ME8793 PROCESS PLANNING AND COST ESTIMATION **L T P C**
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OBJECTIVE:

To introduce the process planning concepts to make cost estimation for various products after process planning

UNIT I INTRODUCTION TO PROCESS PLANNING **9**

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-.Production equipment and tooling selection

UNIT II PROCESS PLANNING ACTIVITIES **9**

Process parameters calculation for various production processes-Selection jigs and fixtures election of quality assurance methods - Set of documents for process planning-Economics of process planning- case studies

UNIT III INTRODUCTION TO COST ESTIMATION **9**

Importance of costing and estimation –methods of costing-elements of cost estimation –Types of estimates – Estimating procedure- Estimation labor cost, material cost- allocation of over head charges- Calculation of depreciation cost

UNIT IV PRODUCTION COST ESTIMATION **9**

Estimation of Different Types of Jobs - Estimation of Forging Shop, Estimation of Welding Shop, Estimation of Foundry Shop

UNIT V MACHINING TIME CALCULATION **9**

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of Machining Time for Different Lathe Operations ,Drilling and Boring - Machining Time Calculation for Milling, Shaping and Planning -Machining Time Calculation for Grinding.

TOTAL: 45 PERIODS

OUTCOMES:

Upon the completion of this course the students will be able to

CO1 select the process, equipment and tools for various industrial products.

CO2 prepare process planning activity chart.

CO3 explain the concept of cost estimation.

CO4 compute the job order cost for different type of shop floor.

CO5 calculate the machining time for various machining operations.

TEXT BOOKS:

1. Peter scalon, "Process planning, Design/Manufacture Interface", Elsevier science technology Books, Dec 2002.

2. Sinha B.P, "Mechanical Estimating and Costing", Tata-McGraw Hill publishing co, 1995.

REFERENCES:

1. Chitale A.V. and Gupta R.C., "Product Design and Manufacturing", 2nd Edition, PHI, 2002.

2. Ostwalal P.F. and Munez J., "Manufacturing Processes and systems", 9 th Edition, John Wiley, 1998.

3. Russell R.S and Tailor B.W, "Operations Management", 4th Edition, PHI, 2003.

4. Mikell P. Groover, "Automation, Production, Systems and Computer Integrated Manufacturing", Pearson Education 2001.

5. K.C. Jain & L.N. Aggarwal, "Production Planning Control and Industrial Management", Khanna Publishers 1990.

UNIT I

INTRODUCTION TO PROCESS PLANNING

INTRODUCTION:

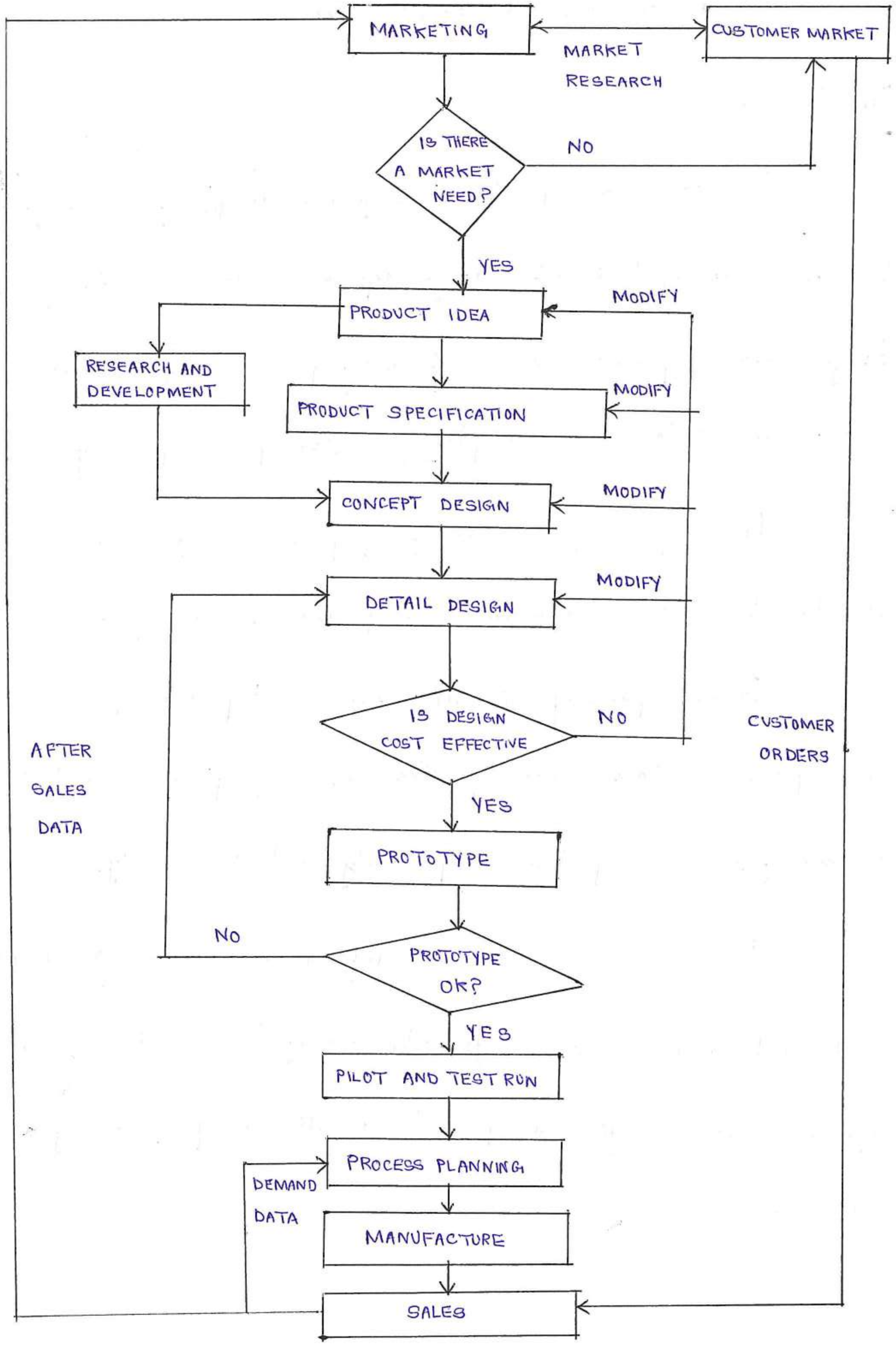
It is understood that the product design for each product has been developed in the design department. To convert the product design into a product, a manufacturing plan is required. The activity of developing such a plan is called process planning.

Process planning consists of preparing set of instructions that describe how to manufacture the product and its parts.

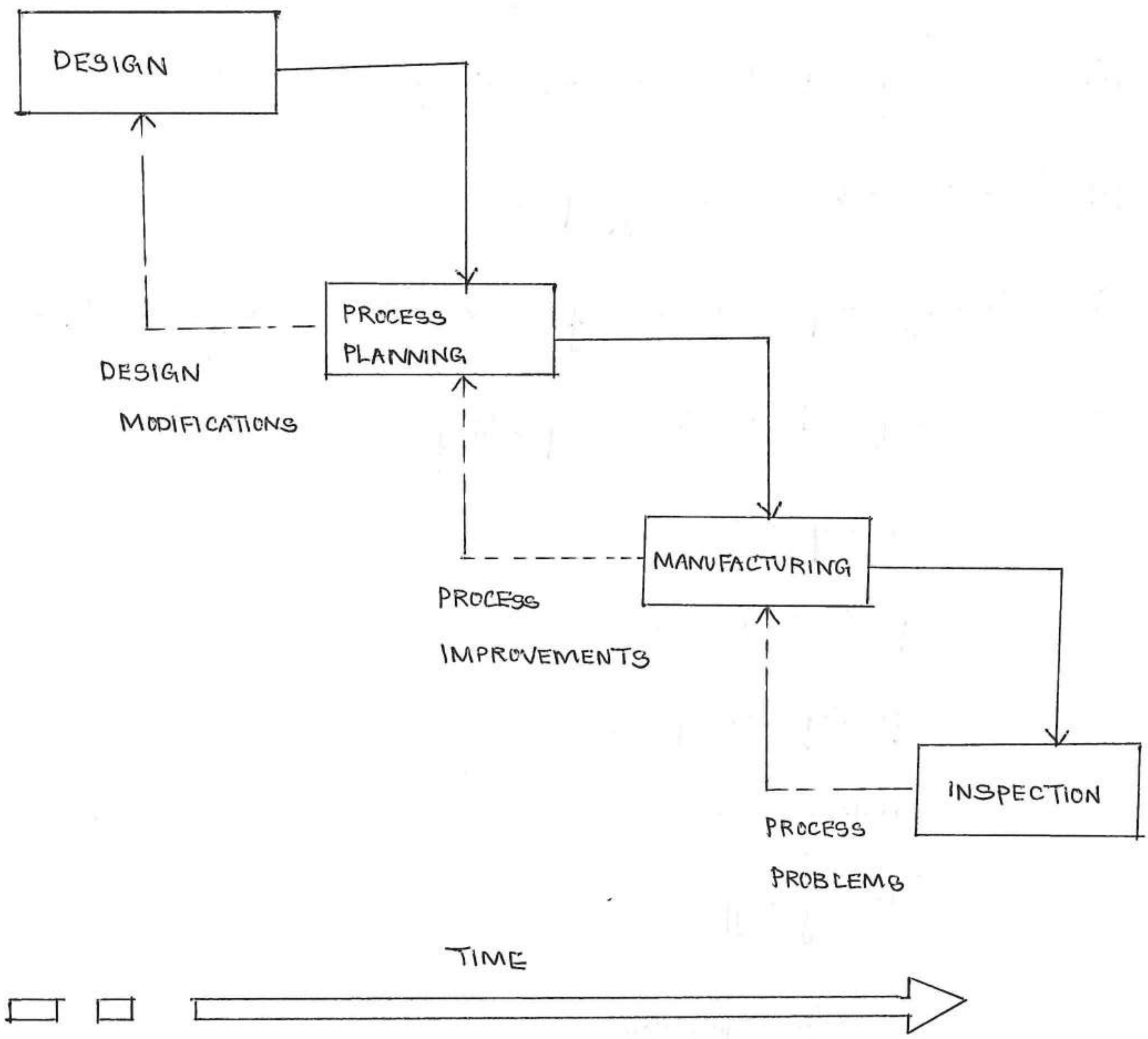
Process planning is also known as operations planning is the systematic determination of the engineering processes and systems to manufacture a product competitively and economically.

Process planning can be defined as "an act of preparing a detailed work instructions for the manufacture and assembly of components into a finished product in discrete part manufacturing environments.

PROCESS PLANNING : THE DESIGN/MANUFACTURE INTERFACE



PROCESS PLANNING : LINK BETWEEN DESIGN AND MANUFACTURING



The design and manufacturing time i.e., the time to market has to be shortened as much as possible by the system. For that purpose, cross-functional teams are employed to simultaneously work on the design and manufacturing functions. This approach is known as simultaneous or concurrent engineering

RESPONSIBILITIES OF PROCESS PLANNING ENGINEER

1. Interpreting part print analysis and symbols.
2. Gathering fundamental details of product design
3. Selecting the machining processes
4. Selecting proper machining with allied tooling based on
   - (i) required machine capability
   - (ii) set-up time
   - (iii) practical lot size
   - (iv) quality of parts
   - (v) Tooling cost
   - (vi) Tooling type
5. Sequencing the operation
6. Deciding on the inspection equipment
7. Determining appropriated production tolerances
8. Determining proper cutting tools
9. Calculating overall times using work measurement techniques.

PROCESS PLANNING ACTIVITIES

Analyse part requirements (Drawing Interpretation)

↓

Determine Operation Sequence (Material Evaluation and Process Selection)

↓

Select Equipment (Selection of Machines, Tooling and Workholding devices)

↓

Calculate processing times (Setting Process Parameters)

↓

Select QA / Inspection Methods (Selecting Quality Assurance Methods)

↓

Estimate Manufacturing Costs (Cost Estimating)

↓

Document Process plan (Preparing the Process Planning Documentation)

↓

Communicate mfg. engr ⟷ shop floor

DRAWING INTERPRETATION:

The component drawings should be analysed in detail to identify its features, dimensions, geometric tolerances, surface finish specifications, the material specification and the number of parts required.

MATERIAL EVALUATION AND PROCESS SELECTION:

The selection of a sound, economic material is another important aspect of process planning. The primary parameters affecting the choice of a material are

i, Function

ii, Appearance

iii, Reliability

iv, Service life

v, Environment

vi, Compatibility

vii, Productivity

viii, Cost

SELECTION OF MACHINES, TOOLING AND WORKHOLDING DEVICES

There are many factors which influence the selection of machines. The following considerations are to be made while selecting a machine.

(i) Economic considerations

(ii) Production rate and unit cost of production

(iii) Durability and dependability

(iv) Lower process rejection

(v) Minimum set up and put away times

(vi) Longer productive life of machines

(vii) Functional versatility

SELECTING PROCESS PARAMETERS

The determination of set up time requires knowledge of available tooling and the sequence of steps necessary to prepare the machine for processing the given workpiece. This activity is called as outplanning

SELECTING QUALITY ASSURANCE METHODS

In this step the tools and techniques to be used for QA inspection are specified clearly. The overuse of QA methods and inspection would increase the processing time and hence the manufacturing costs.

COST ESTIMATING

Cost estimating is the process of determining the probable cost of the product before the start of its manufacture. With the available cost and time data, the materials cost, labour cost and overheads are estimated.

PROCESS PLANNING DOCUMENTATION:

The resulting process plan is generally documented as a job routing or operation sheet. The operation sheet is also called "route sheet", "instruction sheet", "traveller" or "planner". The route sheet lists the production operations and associated machine tools for each component and subassembly of the product.

OPERATION & ROUTE SHEET

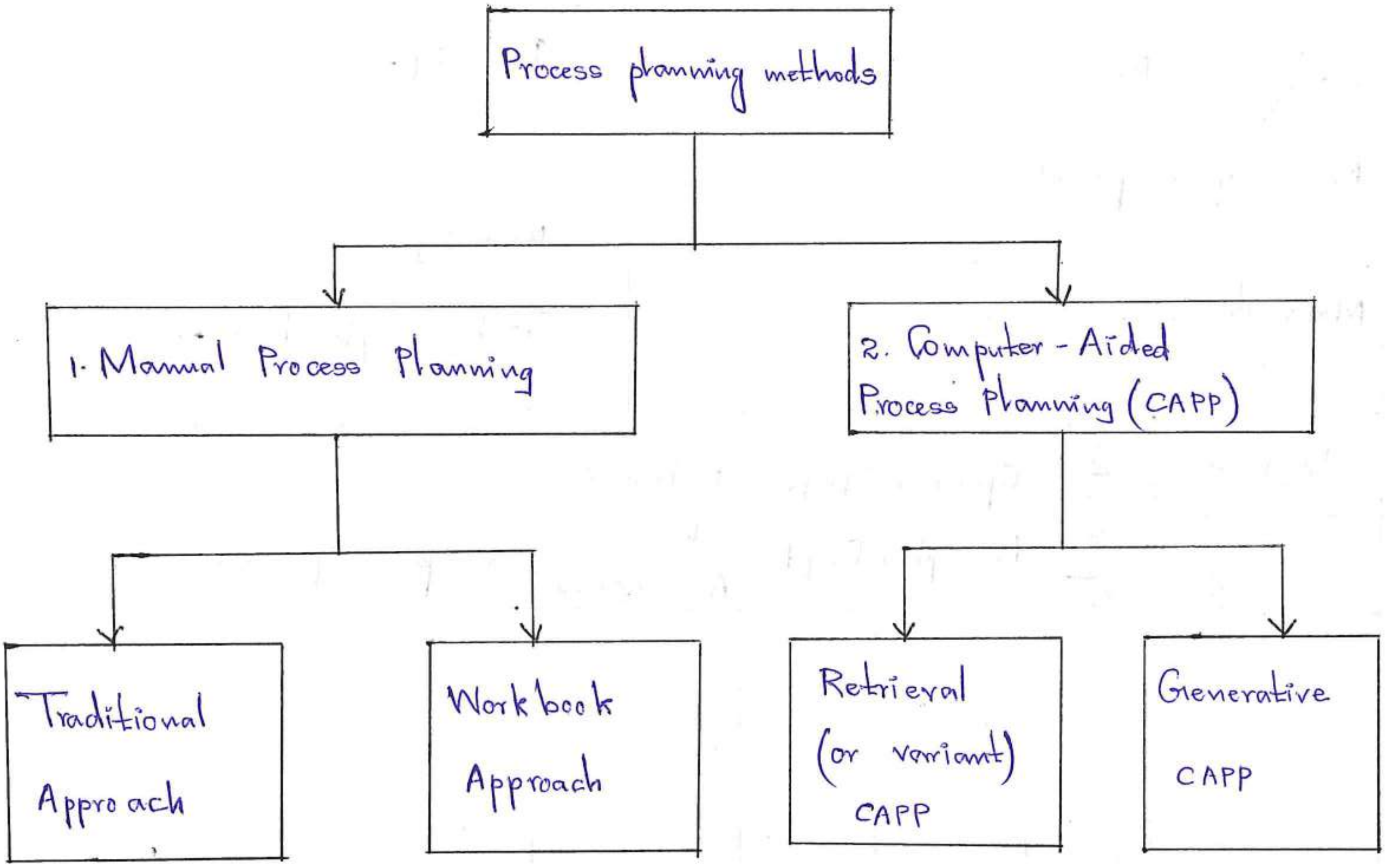
Component No	Drawing ....
Name of component	Quantity ....
Material	To be completed on ....

Routing		Operation No	Operation Description	Tools Reqd	Fixtures & others Accessories	Time		
Section	Machine					Set up	Operation	Total

Route sheet provides the following information

1. Part identification
2. Description of processing steps
3. Operation sequence and machines
4. Standard set up and cycle times
5. Tooling requirements for each operation
6. Production control information

METHODS OF PROCESS PLANNING



MANUAL PROCESS PLANNING:

TRADITIONAL APPROACH:

The process plan is prepared manually. The task involves examining and interpreting engineering drawing, making decisions on machining process selection, equipment selection, operations sequence and shop practices.

The manual process plan is very much dependent on the skill, judgement and experience of the process planner. That's why if different planners were asked to develop a process plan for the same part they would probably come up with different plans.

STAGE 1:

The process planner interprets the component / product drawing using his own experience and intuition.

STAGE 2:

The process planner refers the manual to decide on tools, feeds, speeds etc. for each element of each operation.

