ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 2 PROCESS PLANNING ACTIVITIES

1.PROCESS PARARMETERS CALCULATION FOR VARIOUS PRODUCTION PROCESSES:

INTRODUCTION

The process planning involves the various activities such as drawing interpretation, material evaluation and process selection, selection of machines and tooling, setting process parameters, selection of work holding devices, selection of quality assurance and inspection methods, cost estimating and then documenting the details using route sheets.

- The process planning activities—drawing interpretation, material evaluation and process selection and selection of machines and tooling were discussed in detail.

- In this unit, the remaining process planning activities—setting process parameters, selection of worholding devices (Le.. jigs and fixtures), selection of inspection/quality assurance methods and economics of process planning will be described in detail, one by one.

PROCESS PARAMETERS CALCULATION:

The three important process parameters to be calculated for each operation during process planning are:

1. Cutting speed,
2. Feed rate, and
3. Depth of cut

CUTTING SPEED

The cutting speed also known as surface cutting speed or surface speed, can be defined as the relative speed between the tool and the workpiece.

It is a relative term, since either the tool or the workpiece or both may be moving during cutting. Unit: It is expressed in meters per minute (mpm).

Factors Affecting the Selection of Cutting Speed

The major factors considered for selecting cutting speed are as follows.

1. Nature of the. Cut

- ❖ Continuous cut like turning, boring, drilling, etc., are done at higher cutting speed. Shock initiated cuts in shaping machine, planning machine, slotting machine, etc. are done at lower cutting speed.
- ❖ Intermittent cuts, as in milling, hobbing. etc., are done at quite lower speed for dynamic loading.

2. Work Material (type, strength, heat resistance, toughness, chemical reactivity, etc.)

- ❖ For example, harder, stronger, heat resistant and work harden able materials are machined at lower cutting speed.
- ❖ Soft, non-sticky and thermally conductive materials can be machined at relatively higher cutting speed.

3. Cutting Tool Material (type, strength, hardness, heat and wear resistance, toughness, chemical stability, thermal conductivity, etc)

- ❖ For example, HSS tools are used at within 40 m/mm only in turning mild steel whereas for the same work cemented carbide tools can be used at the cuffing speed of 80 to 300 m/min.

4. Cutting Fluid Application

- ❖ Proper selection and application of cutting fluid may increase in cutting speed by 20 to 50%

5. Purpose of Machining

- ❖ Rough machining with large material removal rate (MRR) is usually done at relatively low or moderate cutting speed.
- ❖ Finish machining with small feed and depth of cut is usually done at high cutting speed.

6. Kind of Machining Operation

- ❖ Unlike turning, boring. etc., the operations like the threading, reaming, knurling. etc., are carried out at much lower cutting speed.

7. Capacity of the Machine Tool

- ❖ Powerful, strong, rigid and stable machine tools allow much higher cutting speed, if required and permissible.

8. Condition of the Machine Tool

Cutting Speeds (metre/minute) for different combinations of operation and material

Material	Operation					
	Turning and boring	Drilling	Reaming	Shaping, slotting and planing	Milling	Grinding
Aluminium	300	120	120	25	200–300	20
Brass	45–75	50	25	12–15	40	22
Cast iron	20	15	10	10	50	12
Copper	30	50	15	10	40	22
Mild steel	30	25	12	20	20	15

Cutting Speed ranges for different combinations workpiece and tool material

S.No.	Workpiece Material	Cutting Speed (m/min)	
		HSS	Carbides
1.	Low-carbon steels	20 – 110	60 – 230
2.	Medium-carbon steels	20 – 80	45 – 210
3.	Steel alloys (Ni-based)	20 – 80	60 – 170
4.	Grey cast iron	20 – 50	60 – 210
5.	Stainless steels	20 – 50	55 – 200
6.	Chromium nickel	15 – 60	60 – 140
7.	Aluminium	30 – 110	60 – 210
8.	Aluminium alloys	60 – 370	60 – 910
9.	Brass	50 – 110	90 – 305
10.	Plastics	30 – 150	50 – 230

FEED AND FEED RATE

Feed is the distance through which the tool advances into the workpiece during one revolution of the workpiece or the cutter. Feed rate is the speed a: which the cutting tool penetrates the workpiece. Unit: Feed rate is usually expressed in millimeters per spindle revolution (mm/rev) or millimetres per minute (mm/mm).

