higher profits to the firm
- If the safety margin is low, then the firm runs the risk of incurring losses.

Margin of safety (in%) = (Sales – Sales at BEP) / Sales * 100

Machine Break Points (Equipment Selection)

- Break even analysis is a useful guide in the selection of most economical equipment or production process
- The most economical alternatives is the one with the lowest costs at the expected volume
- A graph of the respective costs will reveal the machine break points.

SELECTION OF QUALITY ASSURANCE METHODS:

The next activity of process planner is to specify the quality assurance methods/inspection criteria for all the critical processing factors such as dimensional and geometric tolerances and surface finish specifications that are identified during the drawing interpretation.

In general, the process planner provides the inspection criteria and accordingly the quality engineer decides on the QA tools and techniques to be employed. However, the process planner should have clear understanding of QA principles, tools and techniques so that to work in tandem with the quality engineer effectively.

There are various TQM tools and techniques available to improve the product qual ity and the selection of the most appropriate tools and techniques for the given process is the task of the process planner and quality engineer.

BASIC QUALITY STRATEGIES

The two basic quality strategies are

1. Detection strategy
2. Prevention Strategy

1. Detection strategy

This Strategy focuses on the question of “Are we making it correctly?”

- In this strategy, the non – conformance is detected using various inspection methods and then the process is adjusted
- The detection strategy is not the most desirable one as it leads to rework and/or scrap.

2. Prevention Strategy

- This strategy focus on the question of “can we make it correctly?”
- In this strategy, the non-conformance is minimized / eliminated in the process before it can occur
- In this strategy, the SPC and process capability tools and techniques are employed.

Seven Statistical Tools of Quality (Q7 Tools)

The Japanese quality guru Ishikawa proposed ‘seven basic tool’ (Q-7 tools) based on statistical techniques to facilitate successful accomplishment of quality improvement objectives.

The seven statistical tools of quality and their uses are listed in Table

S.No	Statistical Tools	Purpose
1.	**Flow Chart**	For depicting the essential steps of a process by using standard symbols
2.	**Check Sheet**	For systematic data gathering , by tabulating the frequency of occurrence
3.	**Histogram**	For graphically displaying the frequency distribution of the numerical data
4.	**Pareto diagram**	For identifying the vital few causes that account for a dominant share of quality loss
5.	**Cause and effect diagram**	For identifying and analyzing the potential causes of a given problem
6.	**Scatter diagram**	For depicting the relationship between two variables
7.	**Control Chart**	For identifying process variations and signaling corrective action to be taken

Statistical quality control (SQC)

- Statistical quality control (SQC) is about employing inspection methodologies derived from statistical sampling theory to ensure conformance to requirements
- In SQC. the samples arc inspected from a batch and based on the statistical inferences, the conclusions are drawn on the whole batch.

Two main methods employed in SQC are

1. Statistical Process control (SQC)
2. Acceptance sampling

Assignable and Chance Causes of Variations

One of the axioms or .truisms of manufacturing is that no two objects are ever made exactly alike. All manufacturing processes have some degree of inherent variability.

Four sources of variations: The four sources of variations are processes, materials, operations and miscellaneous factors. The source of miscellaneous variations includes environmental factors such as heat, light, radiation and humidity.

Types of variations: There are two kinds of variations, as given below.

Assignable (or Special) Causes of Variations

Assignable causes of variations are larger in magnitude and can be easily traced and detected. The reasons of assignable causes of variation are due to:

(a) Differences among machines,

(b) Differences among materials,

(c) Differences among processes

(d) Differences in each of these factors over time, and

(e) Differences in their relationship to one another.

The prime objective of SQC is detecting assignable causes of variation by analyzing data. Once the assignable causes of variations arc identified and eliminated through remedial actions, the process becomes statistically control.

Chance (or Random or Common) Causes of Variations

Chance causes of variations are inevitable in any process. These are difficult to trace and control eyes, under best conditions of production. All occur at random. Now using the revised values of R-chart, pot the X-chart. Then check whether the process is in control or not. If the points are Out-of-control, revise the control limits for X-chart.