STAGE 3:

Finally the resulting process plan is documented.

WORKBOOK APPROACH

It is a modified version of traditional approach of process planning that uses the developed work book for preparing route sheet.

In this approach the work books of predetermined sequence of operations for possible elements of operations of components / products are developed.

ADVANTAGES:

1. Suitable for small scale companies
2. Highly flexible
3. Low investments cost

DISADVANTAGES:

1. Very Complex and Time consuming
2. Requires skilled process planner
3. Possibilites of human error
4. Increases paper work.
5. Reduced productivity
6. Not very responsive to changes.

COMPUTER AIDED PROCESS PLANNING:

In order to overcome the drawbacks of manual process planning the computer-aided process planning (CAPP) is used.

With the use of computers in the process planning one can reduce the routine clerical work of manufacturing engineers.

BENEFITS OF CAPP:

1. Process rationalization and standardization
2. Productivity improvement
3. Product cost reduction
4. Elimination of human error.
5. Reduction in time
6. Reduced clerical effort and paper work.
7. Improved legibility
8. Faster response to engineering changes
9. Incorporation of other application program

APPROACHES OF CAPP

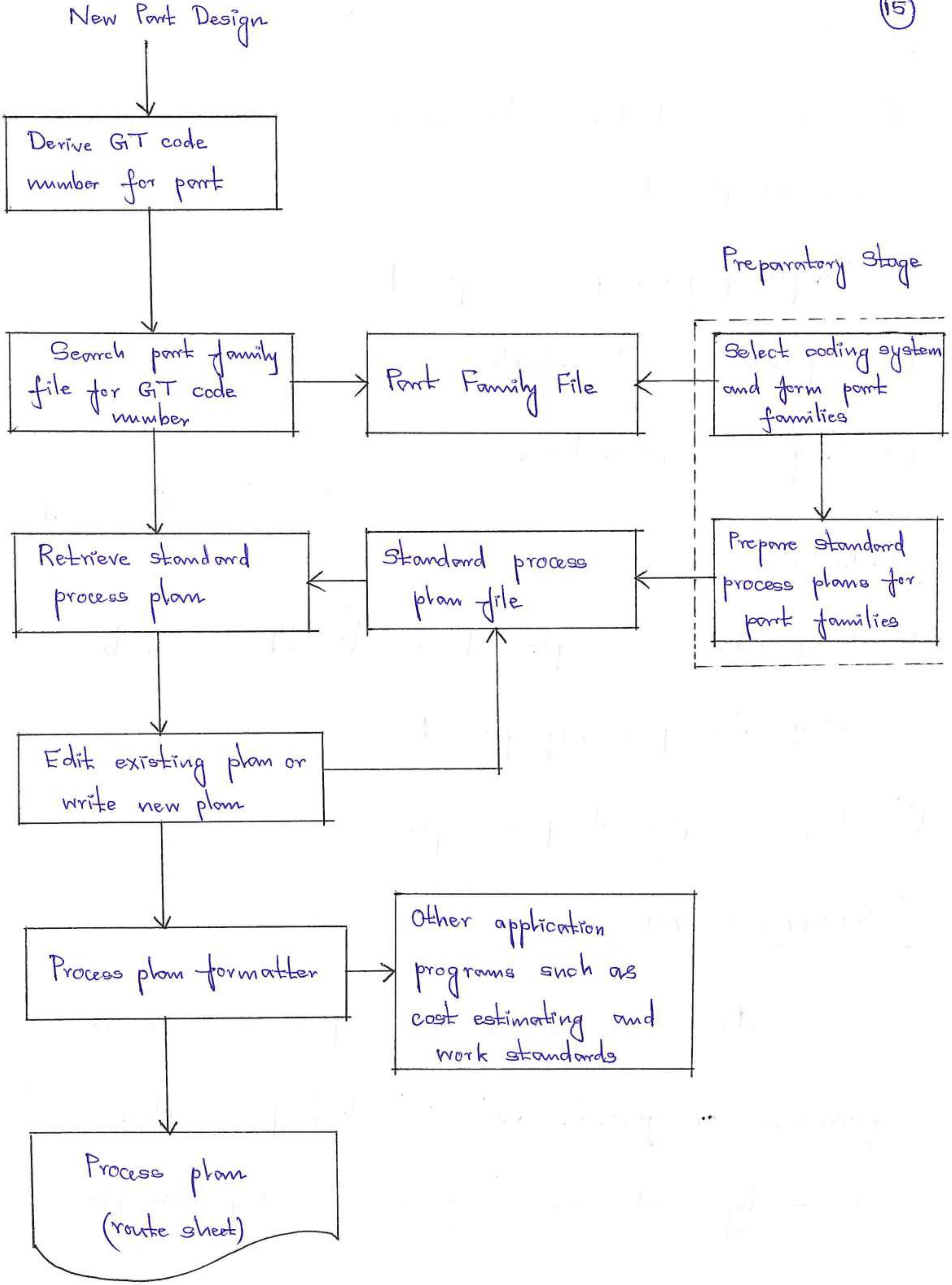
1. Retrieval (or variant) CAPP system
2. Generative CAPP system

RETRIEVAL (OR VARIANT) CAPP SYSTEM

The basic idea is that similar parts will have similar process plans.

In this system a process plan for a new part is created by recalling, identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part.

It is based on the principles of group technology (GT) and parts classification and coding. In this system for each part family a standard process plan (i.e., route sheet) is prepared and stored in computer files.


New Part Design
Derive GT code number for part
Search part family file for GT code number
Part Family File
Preparatory Stage
Select coding system and form part families
Prepare standard process plans for part families
Retrieve standard process plan
Standard process plan file
Edit existing plan or write new plan
Process plan formatter
Other application programs such as cost estimating and work standards
Process plan (route sheet)

MERITS:

1. Once a standard plan has been written a variety of parts can be planned
2. Simple programming is required
3. System is understandable.
4. Easy to learn and use.

DEMERITS:

1. Components to be planned are limited to similar components previously planned
2. Requires experienced process planners.

GENERATIVE CAPP SYSTEM

In this approach the computer is used to synthesize or generate each individual process plan automatically and without reference to any prior plan.

A generative CAPP system generates the process plan based on decision logics and pre-coded algorithms. The computer stores the rules of manufacturing and the equipment capabilities.

Specific process plan for a specific part can be generated without any involvement of a process planner. The human role in running the system includes:

(i) inputting the GT code of the given part design

(ii) monitoring the function.

COMPONENTS OF A GENERATIVE CAPP SYSTEM

a. A part description

b. A subsystem to define the machining parameters

c. A subsystem to select and sequence individual operations.

d. A database

e. A report generator

ADVANTAGES:

1. Generate process plan rapidly
2. New components can be planned easily
3. Provides detailed control information.

DRAWBACKS

1. Complex
2. Difficult to develop.

DRAWING INTERPRETATION:

It is the first step in preparing the process plan for any component / product.

The technical drawing is usally prepared by the design department.

The drawing expresses certain functional requirements of the component / product under consideration.

The component is defined in such a way that when assembled with the whole mechanism it should fulfill its technical functions. Also the component should be well dimensioned and tolerenced so that it can be mounted in a subset of components.

The design and functional requirements of a component / product are translated into a technical language recognized by the production department and depicted in the technical drawing

In general the following information can be obtained from the interpretation of an engineering drawing

* Material of the component, its designation, its coding
* Number of parts to be produced
* Weight of the component
* Dimensions of the parts

* Dimensional and geometric tolerances of the different features of the part

* Size and accuracy of the parts.

TYPES OF DRAWING

(1) Detail drawings.

(i) Single- part drawings and

(ii) Collective drawings

(2) Assembly drawings

(i) Single part assembly drawings and

(ii) Collective assembly drawings

(3) Combined drawing

INFORMATION ON THE DRAWING SHEET REQUIRED FOR PROCESS PLANNING

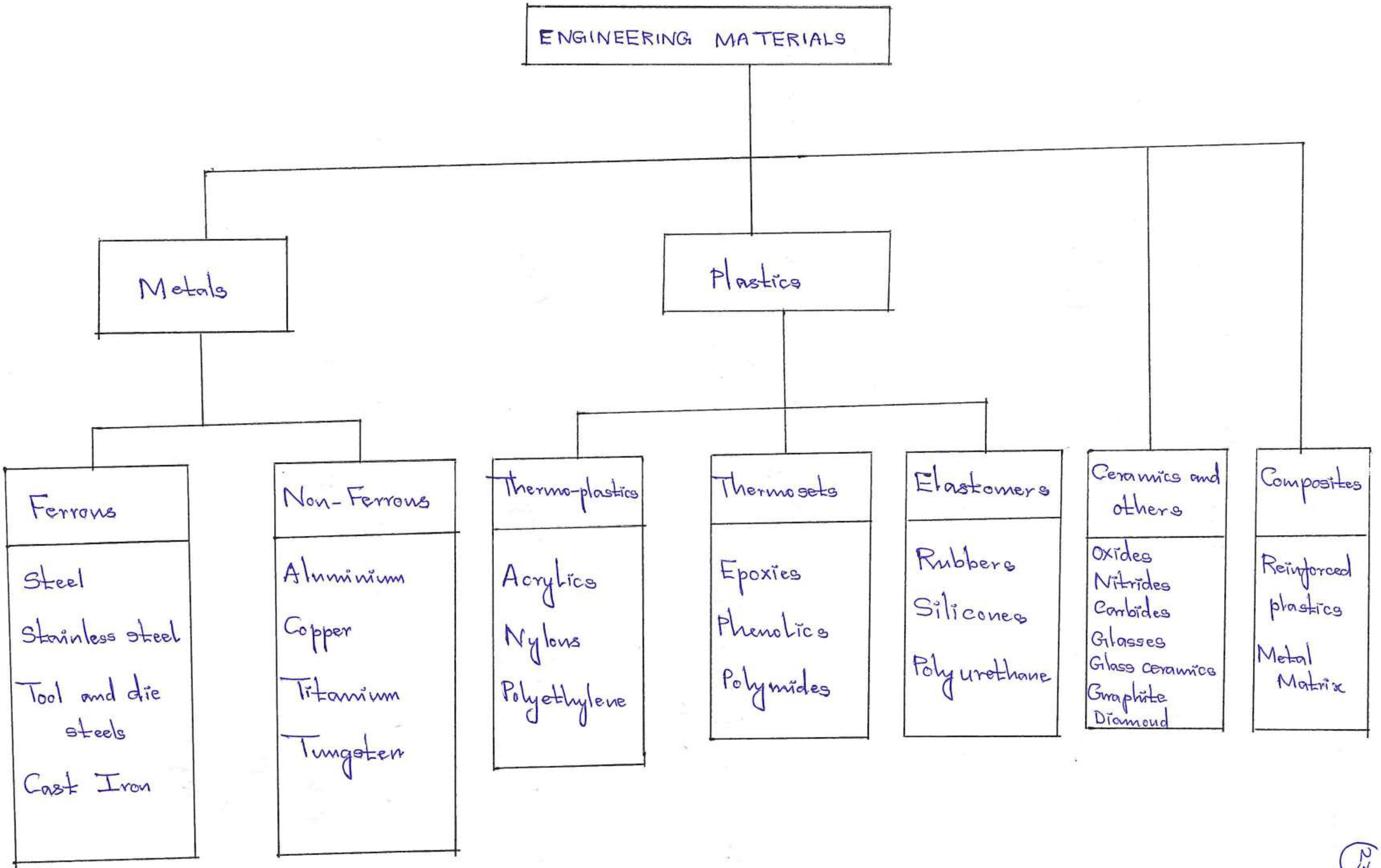
1. Geometric and dimensions
2. Material specifications
3. Notes on special material treatments
4. Dimensional tolerances specifications
5. Geometrical tolerances specifications
6. Surface finish specifications
7. Tool references
8. Gauge references
9. Quantity to be produced
10. Part lists
11. Notes on equivalent parts
12. Notes on screw thread forms

MATERIAL SELECTION AND EVALUATION

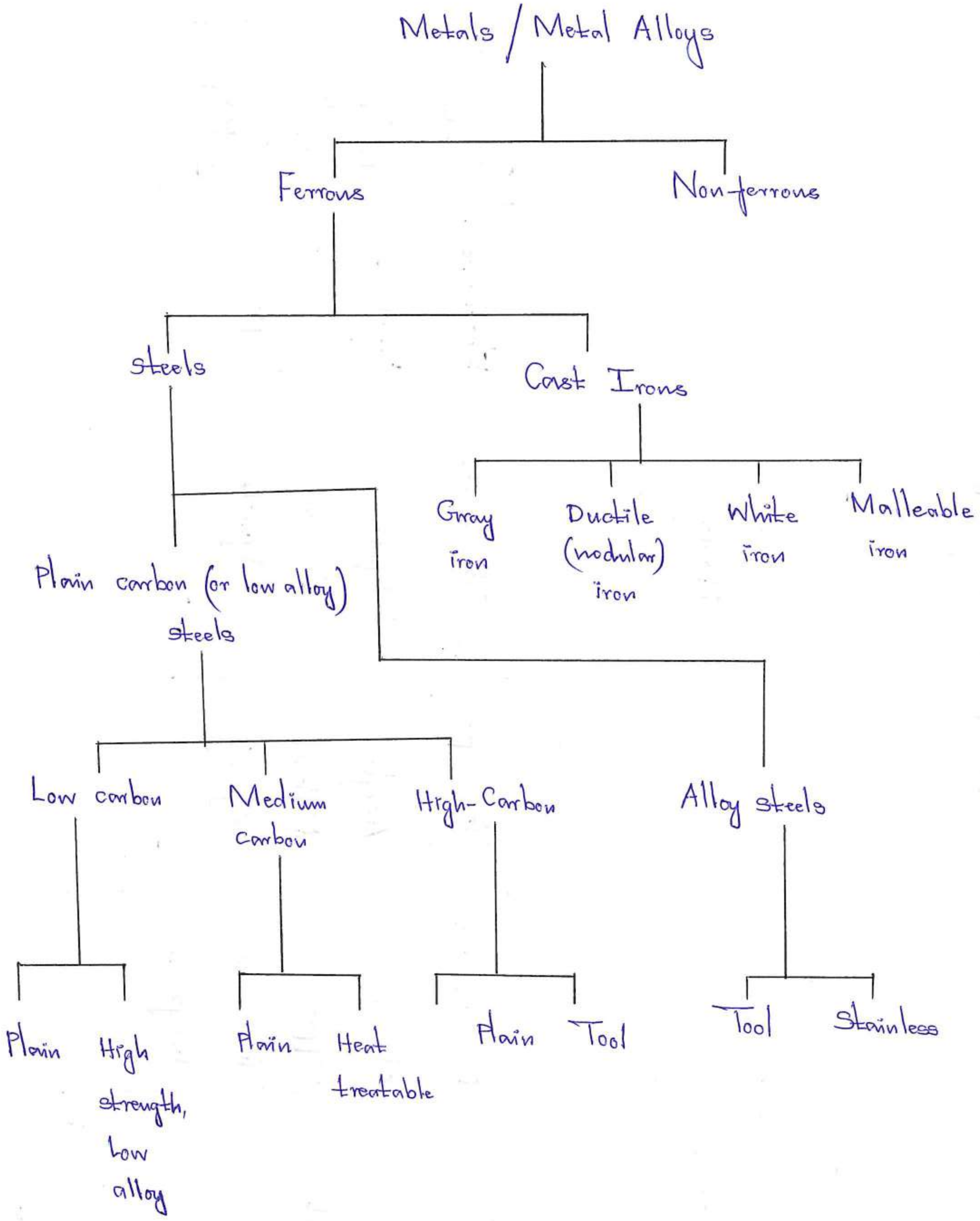
It is the second step. Though the material selection for a component / product is the responsibility of design engineers, the process planner should evaluate the materials specified along with design engineers, based on the availability of manufacturing processes

It should be noted that the material and process selections should be made taking into consideration the products to be manufactured and the materials and processes available within the organization.

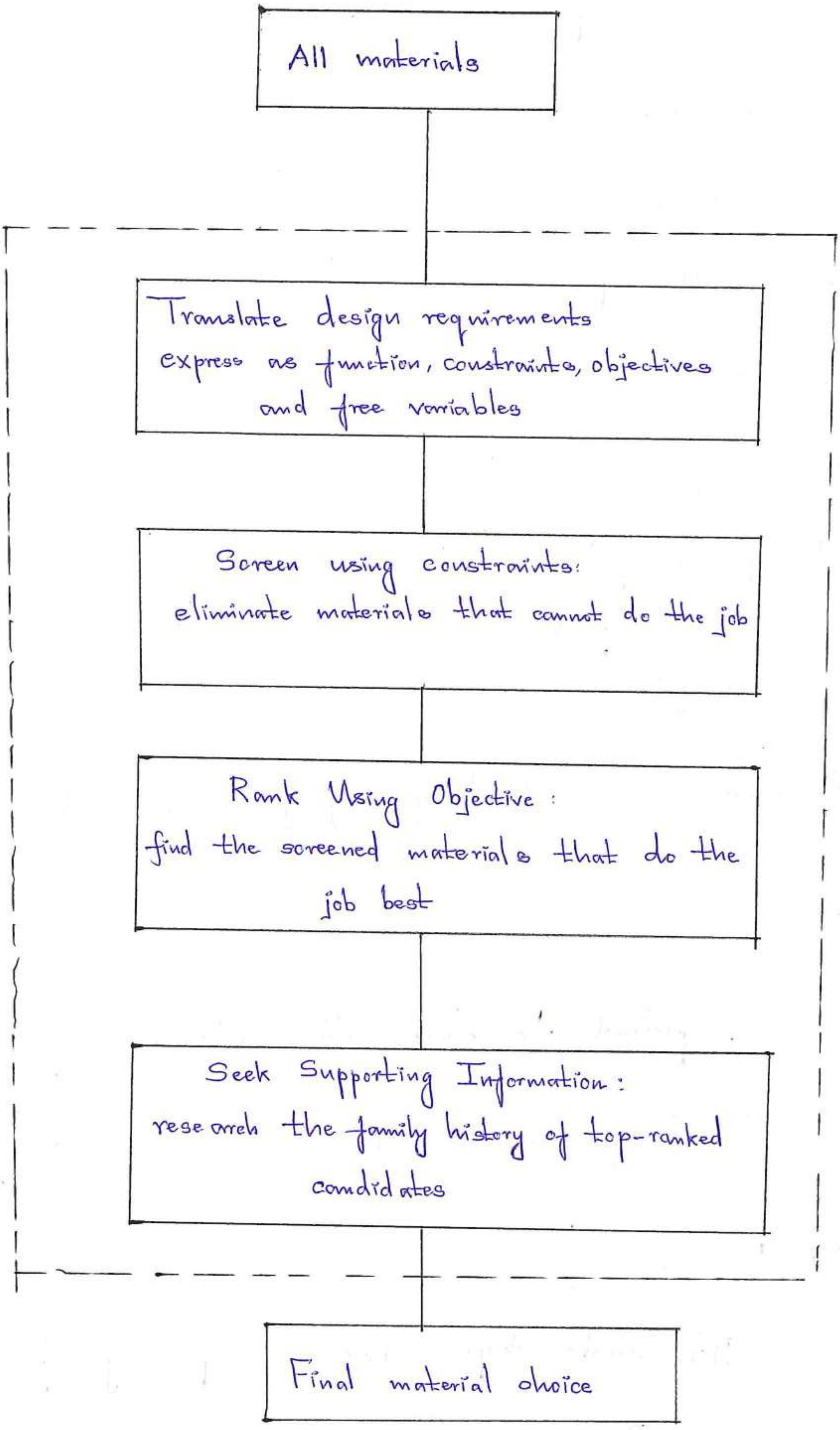
Also the selection of materials influences the selection of appropriate manufacturing processes.