Factors Affecting Feed Rate

The factors that are considered during selection of feed value are:

I. Work material (type, strength, hardness, etc.)

II. Capacity of the machine tool (power, rigidity, etc.)

III. Cutting tool (material, geometry and configuration)

IV. Cutting fluid application

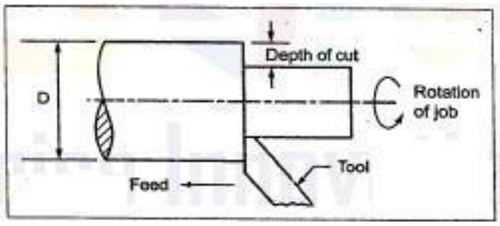
V. Surface finish desired

VI. Type of operation

VII. Nature of cut

DEPTH OF CUT

Depth of cut is the thickness of the layer of metal removed in one cut or pass, measured in a direction perpendicular to the machined surface. The depth of cut is always perpendicular to the direction of feed motion. Unit: It is generally measured in mm.



Illustrates the terms feed and depth of cut.

The feed and depth of cut for a particular operation depend on the material to be machined, surface finish required and tool used.

Selection of Depth of Cut

1. Depth of cut for Turning and Boring

The general guidelines for turning and boring recommend a depth of cut of 6mm for roughing and 0.4mm for finishing

2. Depth of cut for Milling

The maximum depth of cut for milling is generally considered to be half the cutter diameter

3. Depth of cut for Drilling

The maximum depth of cut for drilling is generally considered to be half the feed rate of the tool and minimum considered to be 0.3mm

4. Depth of cut for Shaping and Planning

In general, the recommended depth of cut for shaping and planning are in the range of 1-4mm

5. Depth of cut for Grinding

The general recommendations for depth of cut for surface and cylindrical grinding are equal to the values for feeds selected in mm/pass.

Machining Time Calculations

The important reasons for selecting / calculating the process parameters – cutting speed, feed rate and depth of cut are to determine the machining times. Because the data for cutting speed, feed rate and depth of cut for the processes will be used to calculate the machining times.

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2.SELECTION OF JIGS AND FIXTURES:

INTRODUCTION

From the drawing interpretation, the process planner has to identify the need for a work holding device or a jig or a fixture for the selected operation. The process planner will communicate the identified requirements of the work holding device to a specialist tool engineer for the detailed design and drawings that are needed for manufacturing it.

In the following sections. the overview of the function, types, principles and selection a jigs and fixtures are presented.

WORKHOLDING DEVICE

The main purpose of any work holding device is to position and hold a workpiece In a precise location while the manufacturing operation Is being performed.

Types of workholdlng devices: The work holding devices can be broadly classified into two:

1. General workholdîng devices
   - Vices
   - Clamps and abutments_
   - Chucks
   - Collet
   - Centres
   - Mandrels
   - Face plates
2. Specialist workholding devices
   - Jigs
   - Fixtures

Jigs

A jig may be defined as a work holding device which locales and holds the workpiece for a specific operation. It ¡s also provided with tool guiding elements.

Jigs are usually lighter in construction and direct the tool to the correct position on the workpiece. Jigs are rarely clamped on the machine table because it is necessary to move on the table to align the bushes in the jig with the machine spindle. Jigs are used on drilling, reaming, tapping and counterboring operations.

Functions of jigs are:

1. To locate and position the workpiece relative to the cutting tool.
2. To clamp the workpiece during drilling, reaming or tapping.
3. To guide the tool (drill, reamer or tap) into the proper position on the workpiece.

Fixtures

A fixture may be defined as a work holding device which only holds and positions the workpiece. ¡t does not guide the cutting tool. Sometimes, there is a provision in the fixture for setting the tool with respect to the workpiece.

- ❖ Fixtures are often clamped to the machine table.
- ❖ Fixtures are used in turning, milling, grinding, shaping, planning and boring operations.

Functions of fixtures are:

1. To locate and position the workpiece relative to the cutting tool.
2. To clamp the workpiece during machining, welding, inspection or assembly.

Jigs Vs. Fixtures

S.No	Characteristics	Jig	Fixtures
1.	Definition	Locates and hold the work and guides the cutting tool in true position of the work	Only holds and positions the work, butdoesn'tguidethe work
2.	Elements	Work locating elements,	Work locating elements, tool
		tool guiding elements and work clamping elements	setting elements and work clamping elements
3.	Construction	Light	Heavy
4.	Applications	Drilling, reaming, tapping, counter boring, countersinking	Milling, turning, grinding, broaching etc
5.	Special Features	Drill bushes used for tool guiding	Feeler gauges, setting blocks to adjust position of tool in relation to work

Reasons for Using Jigs and Fixtures

The purpose arid advantages of jigs and fixtures are as follows:

1. It reduce/ eliminates the efforts of marking, measuring and setting of work piece on a machine.

2. The workpiece and tool are relatively located at their exact positions before the operation automatically within negligible time. So it reduces product cycle time,

3. It reduces the production cycle Lime and hence increases production capacity.

4. Interchangeability of manufacture is achieved by enabling the production of identical parts.

5. The operating conditions like speed, feed rate and depth of cut can be set to higher values due to rigidity of clamping of workpiece by jigs and fixtures.