In practice, computer software packages such as Minitab (a popular statistics package) are commonly used for construction of all types of control charts.

Control Charts for Attributes

An attribute refers to those quality characteristics that conform to specification or do not conform to specifications. Control charts for attributes monitor the number of defects or fraction defect rate present in the sample. Types of attributes control chart used are

1. P- chart: The chart for fraction rejected as non-conforming to specifications.
2. np-chart: The control chart for number of non-conforming items.
3. c-chart: The control chart for number of non-conformities.
4. u—chart: The control chart for number of non-conformities per unit.

Process Capability

Process capability compares the output of an in-control process to the specification limits by using capability indices.

In other words, process capability measures the output of a process and compares it to the customer specification limits, or can be considered as comparing 'voice of the process' with 'voice of the Customer'

Definition: Process capability may be defined as the "minimum spread of a specific measurement variation which will include 99.7% of the measurements from the given process".

In other words, [Process capabi1ity = 6ς+. Since 99.7% area in the normal curve is between - 3 ς to +3ς. therefore process capability is equal to 6ς.

Process capability (=6ς), is also called as natural tolerance. The purpose of process capability analysis are:

(i) To find out whether the process is inherently capable of meeting the specified tolerance limits.

(ii) To identify why a process 'capable' is failing to meet specifications.

Process Capability Indices (Measures of Process Capability)

(i) Process Capability Index

- ❖ Cp is a process capability index that indicates the process potential performance by relating the natural process spread to the specification (tolerance) spread.
- ❖ It is often used during the product design phase and pilot production phase.
- ❖ To find Cp : The capability index is defined as

Cp = Total specification tolerance / Process capability Cp = (USL – LSL) / 6ς

- ❖ USL = Upper specification limit
- ❖ LSL = Lower specification limit
- ❖ USL – LSL = Tolerance
- ❖ ς = Population standard revolution
- ❖ 6ς = Process capability
- ❖ Cp = Capability index

Interpretation of Cp

(i) If Cp > 1 means that the process variation is less than the specification. That is the process is capable of meeting the specifications

(ii) If Cp < 1 means that the process is not capable of meeting the specifications

(iii) If Cp = 1 means that the process is just meeting the specifications

The larger the capability index (Cp) the better the quality. So one has to improve the Cp _value by improving process capability and having realistic specifications.

Process capability index Cpk

- ➢ Cpk measures not only the process variation with respect to allowable specifications, it also considers the location of the process average.
- ➢ It is often used during the pilot production phase and during routine production phase.
- ➢ To find Cpk : Cpk = min { (USL-Mean)/3ς) , (Mean-LSL)/ 3ς)}

- Interpretation of Cpk :

(i) Cpk value is always equal to or less than C p value

(ii) If Cpk > 1 means that the process confirms the specification.

(iii) If Cpk < 1 means that the process does not conform to specifications

(iv) If Cpk = 1 means that the process is just conform to specifications

(v) If Cp = Cpk, then the process is centered

Inspection and Measurement Objectives of Inspection

- Inspection s the function by which the product quality is maintained.
- The main aims of inspection are

(i) To sort out the conforming and non- conforming product

(ii) To initiate means to determine variations during manufacture

(iii) To provide means to discover inefficiency during manufacture.

Stages of Inspection

Three stages of inspection are given below

(i) Inspection of incoming materials (Pre-production inspection or Input inspection)

- It consists of inspecting and checking all the purchased raw materials and pans that are supplied before they are taken on to stock or used in actual manufacturing.
- This inspection may take place either at supplier's end or at manufacturer's gate.

(ii) Inspection of production process (Inspection during production or Process Inspection)

- The work of inspection is done while the production process is simultaneously going on. Inspection is done at various work centres and at the critical production points.
- This had the advantage of preventing wastage of time and money on defective units and preventing delays in assembly.