ENGINEERING MATERIALS
Metals
Plastics
Ferrous
Steel
Stainless steel
Tool and die steels
Cast Iron
Non-Ferrous
Aluminium
Copper
Titanium
Tungsten
Thermo-plastics
Acrylics
Nylons
Polyethylene
Thermosets
Epoxies
Phenolics
Polymides
Elastomers
Rubbers
Silicones
Polyurethane
Ceramics and others
Oxides
Nitrides
Carbides
Glasses
Glass ceramics
Graphite
Diamond
Composites
Reinforced plastics
Metal Matrix

METALS AND THEIR CLASSIFICATION



MATERIAL SELECTION PROCESS AND METHODS:



MATERIAL SELECTION METHODS:

1. Selection with computer-aided databases
2. Performance indices
3. Decision matrices
4. Selection with expert systems
5. Value analysis
6. Failure analysis
7. Cost - Benefit analysis

PROCESS SELECTION:

A process is a method of shaping, joining or finishing a material

It is important to choose the right manufacturing process at the design stage itself.

PRIMARY PROCESSES:

It create shapes. The seven primary forming processes are (i) Casting (ii) moulding (iii) deformation

(iv) powder methods (v) methods of forming composites

(vi) special methods (vii) rapid prototyping

SECONDARY PROCESSES:

It modify shapes and properties. They are machining and heat treatment.

FACTORS IN PROCESS SELECTION

* Material form
* Component size
* Component weight
* Economic considerations
* Dimensional and geometric accuracy
* Surface finish specification
* Batch size
* Production rate

GENERAL GUIDELINES FOR PROCESS SELECTION

1. Identify a manufacturing process which can provide the required dimensional/geometric accuracy and surface finish
2. To allow more choice of manufacturing processes.
3. Employ prototypes to verify and validate the potential manufacturing under consideration
4. Perform a comparison analysis of the potential manufacturing processes under consideration.

PROCESS SELECTION METHOD

ASSUMPTIONS MADE:

1. The materials are selected already and are specified at the design stage.
2. Comprehensive information are provided in the design documents i.e., drawings, parts, lists, etc.,

STAGES OF PROCESS SELECTION

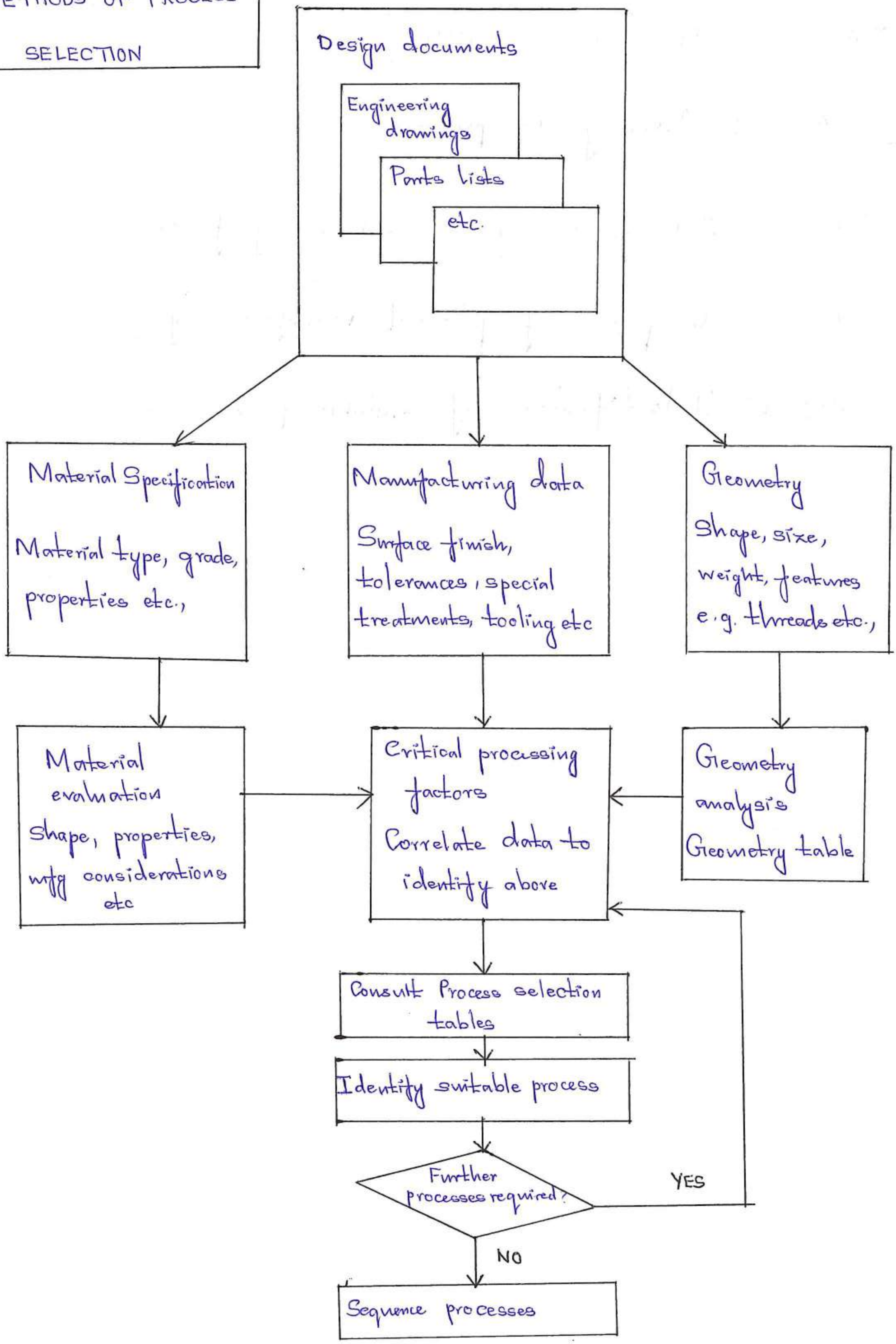
STAGE 1: Drawing interpretation

STAGE 2: Identification of critical processing factors

STAGE 3: Comparison of potential manufacturing processes

STAGE 4: Identification of suitable processes.

METHODS OF PROCESS SELECTION



PRODUCTION EQUIPMENT AND TOOLING SELECTION

It is the third step. Once the process planner has selected the manufacturing processes to be employed then the specific production equipment required for carry out the selected processes should be selected.

FACTORS TO BE CONSIDERED DURING SELECTION OF PRODUCTION EQUIPMENT

* Component size
* Component weight
* Physical size of the machine
* Construction of the machine
* Power and Torque of the machine
* Number of tools available for the machine
* Types of tools available for the machine.

FACTORS TO BE CONSIDERED DURING THE SELECTION OF APPROPRIATE TOOLING

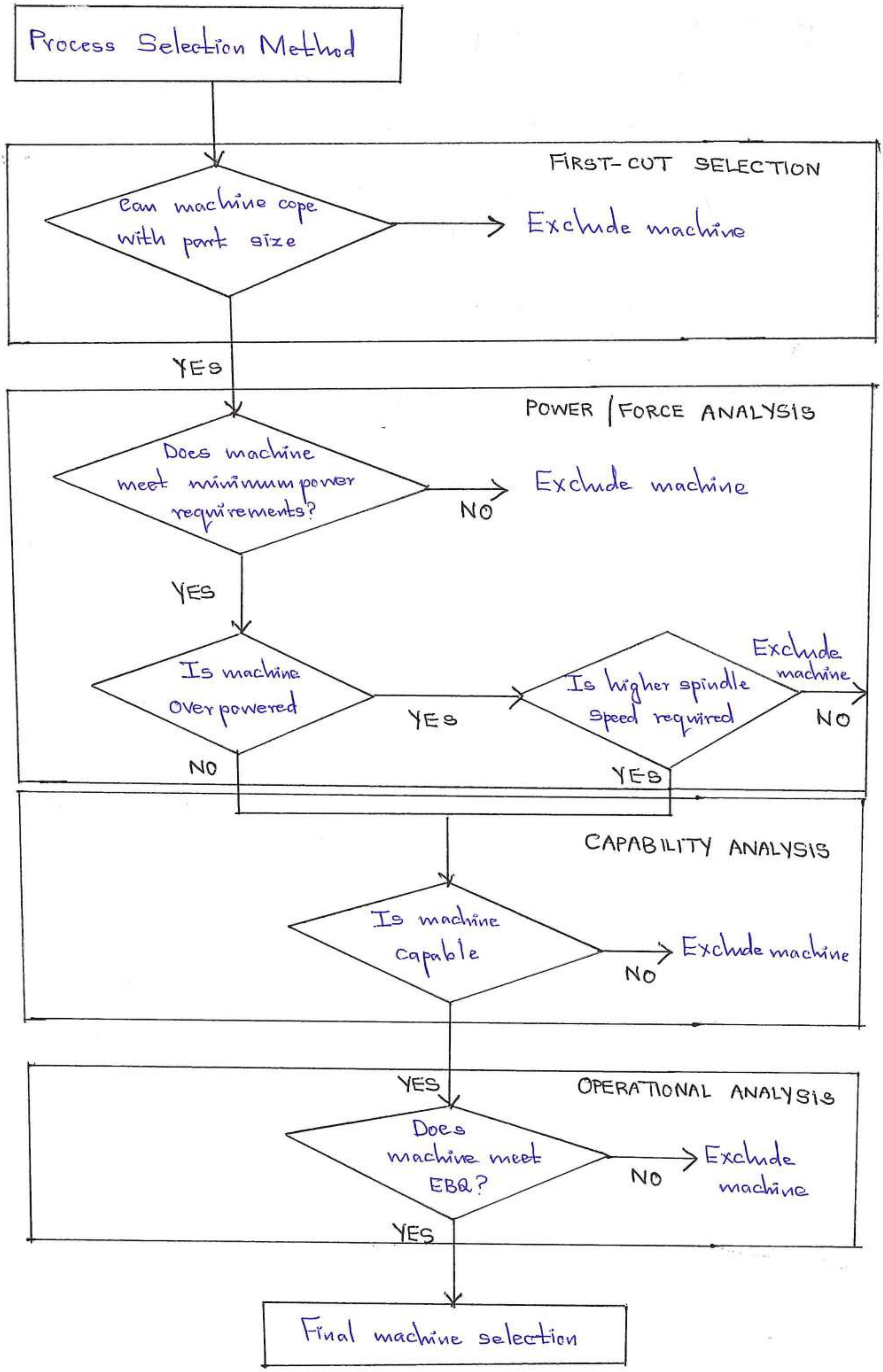
* Availability of tooling
* Workpiece material
* Type of cut

* Part geometry /size
* Tool material
* Machining data
* Machine Tool characteristics
* Cutting tool materials
* Tool holding requirements
* Quality requirements
* Capability requirements.

FACTORS IN EQUIPMENT SELECTION

1. Technical factors
   - (a) Physical size of the workpiece
   - (b) Machine accuracy
   - (c) Surface finish
   - (d) Cutting forces
   - (e) Power of the machine
2. Operational factors
   - (a) Batch size
   - (b) Capacity
   - (c) Availability

STEPS IN MACHINE SELECTION



TOOLING SELECTION METHOD

Stage 1: Evaluation of process and machine selections

Stage 2: Analysis of machining operations

Stage 3: Analysis of workpiece characteristics

Stage 4: Tooling analysis

stage 5: Selection of tooling

UNIT II

PROCESS PLANNING ACTIVITIES

PROCESS PARAMETERS CALCULATION

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

1. Cutting speed
2. Feed rate
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. Unit is mpm.

FACTORS AFFECTING CUTTING SPEED:

* Nature of cut
* Work material
* Cutting Tool Material
* Cutting Fluid application
* Purpose of machining
* Kind of machining operation

* Capacity of the machine tool

* Condition of the machine tool

Material	Operation					
	Turning and Boring	Drilling	Reaming	Shaping, slotting and planing	Milling	Grinding
Aluminium	300	120	125	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 FOR TURNING, BORING, MILLING AND DRILLING OPERATIONS

$$S = \frac{\pi D N}{1000} \text{ m/min}$$

S = Cutting speed in m/min

D = Diameter of the workpiece in mm, for turning / boring operations.

= Diameter of cutter in mm for milling / drilling operations.

N = Revolutions of the workpiece in rpm for turning / boring operations

= Revolutions of the cutter in rpm for milling / drilling operations.

CUTTING SPEEDS FOR SHAPING, PLANING AND SLOTTING OPERATIONS

$$S = \frac{L \times N_s}{1000\,C} \text{ m/min}$$

S = Cutting speed in m/min

L = Length of cutting in mm

N_s = Number of cutting strokes/min

C = Cutting Time Ratio

$$= \frac{\text{Time for cutting (i.e., forward) stroke}}{\text{Time for return stroke}}$$

SPINDLE SPEEDS AND STROKE SPEEDS

In operations like turning, boring, milling and drilling, the actual spindle speeds have to be calculated to achieve the required cutting speeds.

Similarly in shaping, planing and slotting operations, the stroke speed i.e., number of strokes per min have to be calculated to achieve the required cutting speeds.

CUTTING SPEEDS FOR TURNING, BORING, MILLING AND DRILLING

$$N = \frac{1000\ S}{\pi D}\ \text{rpm}$$

N = Revolutions of workpiece in rpm for turning / boring operations

= Revolutions of cutter in rpm for milling / drilling operations

S = Cutting speed in m/min

D = Diameter of workpiece in mm for turning / boring operations

= Diameter of cutter in mm for milling / drilling operations.

STROKE SPEEDS FOR SHAPING, PLANING AND SLOTTING

$$N_s = \frac{1000 \times S \times C}{L}$$

N_s = Stroke speed or number of strokes per min

S = Cutting speed in m/min

C = Cutting ratio

$$= \frac{\text{Time for cutting stroke}}{\text{Time for return stroke}}$$

L = Length of cutting in mm

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 at which the cutting tool penetrates the workpiece.

Unit is mm/rev or mm/min

FACTORS AFFECTING FEED RATE:

(1) Work material

Type, Strength, Hardness etc

(2) Capacity of the machine tool

Power, Rigidity etc

(3) Cutting Tool

Material, Geometry, Configuration

(4) Cutting Fluid application

(5) Surface finish desired

(6) Type of operation

For example, threading operation needs large feed according to the lead of the thread

(7) Nature of cut

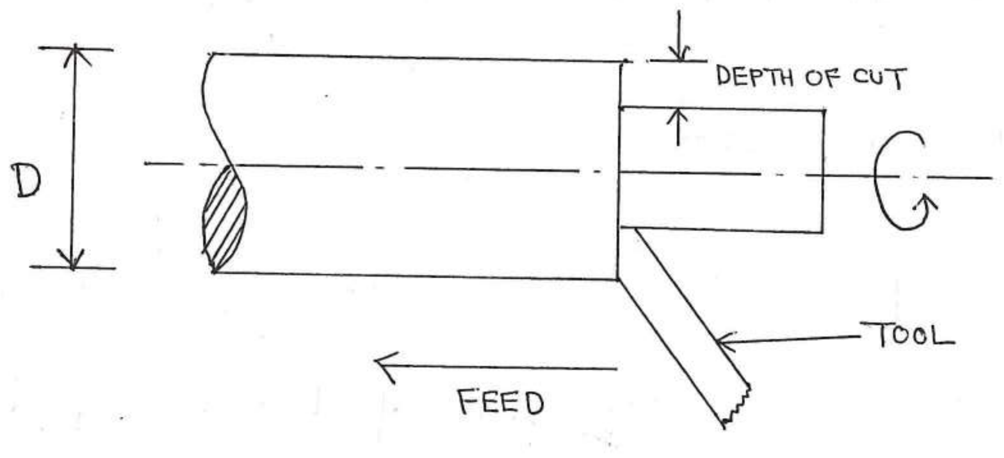
For example, feed is kept low in shock and intermittent type cuts.

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 is mm



SELECTION OF DEPTH OF CUT

(1) Depth of cut for Turning and Boring

6mm for roughing and 0.4mm for finishing

(2) Depth of cut for Milling

1/2 the cutter diameter

③ Depth of cut for Drilling

½ the feed rate of the tool and minimum considered to be 0.3 mm

④ Depth of cut for Shaping and Planing

Range of 1–4 mm

⑤ Depth of cut for Grinding

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.

SELECTION OF JIGS AND FIXTURES

WORKHOLDING DEVICE

The main purpose of any workholding device is to position and hold a workpiece in a precise location while the manufacturing operation is being performed.

TYPES:

(1) General workholding devices

(a) Vices

(b) clamps and abutments

(c) Chucks

(d) Collets

(e) Centres

(f) Mandrels

(g) Face plates

(2) Specialists workholding devices

(a) Jigs

(b) Fixtures

JIGS:

A Jig may be defined as a workholding device which locates and holds the workpiece for a specific operation. It is also provided with tool guiding elements.

Jigs are usually lighter in construction and are used on drilling, reaming, tapping and counterboring operations.

Functions of jig 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 into the proper position on the workpiece.

FIXTURES

A fixture may be defined as a workholding device which only holds and positions the workpiece. It does not guide the cutting tool. Fixtures are often clamped to the machine table.