6. Operators working become comfortable as his efforts in setting the workpiece can be eliminated.

7. Semi-skilled operators can be assigned the work so it also saves the cost of manpower.

8. It reduces the cost of inspection as the products are produced with less defects.

Elements of Jigs and Fixtures

The three basic elements of jigs and fixtures are given below.

1. Clamping elements

Clamping elements are used to exert a force to press the workpiece against locating surfaces and they bold the action of cutting forces.

2. Locating elements

Locating elements are used to position the workpiece accurately with respect to the tool guiding or setting elements in the fixture.

3. Tool guiding and setting elements

Tool guiding elements are used in jigs where a hardened bushing is fastened to sides of the jig to guide the tool to its proper position in the work.

Tool setting elements are used in fixtures where a target or set block is used to set the location of the tool with respect to the workpiece within the fixture.

PRINCIPLES OF JIGS AND FIXTURES DESIGN

The main consideration of jigs and fixture design are summarized below;

1. Location

- Locating surfaces should be as small as possible and the location must be done from the machined surface.
- Sharp corners in the locating surfaces must be avoided.
- Locating pins should be easily accessible and visible to the operator.
- Adjustable locators should be provided for rough surface,

2. Clamping

- Clamping should always be arranged directly above the points supporting the work.
- Quick acting clamps should be used wherever possible.
- Clamps should not cause deformation of the workpiece.
- Position of clamps should provide best resistance to the cutting tool.
- Cutting forces of the tool should act against the solid part of the jig and not against the clamps.
- All the clamps and adjustments should be on the sides.
- Clamps should allow rapid loading and unloading of the components.

3. Loading

- The loading and unloading process of the workpiece should be as easy as possible.
- Loading and supporting surface usually made of hardened material and also it should be renewable wherever possible.
- Enough space should be Left for hand movements between the walls of a jig and workpiece.

4. Stability and Rigidity

- Jigs and fixtures should possess a high rigidity to withstand the cutting forces. At least four legs should be provided on the jigs for stability.
- The fixtures are rigidly fixed on the machine table. Make the equipment as rigid as necessary for the operation.

5. Clearance for chips

Adequate space in the form of channel ways should be provided to enable the metal chips to be blown to clear easily.

6. Fool Proof Design

- Jigs aid fixtures should be fool proof besides being safe to use.
- The design of Jigs and fixture such that it is Impossible to use the workpiece and tool in any position other than the correct one.
- Locating plan a. provided for this purpose.

7. Provisions for Tool Guides

Provisions for tool guides in Jig bushing and cutter setting devices in fixture should be made.

8. Provisions for Indexing

Provisions for indexing the workpiece should be made wherever it is necessary. It enables the workpiece to divide into any number of equi-spaced faces.

9. Weight

- Jigs aid fixtures should be lighter in weight
- Jig weight should be kept below 15 kg since they are to be handled often.

10. Safety

- Jigs aid fixtures are designed for safety
- Handles and Levers should be large enough. All sharp edges should be removed or avoided.

11. Coolant Supply

Adequate arrangements must be made for the supply of coolant to the cutting edges for reducing the friction.

12. Economy

Jigs and fixture should reduce machining aid production costs by providing ease of manufacturing.

GENERAL FACTORS IN WORKHOLDER DESIGN AND SELECTION

Designing and selection of jigs and fixtures depend upon so many factors. These factors should be considered during designing and selection of work holding devices.

The factors lo be considered during designing and selection of Jigs and fixtures are given below.

1. Physical characteristics of the workpiece (i.e., shape/form (geometry), size and mass).
2. Physical characteristics of the finished component.
3. Type and capacity of the machine, Its extent of automation.
4. Provision of locating devices in the machine.
5. Available clamping arrangements in the machine.
6. Available indexing devices, their accuracy.
7. Evaluation of variability in the performance results of the machine.
8. Rigidity of the machine tool under consideration.
9. Study of ejecting devices, safety devices, etc.
10. Required level of the accuracy in the work and quality to be produced.

Types of Jigs and Fixtures

Types of Jigs

Jigs can be classified broadly into two types based on manufacturing process involved as;

1. Drill jigs, and
2. Boring jigs

1. Drill Jig

Drill jigs are used for the following operations:

- Drilling
- Reaming
- Tapping
- Chamfering
- Spot facing
- Counter sinking. etc.