(iii) Inspection of finished goods (Post-production inspection or Output inspection)

- This is the last stage when finished goods are inspected and carried out before marketing to see that poor quality may be either rejected or sold at reduced price.

Methods of Inspection

There are two methods of inspection. They are

1. 100% inspection
2. Sampling inspection

1. 100% inspection

- 100% inspection is quite common when the number of parts to be inspected is relatively small
- Here every part is examined as per the specifications or standard established and acceptance or rejection of the parts depend on the examination

2. Sampling inspection

- The use of sampling Inspection is made when it is not practical or too costly to inspect each piece
- A random sample from a batch is inspected and the batch is accepted if the sample is satisfactory.
- If the sample is not to the desired specification then either entire batch may be inspected piece by piece or rejected as a whole.

- Statistical methods are employed to determine the portion of total quality of batch which will serve as a reliable sample.

TYPES OF INSPECTION

Inspection can be classified according to the type of data involved as

- Inspection of variables
- Inspection of attributes

All qualitative characteristics arc known as attributes. All characteristics that can be quantified and measurable arc known as variables.

Some examples of attributes and variables measurements

ATTRIBUTES	VARAIBLES
• Number of defective pieces found in a sample • Percentage of accurate invoices • Weekly number of accidents in a factory • Number of complaints • Monthly number of tools rejected • Percentage of on-time shipments • Errors per thousand lines of code • Percentage of absenteeism	• Dimension of a part measured • Temperature during heat treatment • Tensile strength of steel bar • Hours per week correcting documents • Time to process travel expense accounts • Days from order receipt to shipment • Cost of engineering changes per month • Time between system crashes • Cost of rush shipments

MEASUREMENT INSTRUMENTS

The selection of appropriate measurement instrument to be employed is basically depend on the type of quality characteristic of the component considered.

Measurement: The different types of quality characteristics that are to be measured are:

I. Dimensions / size,

2. Physical properties,
3. Functionality, and
4. Appearance.

In fact, the first two quality characteristics in the above list are variables and hence they are to be measured/quantified. On the other hand, functionality arid appearance are attributes and hence they are to be counted, checked for qualitative decision.

Measurement Instruments Used for Variables Inspection

Characteristics	Basic measurement instruments used
Measurement of lengths	1. Engineer's rule 2. Micrometers (a) Internal Micrometer (b) Cylindrical gauge 3. Depth Gauge 4. Vernier calipers 5. Vernier depth gauge 6. Vernier height gauge
Measurement of angles	1. Bevel Protractor 2. Sine bar
Measurement of straightness	Autocollimator
Measurement of flatness	Interferometer

Measurement Instruments Used for attributes inspection

Types of Limit Gauges	Purpose
Form Gauges	• Form gauges arc used to check the contour of a profile of workpiece for conformance to certain shape or form specifications.

Feller Gauges	• Feller gauges are used for checking clearances between mating surfaces
Plate and wire Gauges	• The thickness of a sheet metal is checked by means of plate gauges and wire diameters by wire gauges

Selecting Measuring Instruments (Factors to be considered for selecting measuring instruments)

Many factors should be considered while selecting a measuring or gauging instrument for a particular manufacturing inspection operation.

1. Accuracy (or Rule of Teat):

The Rule of Ten, a1so known as the Gage Makers Rule, states that the accuracy of the measuring instrument should be 10 times that of the tolerance of the quality characteristic being measured

2. Linearity:

It is the accuracy of the measurements of an instrument throughout its operating range.

3. Magnification:

It is the amplification of the outputreading on an instrument over the actual input dimension.

4. Repeatability:

It ta the ability of the instrument to achieve the same degree of accuracy on repeated applications (often referred to as precision).

5. Resolution:

It Is the smallest increment of difference in dimension that can he read on an instrument.

6. Sensitivity:

It is the smallest increment of difference in dimension that can he detected by an instrument

7. Stability (or drift):

It is the ability of the instruments to maintain its calibration over a period of time.