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

Sl No	Characteristics	Jig	Fixture
1	Definition	Locates and holds the work and guides the cutting tool in true position of the work	Only holds and positions the work, but doesn't guide the work
2	Elements	Work locating elements, tool guiding elements and work clamping elements	Work locating elements, tool setting elements and work clamping elements
3	Construction	Light	Heavy

4	Applications	Drilling, reaming, tapping, counterboring, 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

ELEMENTS OF JIGS AND FIXTURES

1. Clamping elements
2. Locating elements
3. Tool Guiding and setting elements
4. Tool Setting elements

PRINCIPLES OF JIGS AND FIXTURE DESIGN

1. Location
2. Clamping
3. Loading
4. Stability and Rigidity
5. Clearance for chips

6. Fool Proof Design
7. Provision for Tool Guides
8. Provision for Indexing
9. Weight
10. Safety
11. Coolant supply
12. Economy

GENERAL FACTORS IN WORKHOLDER DESIGN AND SELECTION

1. Physical characteristics of the workpiece
2. Physical characteristics of the finished component
3. Type and capacity of the machine
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. Machine tool rigidity

(9) Study of ejecting devices, safety devices etc

(10) Required level of quality and accuracy in the work

SELECTION OF QUALITY ASSURANCE METHODS

In general 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.

Some of the important tasks of process planner in the selection of QA methods include

* Identification of inspection locations
* Identification of inspection methods
* Determination of the frequency of inspection and testing
* Evaluation of inspection and test data
* Identification of corrective action.

QUALITY AND TQM:

Quality is defined as fitness for use and conformance to requirements.

Total Quality Management is the management approach of an organisation centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction and benefits to all members of the organisation and to society

CONCEPTS OF TQM

1. Top management commitment i.e., Leadership
2. Focus on the customer
3. Effective involvement and utilisation of the entire workforce
4. Continuous improvement
5. Treating suppliers as partners
6. Establishing performance measures for the processes

BASIC QUALITY STRATEGIES:

The two basic quality strategies are

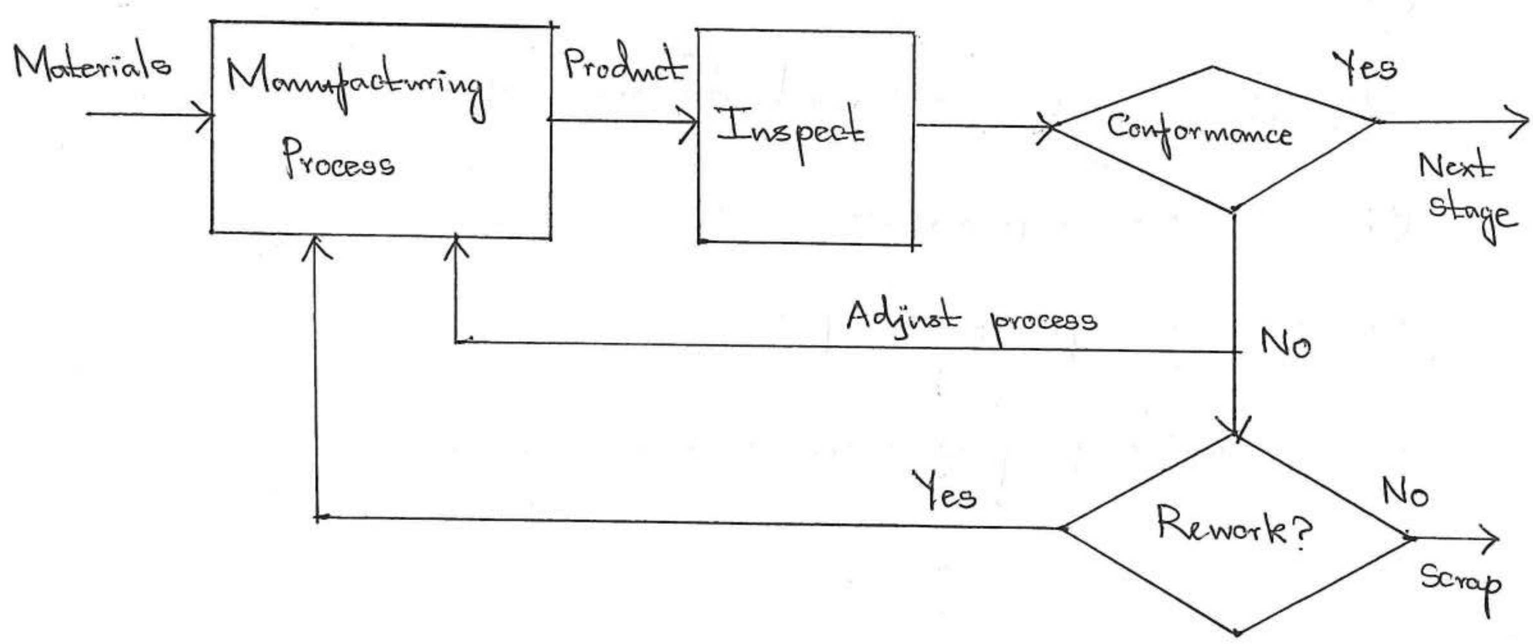
(1) Detection strategy

(2) Prevention strategy

(1) DETECTION STRATEGY

This strategy focuses on the question of "Are we making it correctly?"

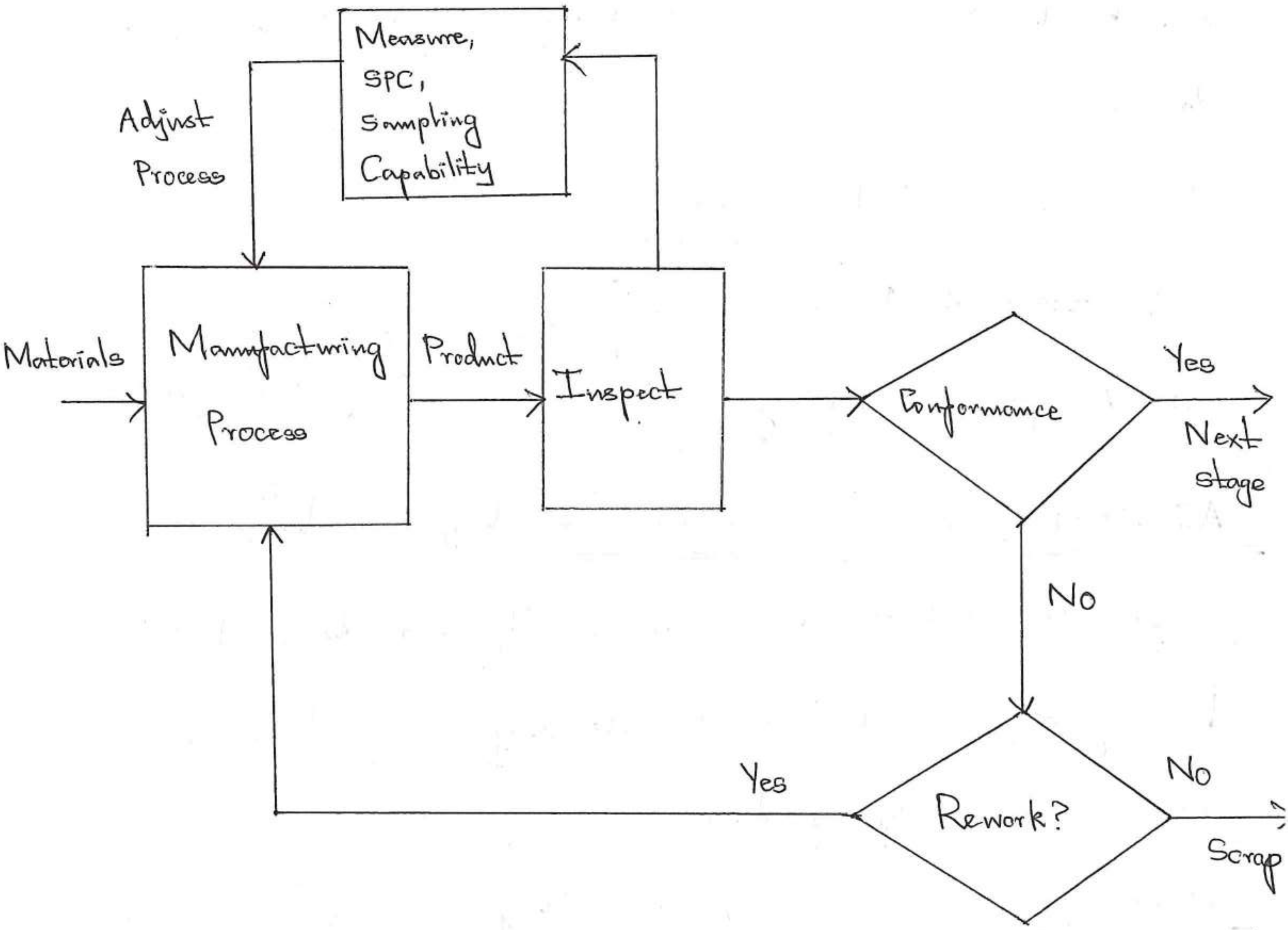
In this strategy the non-conformance is detected using various inspection methods. and then the process is adjusted.



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.



STATISTICAL QUALITY CONTROL:

Statistical Quality Control (SQC) is about employing inspection methodologies derived from statistical sampling theory to ensure conformance to requirements.

In SQC the samples are 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 (SPC)
2. Acceptance sampling

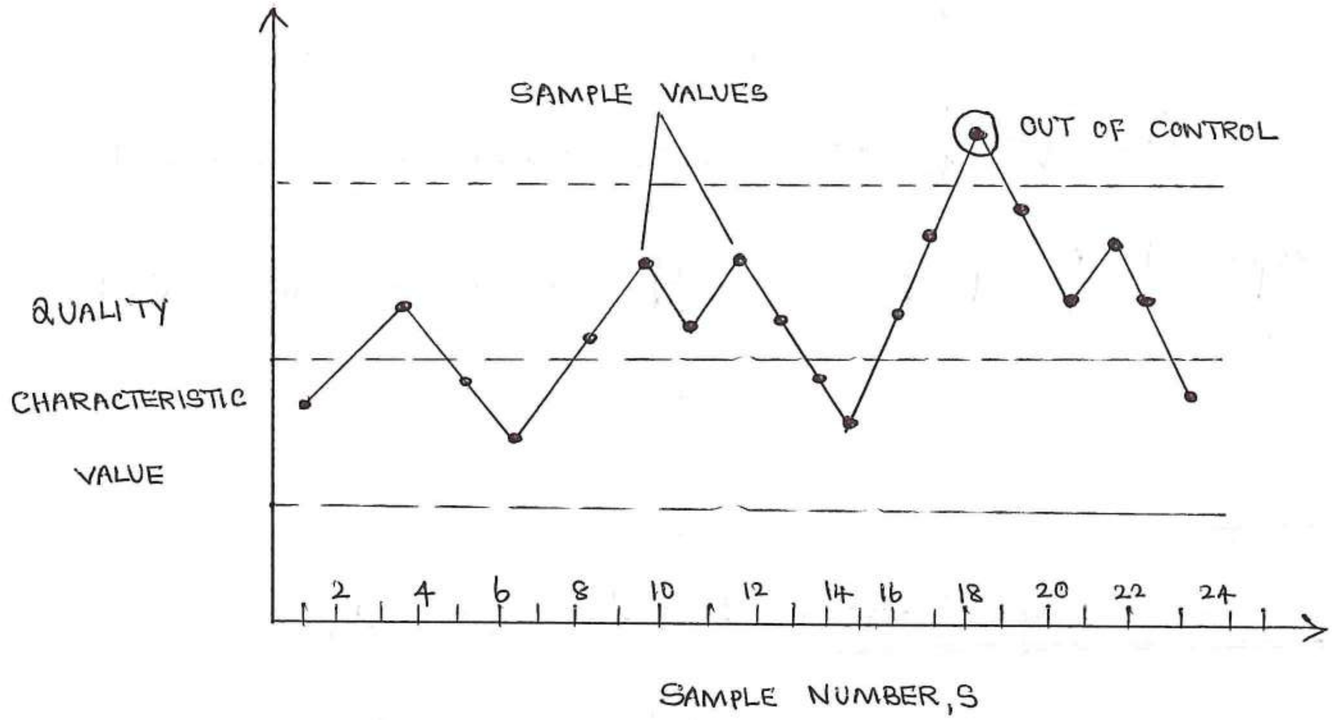
ASSIGNABLE CAUSES OF VARIATION - They are larger in magnitude and can be easily traced and detected.

Primary objective of SQC is detecting assignable causes of variation by analyzing data.

CHANCE CAUSES OF VARIATION - They are inevitable in any process. These are difficult to trace and control even under best conditions of production. All occur at random.

CONTROL CHARTS:

A control chart is a graph that displays data taken over time and the variations of this data.



USE OF CONTROL CHARTS

1. To check whether the process is controlled statistically or not
2. To determine process variability
3. To establish the process capability of the production process
4. To identify the type of variation that occurs
5. To determine the effects of process changes.

TYPES OF CONTROL CHARTS

1. Control charts for variables
2. Control charts for attributes.

CONTROL CHART FOR VARIABLES

The quality characteristics which can be measured and expressed in specific units of measurements are called variables.

TYPES:

(a) $\overline{X}$ or average charts - Used to monitor the centering of the process to control its accurac

(b) R- chart - Monitors the dispersion or precision of the process

(c) s-chart - shows the variation of the process

CONTROL CHART FOR ATTRIBUTES:

An attribute refers to those quality characteristics that confirm to specifications or do not conform to specifications.

Control chart for attributes monitor the number of defects or fraction defect rate present in the sample.

TYPES:

(a) **p-chart** - Chart for fraction rejected as non-conforming to specifications

(b) **np-chart** - Control chart for number of non-conforming items

(c) **c-chart** - Control chart for number of non-conformities

(d) **u-chart** - Control chart for number of non-conformities per unit.

PROCESS CAPABILITY:

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

PROCESS CAPABILITY INDEX C_p:

C_p indicates the process potential performance by relating the natural process spread to the specification spread

$$C_p = \frac{\text{Total Specification Tolerance}}{\text{Process capability}}$$

If $C_p > 1$ - Process meets the specification

If $C_p < 1$ - Process is not capable of meeting the specification

If $C_p = 1$ - Process is just meet the specification

PROCESS CAPABILITY INDEX C_{pk}

C_{pk} measures not only the process variation with respect to allowable specifications it also considers the location of the process average.

$$C_{pk} = \min \left\{ \frac{USL - Mean}{3\sigma}, \frac{Mean - LSL}{3\sigma} \right\}$$

If $C_{pk} > 1$ - Process confirms the specification

If $C_{pk} < 1$ - Process does not conform to specifications

If $C_{pk} = 1$ - Process just conforms to specifications.

If $C_p = C_{pk}$, the process is centered.

INSPECTION

Inspection is 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.

SET OF DOCUMENTS REQUIRED FOR PROCESS PLANNING

1. Assembly and component drawings of the product and bill of materials
2. Specification of various machine tools available in the catalogues of machine tools.
3. Machining / Machinability data handbook
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) Tables of allowances

(12) Process plans of certain standard components.

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

ECONOMICS OF PROCESS PLANNING

The process planner should have the fundamental knowledge on cost estimating, cost accounting, various types of costs, 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

BREAK EVEN ANALYSIS

Break even analysis also known as cost-volume-profit-analysis is the study of inter-relationships among a firm's sales, costs and operating profit at various levels of output.

AIMS OF BREAK-EVEN ANALYSIS

(i) To help in deciding profitable level of output
(ii) To compute costs and revenues
(iii) To take decisions regarding make or buy.
(iv) To decide the product mix and promotion mix
(v) To take plant expansion decisions
(vi) To take equipment replacement decisions

(vii) To indicate margin of safety

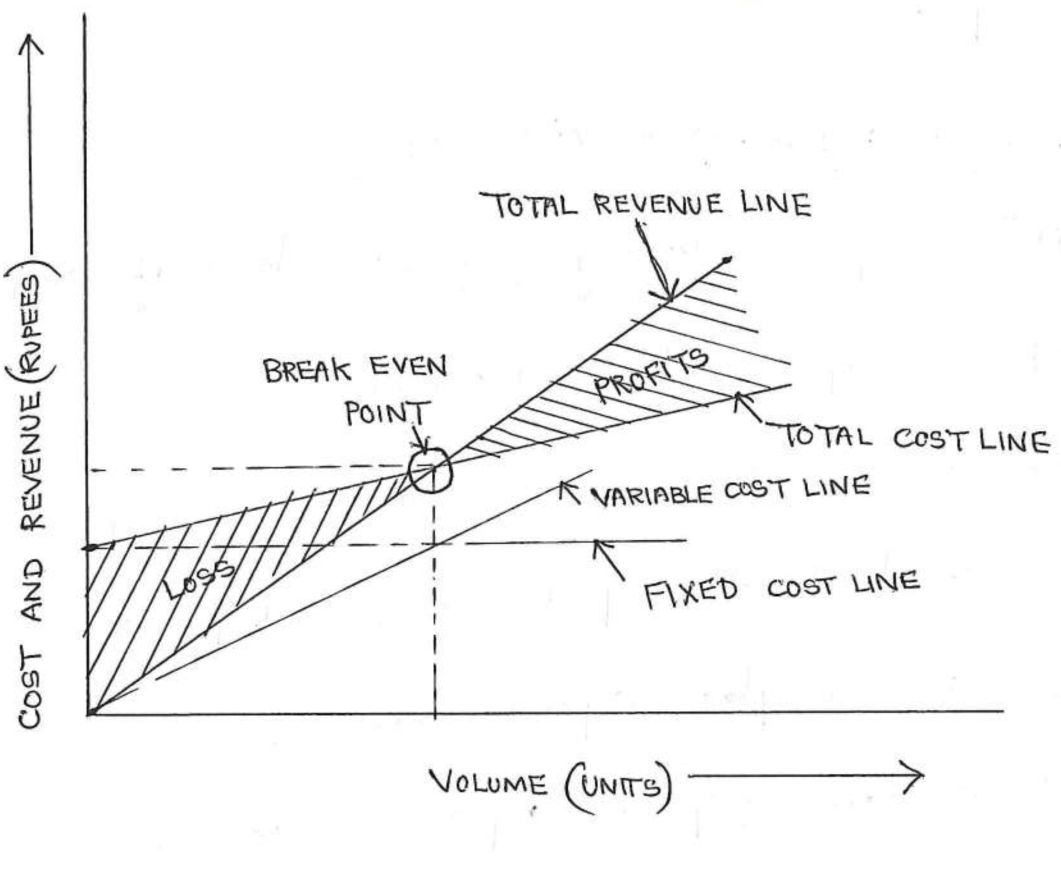
(viii) To fix the price of an article to give the desired profit