Different types of drill1ng jigs used are:

- Template jig
- Plate type jig
- Open type jig
- Swinging leaf type jig
- Box type jig
- Solid type jig
- Pot type jig
- Index jig
- Multi station jig
- Universal Jig

2. Boring Jigs

Boring jigs are used to bore holes that may be too large to drill or must be made on odd size.

Types of Fixtures

Fixtures are designed specifically for an operation and so these can be named on the base the operation to be carried out with their help. Fixtures are used to hold the workpiece properly to carry out the operations.

The different types of fixture based on the operation include:

- Turning fixture
- Milling fixture
- Fixture for grinding
- Fixture for broaching
- Fixture for boring/drilling
- Tapping fixture
- Fixture for welding
- Assembling fixture

Fixtures can also be classified based on their construction type as

- Plate fixtures
- Angle plate fixtures
- Vice-jaw fixtures
- Indexing fixtures

Standard Parts for Jigs and Fixtures

There are various standard parts being used in the design and construction of jigs and fixtures

Some of the standard parts include:

- Mechanical fasteners
- Locating and supporting devices
- Indexing pins
- Drill Bushes
- Hand Knobs and Handles

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3.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 rejectd 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 linesof 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 systemcrashes • 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.

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4.SET OF DOCUMENTS FOR PROCESS PLANNING:

(Information Required for Process Planning)

In order to prepare a process plan, the following documents information are required.

1. Assembly and components drawings of the product and bill of materials:

The details include:

- Components drawings
- Assembly drawings
- Raw material specification
- Dimensional and geometric specifications
- Surface finish specifications
- Number of pans required
- Bill of materials

2. Specification of various machine tools available in the catalogues of machine tools:

- The various possible operations that can be performed.
- The maximum and minimum dimensions that can be machined on the machines.
- The accuracy of the dimensions that can be obtained.
- Available feeds and speeds on the machine
- Capacity/power ratings of motors.
- Spindle size, table size, etc.

3. Machining/Machinability data handbook

- Tables of cutting speeds, depth of cut, feeds for different processes and for different work materials

4. Catalogues of various cutting tools and tool inserts.

5. Sizes of standard materials commercially available in the market.

6. Charts of limits, fits and tolerances.

7. Tables of tolerances and surface finish obtainable for various machining processes.

8. Tables of standard time for each operation.

9. Tables of machine hour cost of all machine tools available.

10. Tables of standard cost.

11. Table of allowances.

12. Process plans of certain standard components such as shafts, bushings, flanges, etc.

13. Handbooks such as Design Data Handbook. Tool Engineers Handbook, etc.

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5.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

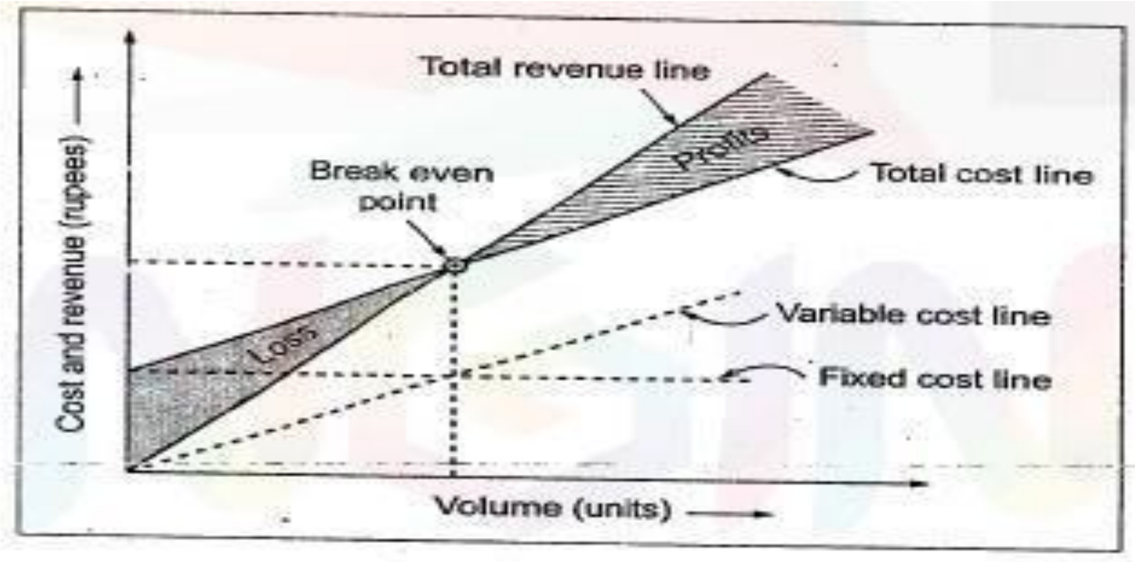
P/V RATIO (PROFIT / VOLUME RATIO)

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.