(ix) To compare a number of business enterprises

(x) To compare a number of facility Locations

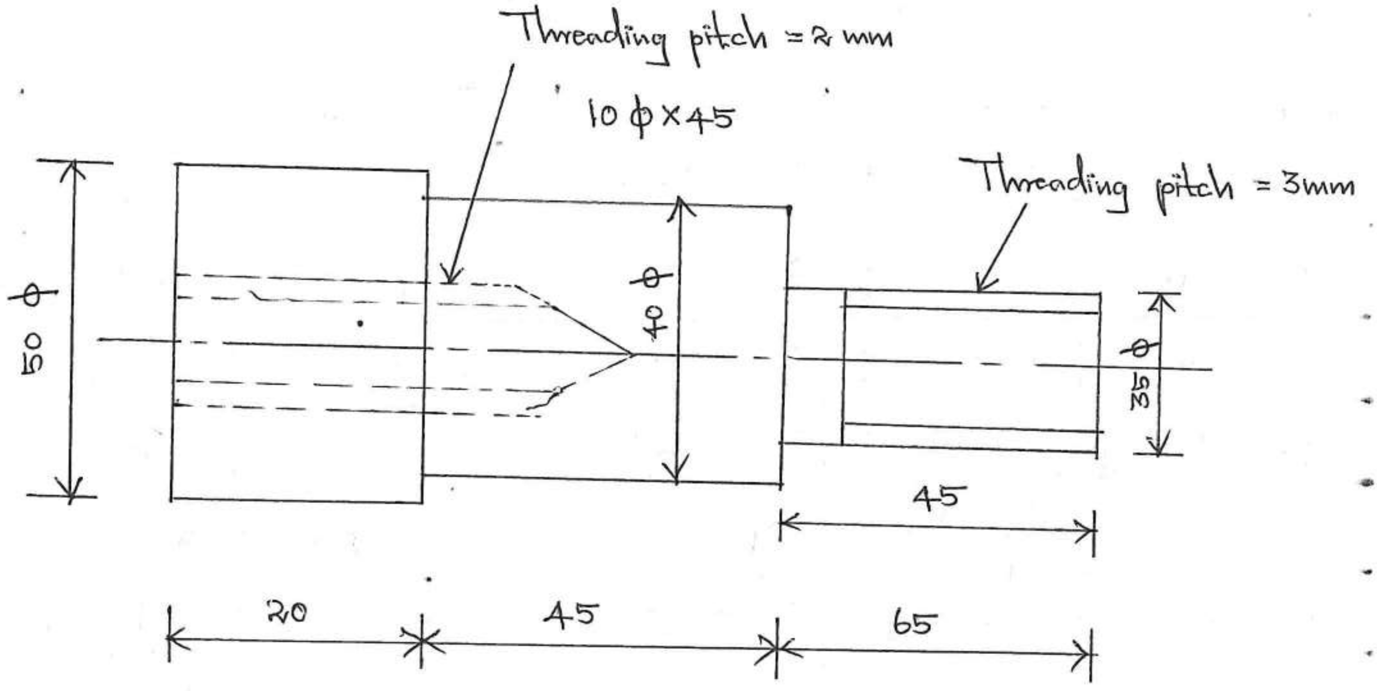
BREAK EVEN POINT:

The break-even point may be defined as the level of sales at which total revenues and total costs are equal. It is the point at which the profit is zero. It is also known as "no-profit no-loss point"



CASE STUDY:

A mild steel spindle is shown in figure is required to be manufactured in a workshop. Present the various activities involved in process planning



All dimensions are in mm

Material 60 mm ϕ and 130 mm length; mild steel

All Tolerances: ±0.05 mm unless otherwise specified

Number of parts required = 200

1. The given component drawing is carefully analysed to identify and list out the key features of the part.

i, The spindle has to be manufactured from 60 mm ϕ and 130 mm length stock.

ii, The spindle consists of three concentric cylinders

iii, One internal thread and one external thread are to be cut

iv, Material of the component is mild steel

v, The dimensional tolerance is ± 0.05 mm

vi, Number of parts to be made = 200.

SL NO	OPERATION	MACHINE	TOOL
1.	Turning to 50 mm ϕ	Centre lathe	Single point cutting tool
2.	Turning to 40 mm ϕ	Centre lathe	Single point cutting tool
3.	Turning to 35 mm ϕ	Centre lathe	Single point cutting tool
4.	Drilling of 10 mm ϕ hole	Centre lathe	Twist drill
5.	Internal threading (Tapping)	Tap	Tap and Tap wrench
6.	External threading	Centre lathe	Die with die holder and collet
Measuring and checking instruments: steel rule, vernier calliper, depth gauge, thread plug gauge, ring thread gauge			

Cutting speed for turning = 28 m/min

Cutting speed for thread cutting = 10 m/min

Cutting speed for drilling = 30 m/min

Feed for turning = 1 mm/rev

Feed for drilling = 0.25 mm/rev

Depth of cut = 3 mm

UNIT III

INTRODUCTION TO COST ESTIMATION

COST ESTIMATING

Cost estimating may be defined as the process of determining the probable cost of the product before the start of its manufacture.

Cost estimation takes into consideration all expenditures involved in design and manufacturing, with all related service facilities such as pattern making, tool making as well as a portion of the general administrative and selling expenses.

Cost estimating under normal manufacturing organisations is performed by an experienced person called by various titles including estimator, cost engineer, product cost estimator, purchase cost analyst and manufacturing cost analyst.

Cost estimating requires high technical knowledge about manufacturing methods, operation times, etc., Cost estimating requires the knowledge of the following factors for calculating the probable cost of the product:

(i) Design time

(ii) Amount and cost of materials required

(iii) Production time required.

(iv) Labour charges

(v) Cost of machinery, overheads and other expenses

(vi) Use of previous estimates of similar parts.

(vii) Effect of volume of production on costing rates

(viii) Effect of changes in facilities on costing rates and

(ix) Probable future changes in unit prices for materials, labour and expenses when the proposed product is manufactured at a future date.

IMPORTANCE OF COST ESTIMATING:

Cost estimating is very important for all organisations before starting actual production or filling up the tenders. Because only accurate estimating can enable the factory owner to make vital decisions such as manufacturing and selling policies. Both over-estimating and under-estimating are dangerous for a concern.

If a job is over-estimated i.e., the estimated cost is much more than the actual cost of the product, then the firm will not be able to compete with its competitors who estimated the price correctly and loses the order to its competitors. On the contrary, if the job is under estimated i.e., the estimated cost is below the actual cost of the product, then the firm will face huge financial loss which may cause utter failure or closure of the firm. Therefore a realistic and accurate estimating should be done. Hence the staffs preparing estimates should be highly qualified and experienced.

ILLUSTRATION:

Suppose you want to start the factory which manufactures Overhead projectors (OHPs). Through market survey you find its market price approximately as Rs. 8000

But for your current design, lets say the estimated price is Rs. 9,500. So if you make OHP's now you will face a great loss. Now, you can try to work out an alternate design, so that price can be reduced. Again estimate the price for the new design. If the estimated price is less than the market price, then make the item. Otherwise just drop the project.

OBJECTIVES OF COST ESTIMATION:

The main objectives of cost estimating are

* To establish the selling price of a product for a quotation or contract so as to ensure reasonable profit to the company.
* To verify quotations submitted by vendors
* To ascertain whether the proposed product can be manufactured and marketed profitably.
* To take make or buy decisions i.e., to determine whether the part or assembly can be manufactured

economically in the plant itself or to be purchased from outside.

* To determine the most economical method process or material for manufacturing a product.
* To establish the standard of performance that may be used to control costs.
* To prepare production budget.
* To evaluate alternate designs of product.
* To initiate means of cost reduction in existing production facilities by using new materials, new methods of tooling and processing.

FUNCTIONS OF COST ESTIMATION

The main functions of cost estimating are given below

(1) Cost estimates are required to submit accurate tenders for getting the contracts.

(2) Cost estimates are required for the manufacturer to choose from various methods of production the one which is likely to be most economical.

(3) Cost estimates are required for fixing the selling price of a product.

(4) Cost estimate gives detailed information of all the operations and their costs, thus setting a standard to be achieved in actual practice

(5) Cost estimate enables the management to plan for procurement of raw materials, tools, etc., and to arrange the necessary capital as it gives detailed requirement.

TYPES OF ESTIMATES:

Two types of cost estimates are

(1) Preliminary cost estimate and

(2) Final cost estimate.

(1) PRELIMINARY COST ESTIMATE:

Preliminary cost estimate is based on incomplete data These estimates are based on assumptions and general information supplied by either the sales or engineering groups especially in areas of incomplete data.

SUITABILITY:

Preliminary cost estimate is usually made for a new project or product before designs and plans are complete.

Also this type of estimate is used to compare alternate designs or manufacturing methods to determine the most economical method or design.

Preliminary estimates can be done with or without the product drawings. It depends upon factors such as the availability of drawing, time and the required accuracy of the estimate.

* If drawings / layouts are available a review of the drawings can be made by an estimator. The common method of making this type of estimate is to compare it with a product in production or already completed, using judgement to determine the percentage of deviation.

* If drawings are not available survey men who have made survey of the product brief the estimators on the available data. From this briefing the estimators estimate the costs of making the product.

2. FINAL COST ESTIMATE

Final cost estimate is based on complete data for a product and hence it is the most accurate estimate.

In this a detailed estimate is made usually for every component, sub assembly and assembly.

However in practice this type of estimate is not justified because huge amount of money has to be spent to make the estimate.

CLASSIFICATION OF COST ESTIMATES BASED UPON DESIGN LEVEL:

The cost estimates can also be classified into three levels based upon design level as

(1) Conceptual design phase (Cost estimate accuracy ± 30 %)

(2) Preliminary design phase (Accuracy ± 20 %)

(3) Detailed design phase (Accuracy ± 10 %)

(1) CONCEPTUAL DESIGN PHASE

In the conceptual design phase, the geometry and materials of the parts are not known; but the functional requirements are known.

A conceptual estimate is an estimate prepared by using engineering concepts and avoiding the counting of individual pieces.

As the name implies, conceptual estimates are generally made in the early phases of a project / product.

Conceptual cost estimating is defined as the forecast of project costs that is performed before any significant amount of information is available from detailed design.

The accuracy of conceptual cost estimate is ± 30 %.

The cost estimation methods used at this level are:

(i) Factor method

(ii) Material cost method and

(iii) The function method (Parametric cost estimating).

2. PRELIMINARY DESIGN PHASE

In the preliminary design phase all of the materials and dimensions of the product are known.

This preliminary cost estimates are generally used to determine the project flexibility.

The accuracy of preliminary cost estimates is ±20%.

The mostly commonly used cost estimating methods in this phase are

(i) Product comparison method

(ii) Database calculations

(iii) Detailed cost functions, and

(iv) Parametric cost estimating.

(3) FINAL DESIGN PHASE

In the final design phase, complete information of the product are known with more accuracy.

The estimate of each and every component in the system will be made and summed up to arrive at the final cost estimate of the product.

The accuracy of final design estimate is ±10%.

The cost estimating methods used for cost estimating in this stage are;

(i) Detailed cost function method and

(ii) Traditional approach

METHODS OF ESTIMATING:

Three commonly used methods of estimating are

(1) Conference method

(2) Comparison method and

(3) Detailed analysis method.

(1) CONFERENCE METHOD:

In this conference method of estimating, representatives of purchasing, process engineering, tool design and methods and time study confer and estimate the costs of material, labour and tooling. A coordinator from either accounting or estimating then collects these costs and applies overhead factors to develop a total manufacturing cost for the product.

This method of estimating is not often supported by detailed paperwork, standard data, or mathematical calculation.

If vague or only verbal information is available, then the total product material, labour and tooling will be estimated as one lump sum for each.

The degree of accuracy of this method depends upon the availability of specifications, samples and drawings.

(2) COMPARISON METHOD:

In this comparison method of estimating the costs of similar parts are applied to the product and are adjusted to suit variations in the workpiece, material and labour costs.

Thus this method of estimating is based on an accumulation of past experience and data.

Another comparison method is the application of a rate per unit of measure factor. The unit rate may be hours per kg, rupees per cubic foot, etc., Many variables can make this procedure dangerous to the uninformed estimator. This method requires judgement skill to assure that rates and data are being applied to comparable products.

3. DETAILED ANALYSIS METHOD.

The details analysis method involves:

(i) calculations of all raw material usage including scrap allowances and salvage material

(ii) processing each individual component (writing the operation sheet

(iii) determining the production time for each operation

(iv) the equipment required

(v) tools, gauges and special fixtures or dies

(vi) inspection and testing equipment and

(vii) packaging and shipping requirements.

This method of estimating is the most reliable of the three methods discussed.

However, it is the most time-consuming and requires strict adherence to the steps discussed under the preparation of the estimate.

NOTE ON PARAMETRIC AND STATISTICAL ESTIMATION

(i) PARAMETRIC ESTIMATING:

Parametric estimating is an estimating technique that uses a statistical relationship between historical data and other variables to calculate an estimate for activity parameters such as scope, cost, budget and duration.

This technique can produce higher levels of accuracy depending upon the sophistication and the underlying data built into the model.

An example for the cost parameter is multiplying the planned quantity of work to be performed by the historical cost per unit to obtain the estimated cost.

(ii) STATISTICAL ESTIMATING:

Statistical estimating is the problem of estimating a probability distribution given a set of random samples from the distribution.

For example estimating the distribution of income of people in a city given the results of a selective poll.

In statistical estimating sampling or random sampling is used in general to study a measurable variable and from that sample mean tries to predict or estimate the population mean given some assumptions of the probability distribution.

DATA REQUIREMENTS FOR COST ESTIMATING:

1. General design specifications. It refers a brief description of the product, its function, performance and purpose.
2. Total anticipated quantity and the rate of production.
3. Assembly or layout drawings.
4. List of the proposed subassemblies of the product.
5. Detail drawings and a bill of material for the product.
6. Test and inspection procedures and equipment.
7. Machine tool and equipment requirements.

(8) Packaging and or transportation requirements

(9) Manufacturing routings.

(10) Detailed tool, machine tool and equipment requirements.

(11) Operation analysis and workplace studies

(12) Standard time data

(13) Material release data

(14) Subcontractor cost and delivery data

(15) Area and building requirements.

DATA SOURCES:

S. NO.	DESCRIPTION OF DATA	SOURCES
1.	General design specifications	Product Engineering and or sales department
2.	Quantity and rate of production	Request for estimate or sales department
3.	Assembly or layout drawings.	Product engineering or sales department or customer's contact man
4.	General tooling plans and list of proposed subassemblies of product	Product engineering or manufacturing engineering
5.	Detail drawings and bill of material	Product engineering or sales department
6.	Test and inspection procedures and equipment	Quality control or product engineering or sales department
7	Machine tool and equipment requirements	Manufacturing engineering or vendors of materials.

(8)	Packaging and or transportation requirements	Sales department, or shipping department or product engineering
(9)	Manufacturing routings and operation sheets	Manufacturing engineering or methods engineering
(10)	Detail tool, gauge, machine and equipment requirements	Manufacturing engineering or material vendors
(11)	Operation analysis and workplace studies.	Methods engineering
(12)	Standard time data	Special charts, tables, time studies and technical books and magazines.
(13)	Material release data	Manufacturing engineering and or purchasing department or material vendors
(14)	Subcontractor cost and delivery data	Manufacturing engineering and or purchasing department or customer
(15)	Area and building requirements	Manufacturing engineering or plant layout or plant engineer
(16)	Historical records of previous cost estimates (for comparison purposes etc)	Manufacturing engineering or cost department or sales department
(17)	Current costs of items presently in production	Cost department or treasurer or controller.

In addition to the above usual sources of cost estimating information within the given organization of company, there are other useful sources. They include:

(a) Vendors salesmen

(b) Professional acquaintances

(c) Technical societies and trade associations.

(d) Foreman and supervisors.

(e) The workman.

IMPORTANCE OF REALISTIC ESTIMATES

Three possible estimating are

(i) Overestimation

(ii) Under-estimation and

(iii) Realistic estimation

ELEMENTS OF COST ESTIMATION

The total estimated cost of a product consists of the following cost components

(1) Design cost

(2) Drafting cost

(3) R&D Cost

(4) Materials cost

(5) Labour cost

(6) Inspection cost

(7) Cost of tools, jigs and fixtures and

(8) Overhead cost

(1) DESIGN COST

The cost of design of a product is estimated by ascertaining the expected time for the design of that product

$$\text{Estimated design cost} = \left\{\text{Estimated design time}\right\} \times \left\{\text{Salary of designer per unit time.}\right\}$$

The design time can be estimated on the basis of similar products already designed in the past or on the basis of good judgement of designer

If the design of the product is done by some outside agency the total amount paid to outside agency gives the cost of design.

(2) DRAFTING COST:

After the completion of the design the drawing have to be prepared by draftsman

$$\text{Drafting cost} = \begin{Bmatrix} \text{Estimated time} \\ \text{to be consumed} \\ \text{by draftman in} \\ \text{preparing drawings} \end{Bmatrix} \times \begin{Bmatrix} \text{Salary of the draftsman} \\ \text{per unit time} \end{Bmatrix}$$

(3) COST OF RESEARCH AND DEVELOPMENT WORK

Considerable time and money has to be spent on research and development work. The research may be theoretical, experimental or developmental research. The estimated time and the costs to be incurred on it are decided by judgement or past experience.

(4) MATERIALS COST

The steps involved in the estimation of materials costs are given below.

(i) First prepare the list of all materials required to manufacture the product.

(ii) Estimate the weight of all the materials expected to be used in the manufacture of the product. The allowance for material wastage, spoilage and scrap are also added for each part.

(iii) Estimated materials cost = {Estimated weight of each part} × {Estimated future price}

(iv) Finally the estimated cost of all the parts is added to get the total estimated material cost of the product

5 LABOUR COST

Labour cost = {Estimated labour time needed to produce the product} × {Cost of labour per hour}

To estimate the labour cost the estimator should have the thorough knowledge of the various operations to be performed, machines to be used, sequence of operations, tools to be used and labour rates.

6 INSPECTION COST:

While estimating the inspection cost one should consider the cost of inspection equipments, gauges and consumables and wages to the inspectors.

7 COST AND MAINTENANCE CHARGES OF TOOLS, JIGS AND FIXTURES

Estimated cost of a product includes the estimated cost and maintenance charges for the tools, jigs and fixtures, dies required in the production.

The cost of tools, jigs, fixtures etc are estimated considering their present prices, market trend and the number of times a particular tool can be used during its life-time.

$$\text{Tool cost per unit produced} = \frac{\text{Estimated cost}}{\text{Number of jobs}}$$

8. OVERHEAD COST:

Overhead expenses are those which cannot be charged directly to a particular product manufactured.

All expenses other than the direct material cost, direct labour cost and direct expenses are known as overhead costs or indirect expenses. Administrative expenses, selling and distribution expenses are added to the overhead costs.

The overhead costs may be estimated by referring to the records of overhead costs in similar parts produced in past.

COST ESTIMATING PROCEDURE

The step by step procedures in the cost estimation of any product are given below:

STEP 1:

Study the cost estimation request thoroughly and understand it completely

STEP 2:

Analyse the product and decide the requirements and specifications of the product.

STEP 3:

Prepare the list of all the parts of the product and their bill of materials.

STEP 4:

Take make or buy decisions and prepare separate lists of parts to be manufactured within the plant and parts to be purchased outside the plant.

STEP 5:

Estimate the materials cost for the parts to be manufactured in the plant

Material cost = Weight of the material × Material cost per unit weight

STEP 6:

Determine the cost of parts to be purchased from outside

STEP 7:

Make a manufacturing process plan for the parts to be manufactured in the plant

STEP 8:

Estimate the machining time for each operations listed in the manufacturing process plan.

STEP 9:

Determine the direct labour cost

Direct labour cost = Total operation time × Labour wage rate

STEP 10:

Determine the prime cost by adding direct expenses, direct material cost and direct labour cost

∴ Prime cost = Direct labour cost + Direct material cost + Direct expenses

STEP 11:

Estimate the factory overheads, which include all indirect expenditure incurred during production such as indirect material cost, indirect labour cost, depreciation and expenditure on maintenance of the plant, machinery, power etc.,

STEP 12:

Estimate the administrative expenses

STEP 13:

Estimate the selling and distribution expenses, which include packing and delivery charges, advertisement charges, etc.,

STEP 14:

Now calculate the total cost of the product

Total cost = Prime cost + Factory overheads + Administrative expenses + Selling and distribution expenses.

STEP 15:

Decide the profit and add the profit to the total cost to fix the selling price of the part.

Selling price = Total cost + Profit

STEP 16:

Finally estimate the time of delivery in consultation with the production and sales department

ESTIMATE FORM

Description .... Date ....

Drawing No. .... Enquiry No. ....

Lot size .... components Customer ....

Estimated by ....

S.No.	Item of Expenditure	Total cost for the Entire lot	Cost / Component
1.	Direct material cost per component 1. .... 2. .... 3. .... 4. .... Total:		
2.	Labour cost per component Operation Labour cost Overhead (i) (ii) (iii) (iv)		
3.	Other direct expenses		
4.	Factory expenses		
5.	Administrative expenses		
6.	Selling expenses (i) Packing and carriage (ii) Advertising and publicity (iii) Other allied expenses		
7.	Total cost / Component		
8.	Profit (usually as a percent of total cost per component)		
9.	Total (selling price per component)		

COSTING OR COST ACCOUNTING

DEFINITION AND CONCEPT

Costing also known as cost accounting is the determination of an actual cost of a component after adding different expenses incurred in various departments.

Costing or cost accounting may be defined as a systematic procedure for recording accurately every item of expenditure incurred on the manufacture of a product by different sections of any manufacturing concern.

Wheldon has defined costing as "Costing is the classifying and recording the appropriate allocation of expenditure for the determination of the costs of products or services and for presentation of suitably arranged data for the purpose of control, and guidance of management.

Cost accounting is a powerful management tool, which provides the management with detailed records of costs relating products, operations or functions.

The different probable elements of cost to be recorded are material, labour and other charges which jointly complete the cost of the product.

OBJECTIVES OF COST ACCOUNTING:

The main aims of costing are

1. Cost determination - To determine the actual cost of each component and cost of the final product
2. For fixing selling price:- To provide information to ascertain the selling price of the product.
3. Cost control - To analyse the expenses incurred in production, so that control can be kept over them
4. Comparison with estimate - To compare the actual cost with the estimated cost to know whether the estimate had been realistic or not
5. Make or buy decisions - To decide which of the components to be manufactured and which parts to be purchased from outside
6. Wastage reduction:- To help in detecting the undesirable wastages and expenses, so that corrective measures can be taken.
7. To suggest changes in design - To suggest changes in design if the cost of production is higher as compared to the competing product.
8. Profit and Loss - To locate the reasons for the increase or decrease in profits or loss of a company.

(9) Fixing the discount - To help in determining the discount on catalogue or market price of the product

(10) Pricing policy - To help in formulating the policies for changing or prices of the product

(11) Budget preparation - To help the enterprise to prepare its budget.

(12) For preparing quotations / tenders - To facilitate preparation of estimate for submitting in quotations or tenders.

(13) Output targets - To help in regulating, from time to time, the production of a job so that the enterprise can earn more profits.

(14) Legal provisions - To meet certain legal and government regulations, cost data is necessary.

(15) Purchasing new machines / plants - To provide information for economic consideration for purchasing new machines, plants, etc.,

IMPORTANCE OF COSTING:

Costing is necessary because it provides information for:

(i) Determining, classifying and analysing the cost and income to a business firm.

(ii) Determining the prices to be quoted to customers.

(iii) Forming basis for managerial decisions that have to do with,

(a) Make or buy decisions,

(b) To introduce a new product or to drop an existing one and

(c) To expand or contract the existing one.

(iv) Cost control through accumulation and utilisation of cost data.

(v) Establishing standards for measuring efficiency.

DIFFERENCE BETWEEN ESTIMATING AND COSTING

S.NO.	PARTICULAR	ESTIMATING	COSTING
1.	Nature of cost	It gives the probable cost of the product before the start of its manufacture	It gives the actual cost of the product after adding different expenses incurred in various departments.
2.	Quality of personnel required	Estimation requires a highly technical knowledge hence an estimator is basically an engineer	Costing requires the knowledge of accounts and therefore costing is done by accountants
3.	Duration of process	Estimating is carried out before the actual production of a product	Costing usually starts with the issue of order for production of a product and

4	Main objectives	To establish the selling price of a product for a quotation or contract	To determine the actual cost of the final product
5.	Organising department	Estimating work is done under the planning department	Costing work is done under the accounting department

METHODS OF COSTING:

① JOB COSTING OR ORDER COSTING

This method is concerned with finding the cost of each individual job or contract. In this method the total cost for each order is obtained from the daily cost sheet

② BATCH COSTING

Batch costing is a form of job costing. In this method instead of costing each components separately each batch of components is taken together and treated as a job

③ PROCESS COSTING:

This method is employed when a standard product is made which involves a number of distinct processes performed in a definite sequence. This method indicates the costs of a product at different stages as it passes through various operations or processes or departments.

(4) DEPARTMENTAL COSTING

This method is adopted in determining the cost of the output of each department separately for the manufacture of the standardised products. In this method the actual expenditures of each department on various departments is entered on a separate cost sheet and the costing for each department is separately undertaken

(5) OPERATING COST METHOD

This method is used in firms providing utility services. It is also known as service costing

(6) UNIT COST METHOD

This method is adopted by the firms which supply a uniform product rather than a variety of products.

(7) MULTIPLE COST METHOD

This method is used in firms which manufacture variety of products having no relation to one another.

CLASSIFICATION OF COST

(1) Classification of cost according to elements

i. Materials cost

ii. Labour cost

iii. Overheads

(2) Classification of cost according to function

i. Production cost

ii. Administrative cost

iii. Selling cost

iv. Overhead cost

(3) Classification of cost according to variability

i. Fixed cost

ii. Variable cost

iii. Semi-variable cost

(4) Classification of cost into direct and indirect costs

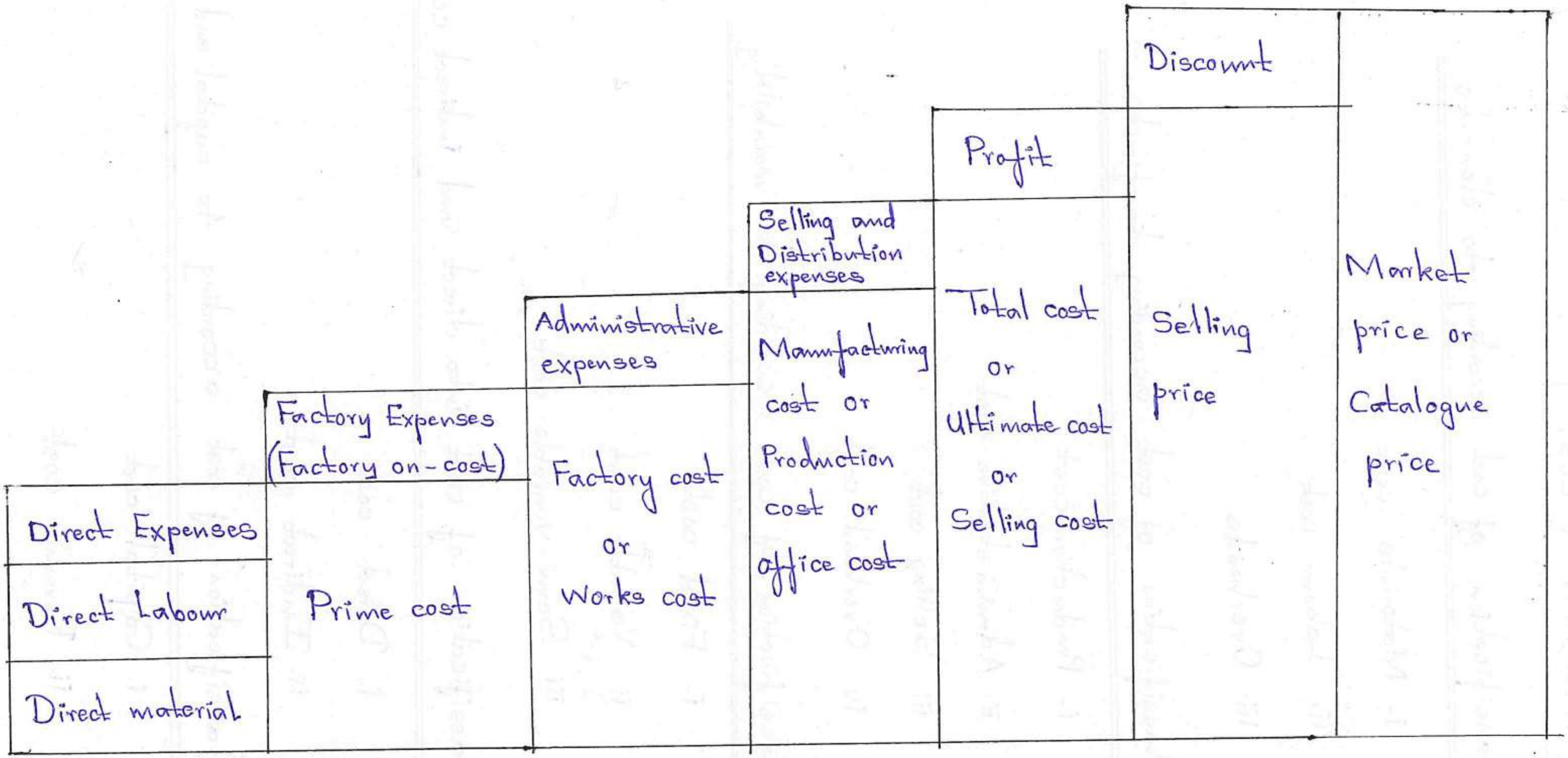
i. Direct cost

ii. Indirect cost

(5) Classification of cost according to capital and revenue

i. Capital cost

ii. Revenue cost



LADDER OF COST

ESTIMATION OF MATERIALS COST

For calculating the materials cost of a product the following step by step procedure can be used

1. Study the drawing carefully. Then break up the product into simple geometrical shapes such as cubes, prisms, cylinders etc., so that their volumes can be easily calculated.

2. Calculate the volume of each part by applying the formulae of mensuration

3. Add volumes of all the parts to get the total volume of the product

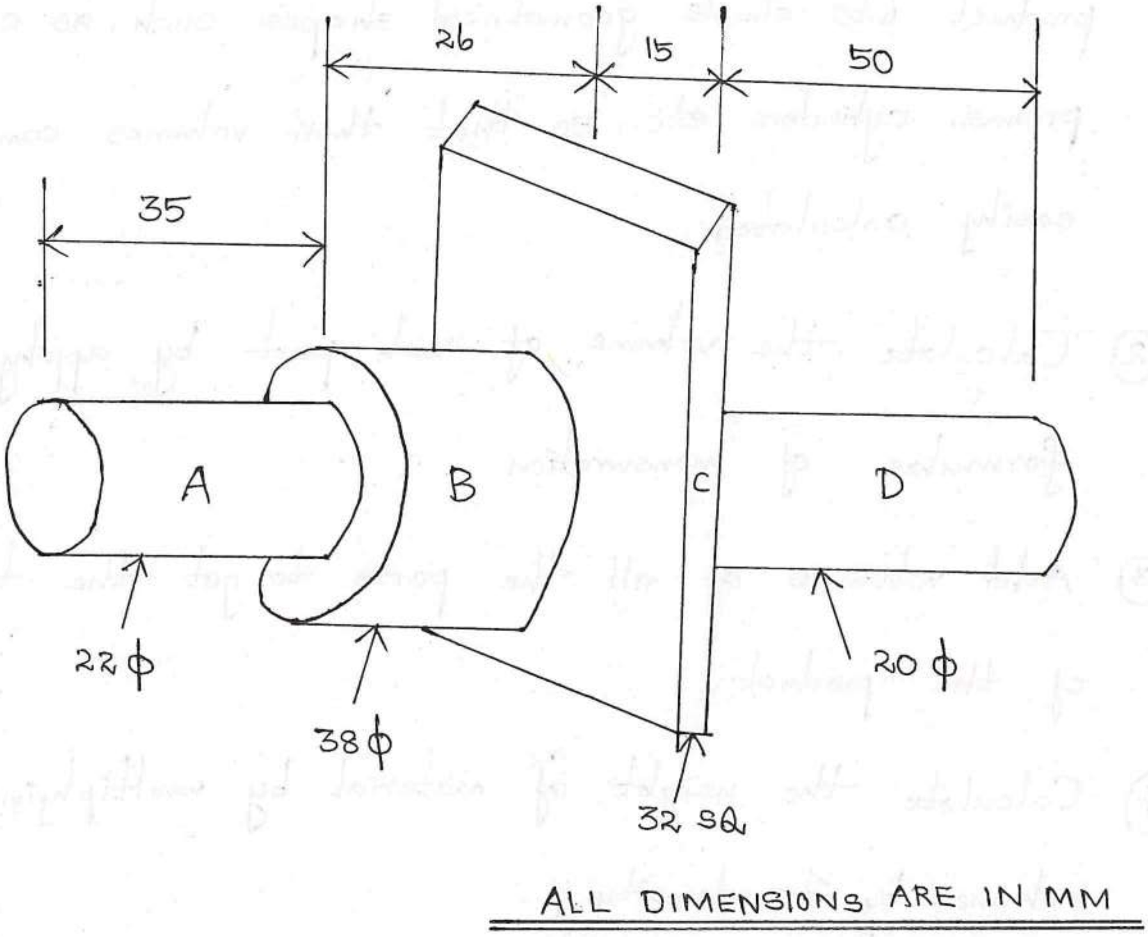
4. Calculate the weight of material by multiplying the volume by its density

5. Finally calculate the material cost by multiplying the cost per unit weight to the weight of the material

Material cost = Weight of the material × Cost per unit weight

Weight of the material = Total volume of the material × Material density

① An isometric view of a work piece is shown in figure. what will be the weight of the mild steel material required to produce it. The density of material is 2.681 gm/cc. Find also the material cost if its rate is Rs. 100 per kg. All dimensions are in mm.



GIVEN DATA:

$\rho = 2.681 \ gm/cm^3 = 2681 \ kg/m^3$

Unit cost = Rs. 100 per kg

TOFIND:

i. Weight of the material

ii. Material cost

SOLUTION:

1. Weight of the material

Volume of cylinder A $= \frac{\pi}{4} d^2 l = \frac{\pi}{4} (22)^2 35$

$= 13304.64 \text{ mm}^3$

Volume of cylinder B $= \frac{\pi}{4} (38)^2 26$

$= 29486.99 \text{ mm}^3$

Volume of portion C $= 32 \times 32 \times 15$

$= 15360 \text{ mm}^3$

Volume of cylinder D $= \frac{\pi}{4} (20)^2 50$

$= 15707.96 \text{ mm}^3$

Total volume = Vol of A + Vol of B + Vol of C + Vol of D

$= 13304.64 + 29486.99 + 15360 + 15707.96$

$= 73859.59 \text{ mm}^3 = 75859.59 \times 10^{-9} \text{ m}^3$

Weight of the material = Total volume × Density

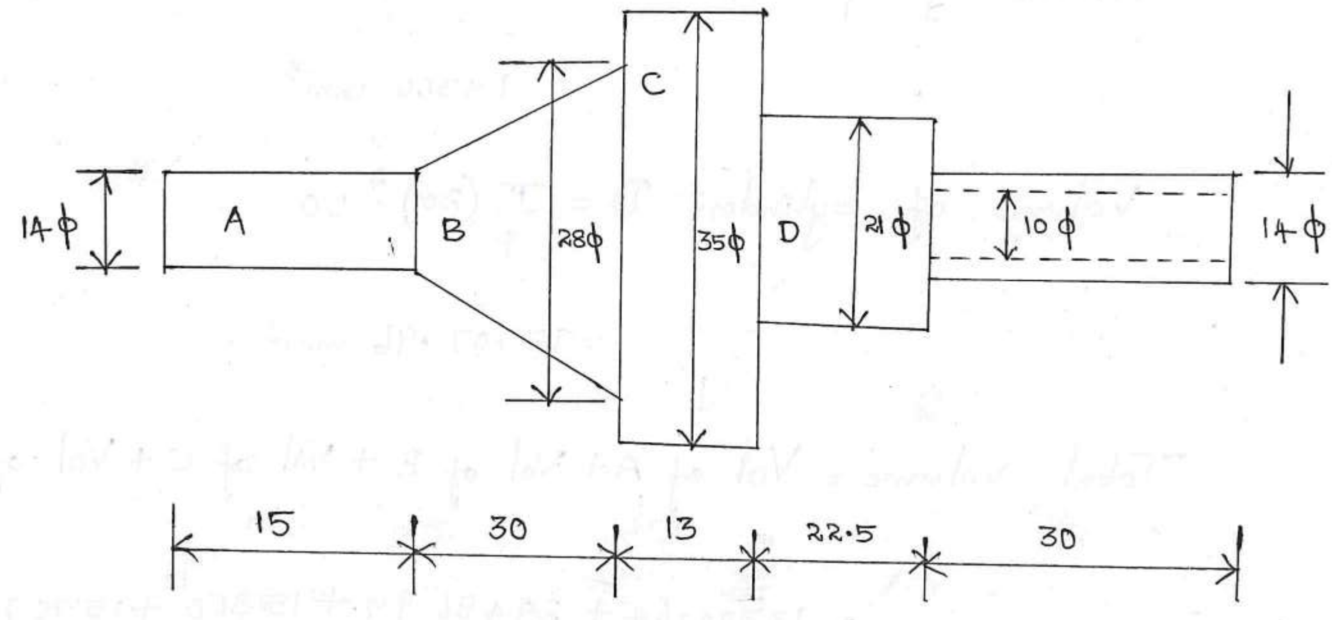
$= 75859.59 \times 10^{-9} \times 2681$

$= 0.198$ kg

Material cost = Weight × Cost per unit weight

$= 0.198 \times 100$ = Rs. 19.80

② Estimate the weight of material required for manufacturing 220 pieces of shaft as shown in figure. The shafts are made of mild steel which weighs 7.87 gm/cm³ and costs Rs.100 per kg. Also calculate the material cost for 220 such shafts



ALL DIMENSIONS ARE IN MM

GIVEN DATA:

$n = 220$ pcs

$\rho = 7.87\ gm/cm^3 = 7.87 \times 10^{-6}\ kg/mm^3$

TOFIND:

Weight and cost of the materials required for 220 shafts

SOLUTION:

Volume of A $= \frac{\pi}{4}(14)^2 15 = 2309.07 \ mm^3$

Volume of B = Volume of frustum of a cone

$= \frac{h}{3}\left[a_1 + a_2 + \sqrt{a_1 a_2}\right]$

$h = 30 \ mm$

$a_1 = \frac{\pi}{4}(14)^2 = 153.94 \ mm^2$

$a_2 = \frac{\pi}{4}(28)^2 = 615.75 \ mm^2$

Volume of B $= \frac{30}{3}\left[153.94 + 615.75 + \sqrt{153.94 \times 615.75}\right]$

$= 10775.675 \ mm^3$

Volume of C $= \frac{\pi}{4}(35)^2 13 = 12507.46 \ mm^3$

Volume of D $= \frac{\pi}{4}(21)^2 22.5 = 7793.11 \ mm^3$

Volume of E $= \frac{\pi}{4}\left[14^2 - 10^2\right] \times 30 = 2261.95 \ mm^3$

Total volume = Vol of A + Vol of B + Vol of C + Vol of D + Vol of E

$= 2309.07 + 10775.675 + 12507.46 + 7793.11 + 2261.95$

$= 35647.265 \ mm^3$

Weight = Total volume × Density

$= 35647.265 \times 7.87 \times 10^{-6}$

$= 0.2805$ kg

Weight of 220 shafts $= 0.2805 \times 220$

$= 61.72$ kg

Cost of materials required for 220 shafts

= Total weight × Cost per unit weight

$= 61.72 \times 100$

= Rs. 6172

ESTIMATION OF LABOUR COST:

The estimator should consider the following factors while calculating the time required for a particular job

i. Set up time

ii. Operation time

  a. Handling time

  b. Machining time

iii. Tear down time

iv. Miscellaneous allowances

  a. Personal allowance

  b. Fatigue allowance

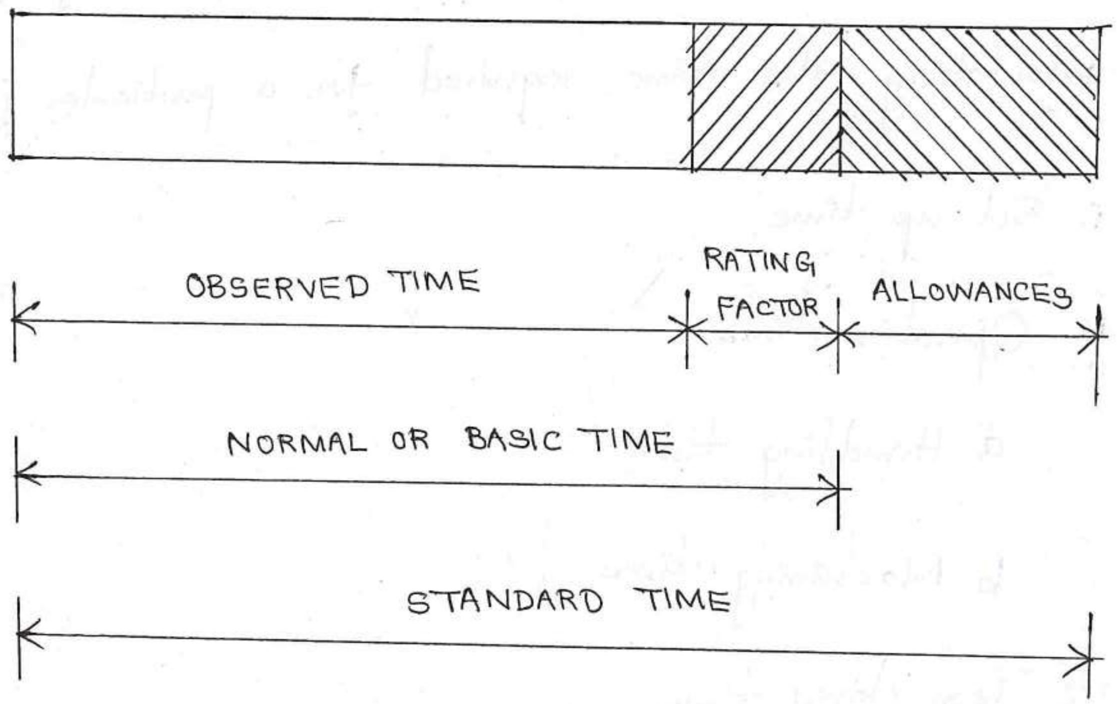
  c. Contingency allowances

  d. Process allowances

  e. Interference allowances

  f. Special allowances.

CALCULATION OF STANDARD TIME



DETERMINATION OF OVERHEADS AND VARIOUS COST COMPONENTS

1. Prime cost = Direct labour cost + Direct materials cost + Direct expenses

2. Factory cost = Prime cost + Factory expenses

3. Manufacturing cost = Factory cost + Administrative expenses

4. Total cost = Manufacturing cost + Selling expenses + Distribution expenses

5. Selling price = Total cost + Profit

6. Market price = Selling price + Discount

For manufacturing a 'milling machine' the expenditure is tabulated in Table

SL NO	Particulars	Expenses in Rupees
1.	Material consumed	46,000
2.	Indirect factory wages	7,000
3.	Director's fees	2,500
4.	Advertising	8,000
5.	Net profit	11,750
6.	Depreciation on sales department's car	900
7.	Printing and stationery	350
8.	Depreciation on plant	4,200
9.	Direct wages	59,000
10.	Factory rent	5,750
11.	Telephone and postal charges	250
12.	Gas and electricity	400
13.	Office salaries	2,000
14.	Office rent	600
15.	showroom rent	1200
16.	Salesman's commission	1850
17.	Sales department car expenses	1200

Find out (a) Prime cost (b) Factory cost (c) Total cost of production (d) Cost of sales and (e) Selling price

S.NO.	Particulars	Amount in Rs.	
1.	DIRECT OR PRIME COST		
	a. Direct material cost	46,000	
	b. Direct labour cost	59,000	
	c. Direct expenses	–	
	Prime cost	1,05,000	1,05,000
2.	FACTORY EXPENSES		
	a. Indirect factory wages	7,000	
	b. Depreciation on plant	4,200	
	c. Factory rent	5,750	
	d. Gas and electricity	400	
	Total factory expenses	17,350	17,350
3.	ADMINISTRATIVE EXPENSES		
	a. Director's fees	2,500	
	b. Printing and stationery	350	
	c. Telephone and postal charges	250	
	d. Office salaries	2,000	
	e. Office rent	600	
	Total administrative expenses	5,700	5,700

4.	SELLING AND DISTRIBUTION EXPENSES		
	a. Advertising	8,000	
	b. Depreciation on sales department's car	900	
	c. show-room rent	1,200	
	d. Saleman's commission	1,850	
	e. Sales department car expenses	1,200	
	Total selling and distribution expenses	13,150	13,150
5.	Net profit	11,750	11,750

a. Prime cost

Prime cost = Direct material cost + Direct labour cost + Direct expenses

= Rs. 1,05,000

b. Factory cost

Factory cost = Prime cost + Total factory expenses

= 1,05,000 + 17,350

= Rs. 1,22,350

c. Total cost of production

Production cost = Factory cost + Total administrative expenses

= 1,22,350 + 5700

= Rs. 1,28,050

d. Cost of sales (Selling cost)

Selling cost or Total cost = Production cost + Total selling and distribution expenses

= 1,28,050 + 13,150

= Rs. 1,41,200

e. Selling price

Selling price = Total cost + Profit

= 1,41,200 + 11,750

= Rs. 1,52,950

DEPRECIATION

The reduction in the value and efficiency of the plant, equipment or any fixed asset because of wear and tear due to passage of time use and climatic conditions is known as depreciation.

CAUSES OF DEPRECIATION

Depreciation due to physical conditions

1. Wear and tear
2. Physical decay
3. Accident
4. Poor maintenance and neglect.

Depreciation due to functional conditions

1. Inadequacy.
2. Obsolescence.

METHODS OF DEPRECIATION

1. Straight line method
2. Diminishing balance (or reducing balance) method
3. Sinking fund method
4. Annuity method

5. Sum of year's digits method

6. Insurance policy method

7. Machine-hour method

8. Production-unit method

9. Revaluation (or regular valuation) method

10. Retirement method.

STRAIGHT LINE METHOD (OR FIXED INSTALMENT METHOD)

In this method, the amount of depreciation is distributed over the useful life of the machine in equal periodic instalments.

$$D = \frac{C-S}{n} \text{ Rs.}$$

C = Initial cost of the machine in Rs.

S = Scrap (or salvage) value in Rs.

n = Estimated life of the machine in years

D = Depreciation amount per year

A CNC machine was purchased for Rs. 1,25,000 on 15th june 1995 the erection and installation cost was Rs. 10,000. The CNC machine is to be replaced by a new one on 14th June 2010. If the estimated scrap value is Rs. 25,000, what should be the rate of depreciation and depreciation fund on June 14th 2002.

If after 9 years of running some machine parts are replaced and the estimated replacement cost is Rs. 4000 what will be the new rate of depreciation?

GIVEN DATA:

Machine cost = Rs. 1,25,000

Erection and installation cost = Rs. 10,000

S = Rs. 25,000

SOLUTION:

a. i. Rate of depreciation (D)

Total cost = Machine cost + Erection and installation costs

$C = 1,25,000 + 10,000$

C = Rs. 1,35,000

n = From 15th June 1995 to 14th June 2010

= 15 years

$$\text{Rate of depreciation} = \frac{C-S}{n} \text{ rs.}$$

$$= \frac{135000 - 25000}{15}$$

$$= \text{Rs. } 7333.33$$

ii. Depreciation fund on 14th June 2002

Depreciation fund collected upto 14th June 2002

$$= 7333.33 \times 7$$

$$= \text{Rs. } 51,333.33$$

b. New rate of depreciation (D')

Replacement cost = Rs. 4000

After 9th year the book value of the machine

= Initial capital cost (C) − Depreciation cost for 9 year

$$= 135000 - (7333.33 \times 9)$$

$$= \text{Rs. } 69000.03$$

Replacement cost = Rs. 4000

$$C' = 69000.03 + 4000$$

$$= \text{Rs. } 73000.03$$

$$D' = \frac{C' - S}{n'}$$

$$= \frac{73000 \cdot 03 - 25000}{6}$$

$$D' = Rs. 8000$$

DIMINISHING BALANCE (OR REDUCING BALANCE) METHOD

$$p = 1 - \left(\frac{S}{C}\right)^{1/n}$$

C = Initial cost of the machine in rs

S = Scrap value in rs

p = Fixed percentage for calculating yearly depreciation

n = Estimated life of the machine in years

A certain machine was purchased for Rs. 25000 and it was presumed that it will last for 20 years. It was also considered that by selling the scrap of the machine the residual value will be Rs. 4000. If the depreciation is charged by reducing balance method find out the depreciation fund after and depreciation amount for the 3rd year.

Also find out the depreciation percentage by which value of the machine is reduced every year.

GIVEN DATA:

$C = Rs.\ 25{,}000$

$n = 20$ years

$S = Rs.\ 4000$

TO FIND:

i. Depreciation fund after 3rd year

ii. Depreciation amount for the 3rd year

iii. Percentage by which value of the machine is reduced every year (p)

SOLUTION:

$$p = 1 - \left(\frac{S}{C}\right)^{1/n}$$

$$= 1 - \left(\frac{4000}{25000}\right)^{1/20}$$

$$= 0.08755$$

$$= 8.76\ \%$$

Depreciation fund after 3rd year

Value of machine after 1 year $= C(1-p)$

$= 25000\left(1-0.08755\right)$

$= Rs.\ 22811.09$

Depreciation fund for first year = 25000 − 22811.09

= Rs. 2188.91

Value of machine after 2 years = $22811.09\left(1-0.08755\right)$

= Rs. 20813.98

Depreciation fund after 2 years = 22811.09 − 20813.98

= Rs. 1997.11

Value of machine after 3 years = $20813\left(1-0.08755\right)$

= Rs. 18990.82

Depreciation fund for 3rd year = 20813.98 − 18990.82

= Rs. 1823.16

Depreciation fund after 3rd year = Sum of depreciation funds for first 3 years

= 2188.91 + 1997.11 + 1823.16

= 6009.18 Rs.

Depreciation fund for the 3rd year = Rs. 1823.16

SINKING FUND METHOD:

$$D = \frac{(C-S)r}{(1+r)^n - 1}$$

D = Rate of depreciation per year

r = Rate of interest on depreciated fund in percentage

C = Initial cost

S = Scrap value

n = Estimated life of the machine in years

A power hacksaw machine was purchased for Rs. 25,000. After 5 years the machine was valued at Rs. 10,000. Find out the depreciation amount according to the sinking fund method, the rate of interest being 5%.

GIVEN DATA:

$C = 25000$

$n = 5$ years

$S = Rs.\,10000$

$r = 5\% = 0.05$

TOFIND:

Depreciation amount by sinking fund method

SOLUTION:

$$D = \frac{(C-S)r}{(1+r)^n - 1} = \frac{(25000 - 10000)\,0.05}{(1+0.05)^5 - 1} = Rs.\,2714.62$$

UNIT IV

PRODUCTION COST ESTIMATION

FORGING

Forging is defined as the process in which the desired shape and size of an object is obtained through the plastic deformation of the metal of the object

TYPES OF FORGING

(i) HOT FORGING:

When the forging is performed on the metal above the recrystallisation temperature it is called hot forging

(ii) COLD FORGING

When the forging is performed on the metal below the recrystallisation temperature it is called cold forging

FORGING PROCESSES

(1) HAND OR SMITH FORGING

If the metal is heated in a smithy and forged using forging tools manually or using hand then this type of forging is known as hand forging or manual forging

(2) DROP FORGING

Drop forging utilises a closed impression die to obtain the desired shape of the component. The drop forging die consists of two halves. The lower half of the die is fixed to the anvil of the machine while the upper half is fixed to the ram. The heated stock is kept in the lower die while the ram delivers four to five blows on the metal.

(3) PRESS FORGING

Press forging is similar to drop forging. In press forging the metal is shaped not by means of a series of blows as in drop forging but by means of a single continuous squeezing action

(4) MACHINE OR UPSET FORGING

In upset forging the heated bar stock is held between two dies and the protruding end is hammered using another die.

FORGING OPERATIONS

(1) UPSETTING

Upsetting is the process of increasing the thickness or the cross-sectional area of the work piece by reducing its length. Only the part to be upset is heated to the forging temperature and the workpiece is struck at the end between hammer and anvil

(2) DRAWING DOWN (FULLERING)

Drawing down is the process of increasing the length of a bar and reducing its thickness or width. Force applied in a direction perpendicular to length axis

(3) SETTING DOWN

This is an operation which usually follows drawing down. It can be performed with a hammer and a flatter. Used for smoothening.

(4) BENDING

Bending is the operation by which a metal rod or pipe can be bent to form various shapes without damaging its internal gain structure. It is carried out by hammering the workpiece which is kept on the edge of the anvil face or horn.

(5) PUNCHING

Punching is the process of producing holes in a workpiece. It is done by placing the workpiece over the hole in the anvil or a cylindrical die to the required size or over a hole of correct size in a swage block.

(6) DRIFTING

After a hole is punched it may be opened out to any size and shape by driving a tapered drift through it. This operation is known as drifting

(7) SWAGING

Swaging is the process of removing the irregularities on the surface of the workpiece produced by the process of drawing down. Upper swage and bottom swage are used for swaging operation. Bottom swage is held in anvil. Hot workpiece is held in between the top and bottom swages. Hammer blows are given over the top swage.

ESTIMATION OF MATERIAL LOSSES IN FORGING

(1) SHEAR LOSS

During sawing the material equal to the product of thickness of sawing blade and cross-section of bar is lost for each cut. This material loss is known as shear loss. It is generally taken as 5% of the net weight

(2) TONGHOLD LOSS

While performing forging operations some length of the stock is required for holding the stock in tong. This small extra length will be removed after completion of the workpiece. This loss is known as tonghold loss.

Tonghold loss = Area of cross-section of bar × Length of tonghold

It is generally taken as 2 to 2.5 cm of the stock length

(3) SCALE LOSS

As the workpiece is heated at high temperature during the forging processes the oxidation of the outer surface of the workpiece will take place. The heated workpiece reacts with oxygen from air forms a thin film of iron oxide on the outer surface of the workpiece.

This thin film of iron oxide is called scale. When hammering is done the scale is broken and falls down as a waste. This waste is known as scale loss.

Scale loss is taken as 6% of net weight.

(4) FLASH LOSS

When dies are used for forging certain quantity of material comes out of the die at the parting line of the top and bottom halves of the die. This surplus wastage material is called flash loss.

Flash is generally taken as 20mm wide and 3mm thick.

Flash loss = Volume of flash × Density of the material

Volume of flash = Circumference of component at parting line × Cross-sectional area of flash

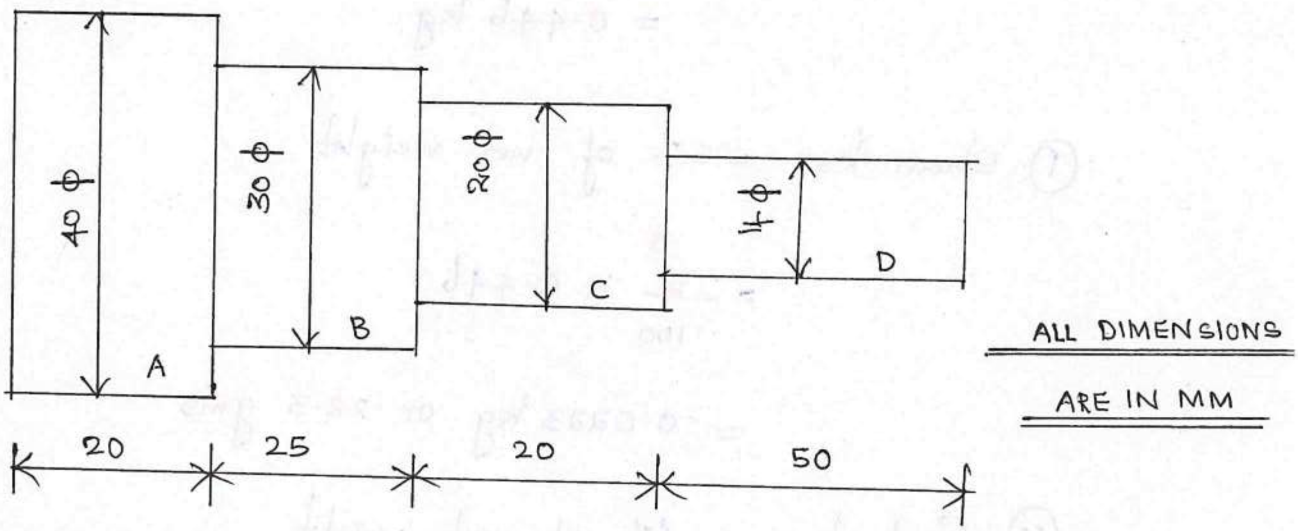
Cross-sectional area of flash = Flash thickness × Flash width

(5) SPRUE LOSS:

The portion of metal between the length held in the tong and the material in the die is called sprue or runner. This is cut off when workpiece is completed. The material loss due to this portion of the material used as a contact is called sprue loss.

---

(1) Calculate the net weight and gross weight for the component shown in figure. Density of material used is 7.86 gm/cc. Also calculate (i) Length of 14 mm dia bar required to forge one component (ii) Cost of forging / piece if : Material cost = Rs. 80 per kg; Labor cost = Rs. 15 per piece. Overheads = 150 percent of labour cost



GIVEN DATA:

$D = 14$ mm

$\rho = 7.86\ gm/cm^3 = 7.86 \times 10^{-6}\ kg/mm^3$

TOFIND:

(i) Net weight and gross weight of the component

(ii) Length of 14mm Φ bar required to forge one piece

(iii) Cost of forging / piece

SOLUTION:

(I) Net weight and gross weight required

Net volume = Volume of (A+B+C+D)

$$= \left[\frac{\pi}{4}(40)^2\, 20\right] + \left[\frac{\pi}{4}(30)^2\, 25\right] + \left[\frac{\pi}{4}(20)^2\, 20\right] + \left[\frac{\pi}{4}(14)^2\, 50\right]$$

$$= 56784 \text{ mm}^3$$

Net weight / piece = Net volume × Density

$$= 56784 \times 7.86 \times 10^{-6}$$

$$= 0.446 \text{ kg}$$

(i) Shear loss = 5% of net weight

$$= \frac{5}{100} \times 0.446$$

$$= 0.0223 \text{ kg or } 22.3 \text{ gms}$$

(ii) Scale loss = 6% of net weight

$$= \frac{6}{100} \times 0.446$$

$$= 0.0267 \text{ kg} = 2.67 \text{ gms}$$

(iii) Flash loss

Taking flash width = 20 mm and

flash thickness = 3 mm

Flash loss = Volume of flash × Density

Volume of flash = Circumference of component at parting line × Flash width × Flash thickness

$$= \left[2(20+25+20+50) + 40 + (40-30) + (30-20) + (20-14) + 14\right] \times \{20 \times 3\}$$

$$= 18600 \text{ mm}^3$$

Flash loss $= 18600 \times 7.86 \times 10^{-6}$

$= 0.1462$ kg $= 146.2$ gm

(iv) Tonghold loss

Taking 20 mm extra length required to be held in tong

Tonghold loss = {Area of cross-section of bar × Length of the tonghold} × Density

$$= \left[\frac{\pi}{4}(14)^2\, 20\right] \times 7.86 \times 10^{-6}$$

$= 0.0242$ Kg

$= 24.2$ gms

(v) Sprue loss

$= 7\%$ of net weight

$= \frac{7}{100} \times 0.446$

$= 0.031$ kg $= 31$ gms.

Total material loss $= 24.3 + 26.7 + 146.2 + 24.2 + 31$

$= 250.6$ gm

$= 0.251$ kg

Gross weight = Net weight + Total material loss

$= 0.446 + 0.251$

$= 0.697$ kg

(ii) Length of 14mm dia bar required to forge one component

$$\text{Gross volume} = \frac{\text{Gross weight}}{\text{Density}}$$

$$= \frac{0.697}{7.86 \times 10^{-6}}$$

$= 88676845$ mm^3

Let L = Length of the 14mm ϕ required

$$\text{Volume of bar} = \frac{\pi}{4}(14)^2 L$$

$$= 153.94 L$$

$$153.94 L = 88676845$$

$$L = 576048 \text{ mm} = 576 \text{ m}$$

(iii) Cost of forging / piece

Material cost = Gross weight x Material cost per kg

$$= 0.697 \times 80$$

$$= \text{Rs. } 55.76$$

Labour cost = Rs. 15

Overhead cost = 150% of labour cost

$$= \frac{150}{100} \times 15$$

$$= \text{Rs. } 22.25$$

Cost of forging piece = Material cost + Labour cost + Overhead cost

$$= 55.76 + 15 + 22.25$$

$$= \text{Rs. } 93.26$$

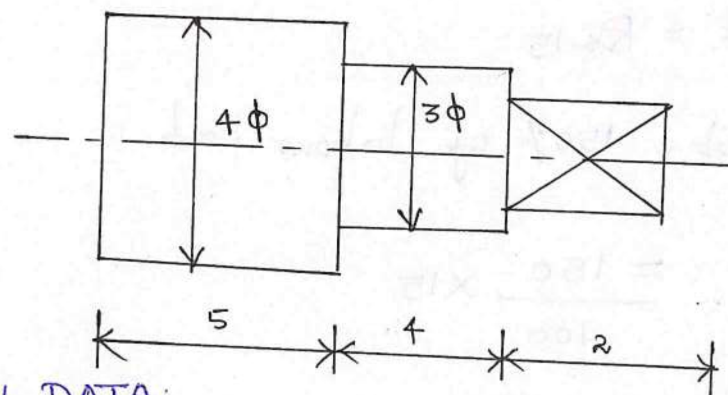
---

(2) 200 pieces of a component as shown in figure are to be drop forged from a 4cm diameter stock bar. Calculate the cost of manufacture, if

(i) Material cost is Rs. 500 per metre

(ii) Forging charges @ Rs. 1000/m^2 of surface area to be forged

(iii) On cost is 10% of material cost. Consider all possible losses during operations.



GIVEN DATA:

$D = 4\text{ cm} = 40\text{ mm}$

TO FIND:

Total cost of forging 200 pieces of component

SOLUTION:

(i) To find material cost

$$\left.\begin{array}{l}\text{Net volume of the}\\ \text{finished material}\end{array}\right] = \left[\frac{\pi}{4}(40)^2 50\right] + \left[\frac{\pi}{4}(30)^2 40\right] + [20 \times 20 \times 20]$$

$= 99106\ mm^3$

(i) Shear loss = 5% of net volume

$= \frac{5}{100} \times 99106$

$= 4955\ mm^3$

(ii) Scale loss = 6% of net volume

$= \frac{6}{100} \times 99106$

$= 5946\ mm^3$

(iii) Flash loss

Taking flash width = 20 mm and flash thickness = 3 mm we get

Volume of flash = Periphery of parting line of dies × Flash width × Flash thickness

$= \left[2(50+40+20) + 40 + (40-30) + (30-20) + 80\right] \times 20 \times 3$

$= 18000\ mm^3$

(iv) Tonghold loss

Taking 20 mm extra length required to be held in tong

Tonghold loss = Area of cross-section of bar × Length of the tonghold

$$= \left[\frac{\pi}{4}(40)^2\right] \times 20$$

$$= 25133 \text{ mm}^3$$

(v) Sprue loss

= 7% of net volume

$$= \frac{7}{100} \times 99106$$

$$= 6937 \text{ mm}^3$$

Total material loss = 4955 + 5946 + 18000 + 25133 + 6937

$$= 60971 \text{ mm}^3$$

Gross volume of material required = Net volume + Material loss

$$= 99106 + 60971$$

$$= 160077 \text{ mm}^3$$

Area of cross-section of 20 mm square bar stock

$$= 20 \times 20 = 400 \text{ mm}^2$$

$$\text{Length of bar stock required} = \frac{\text{Gross volume}}{\text{Area of cross-section of bar stock}}$$

$$= \frac{160077}{400}$$

$$= 400.19 \text{ mm}$$

$$= 0.4 \text{ m}$$

Material cost = Rs. 200 / m

Total material cost = 200 × 0.4 = Rs. 80

② Cost of forging

Surface area of the shaft $= \left\{ \left[\frac{\pi}{4}(40)^2\right] + \left[\pi \times 40 \times 50\right] + \left[\frac{\pi}{4}(40^2 - 30^2)\right] + \left[\pi \times 30 \times 40\right] + \left[\frac{\pi}{4}(30)^2\right] - (20 \times 20) \right\} + \left[4 \times 20 \times 20\right] + (20 \times 20)$

$$= 14167 \text{ mm}^2 = 14167 \times 10^{-6} \text{ m}^2$$

Cost of forging = Rs. 1000 / m^2 surface area forged

Total cost of forging $= (14167 \times 10^{-6}) \times 1000$ = Rs. 14.17

③ To find overhead expenses

Over heads = 10% of material cost

$$= \frac{10}{100} \times 80$$

= Rs. 8

(4) To find the total forging cost of 150 pieces of shaft

$$\text{Total cost of forged shaft} = \text{Material cost} + \text{Forging cost} + \text{Overheads}$$

$$= 80 + 14.17 + 8$$

$$= \text{Rs. } 102.17$$

$$\left.\begin{array}{r}\text{Total cost of 200 pieces}\\ \text{of forged shafts}\end{array}\right\} = 102.17 \times 200 = \text{Rs. } 51085$$

ESTIMATION IN WELDING SHOP

WELDING

Welding is the process of joining similar or dissimilar metals by the application of heat. Welding can be done with or without application of pressure and with or without the addition of filler metal

TYPES OF WELDING

The two main types of welding process are

(i) Plastic or pressure welding

(ii) Fusion or non-pressure welding

(i) Plastic or Pressure Welding

In plastic welding the metal pieces are heated to a plastic state. They are pressed together to make the joint. Since the pressure is applied the plastic welding is also known as pressure welding. Examples are Spot welding, Seam welding

(ii) Fusion or Non-pressure welding

In fusion welding the metal at the joint is heated to molten state. Then it is allowed to solidify. Pressure is not applied in the welding process. So it is known as non-pressure welding. Examples Gas welding and electric arc welding

GAS WELDING:

Gas welding is the process of joining two metal pieces by a gas flame obtained by the combustion of fuel gas and oxygen. It comes under a fusion or non-pressure welding process.

GAS CUTTING:

Gas cutting or flame cutting is a process of cutting metals into pieces using oxy-acetylene flame.

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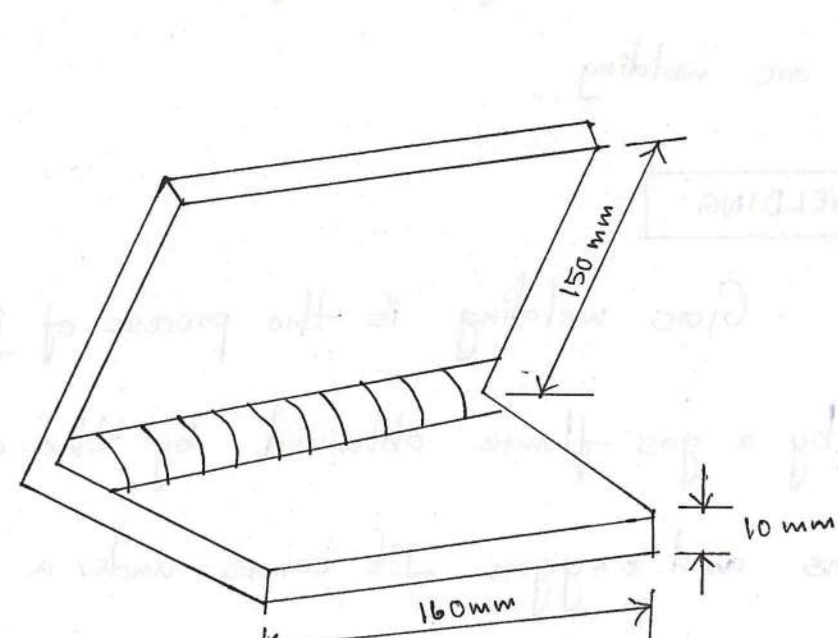
① Estimate the material cost for welding 2 flat pieces of M.S 15 x16 x1 cm size at an angle of 90° by gas welding. Neglect edge preparation cost and assume:

Cost of O_2 = Rs.15 / m^3; Cost of C_2H_2 = Rs.60 / m^3; Density of filler metal = 7 gm/cc; Cost of filler metal = Rs.50/kg; Filler rod dia. = 5 mm; Filler rod required 4.5 m/m of welding

Assume O_2 consumption = 0.7 cu.m/hr; C_2H_2 consumption = 0.5 cu.m/hr; Welding time = 30 min/m of welding



SOLUTION:

Total length of weld = 160 mm = 0.16 m

(a) Cost of filler material

Filler rod required per metre of weld = 4.5 m

Filler rod required per 0.16m of weld = 4.5 × 0.16 = 0.72 m

Volume of filler rod used $= \frac{\pi}{4} d^2 L$

$= \frac{\pi}{4} (0.5)^2 \times 72$

$= 14.14 \text{ cm}^3$

Weight of filler rod = Volume × Density

= 14.14 × 7

= 98.98 gms

Cost of filler material = Rs. 50/kg

Actual cost of filler material $= 98.98 \times 50 \times 10^{-3}$

= Rs. 4.95

(b) Cost of O_2 and C_2H_2 consumed

Welding Time = 30 min/m of welding

Welding time for 0.16 m of weld = 30 × 0.16 = 4.8 min

$= \frac{4.8}{60} = 0.08$ hrs

Consumption of $O_2 = 0.7\ m^3/hr$

Cost of $O_2 = Rs.\ 15/m^3$

Actual consumption of $O_2 = 0.7 \times 0.08 = 0.056\ m^3$

Actual cost of $O_2 = 15 \times 0.056 = Rs.\ 0.84$

Consumption of $C_2H_2 = 0.5\ m^3/hr$

Cost of $C_2H_2 = Rs.\ 60/m^3$

Actual consumption of $C_2H_2 = 0.5 \times 0.08 = 0.04\ m^3$

Actual cost of $C_2H_2 = 60 \times 0.04 = Rs.\ 2.40$

(c) To find total material cost

Total material cost = Cost of filler material + Cost of O_2 consumed + Cost of C_2H_2 consumed

= Rs. 4.95 + Rs. 0.84 + Rs. 2.40

= Rs. 8.19

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(2) A closed water tank of dimensions 50 X 50 X 50 cm is to be welded from a metallic sheet of size 55 X 50 X 1 cm. What is the cost of material involved if the rates of oxygen, acetylene and filler materials are Rs. 15 per cu. metre, Rs. 60 per cu. metre and Rs. 50 per kg respectively.

Find also the labour cost, overhead charges, prime cost and factory cost of making 50 such tanks, if worker gets Rs.40 per hour. Take density of filler metal as 11.28 gm/cc.

GIVEN DATA:

Rate of O_2 = Rs.15/m^3

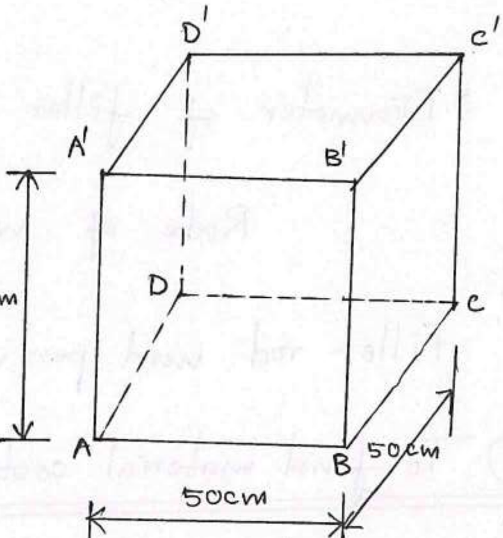
Rate of C_2H_2 = Rs.60/m^3

Rate of filler material = Rs.50 per kg

$n = 50$

Labour rate = Rs. 40/hour

$\rho = 11.28$ gm/cc



TOFIND:

(i) Material cost

(ii) Labour cost

(iii) Overheads and

(iv) Factory cost

SOLUTION:

Total length of weld = AB + BC + CD + DA + A'B' + B'C' + C'D' + D'A' + AA' + BB' + CC' + DD'

= 12 X 50

= 600 cm

= 0.6 m

Since the thickness of sheet i.e., 10 mm is more than 5 mm therefore the rightword welding technique is employed

From table for 10 mm thickness and rightword welding

Consumption of O_2 and C_2H_2 = 1.00 – 1.30 m^3/hr

say 1.15 m^3/hr

Diameter of filler rod used = 5 mm

Rate of welding = 1.7 – 2.0 m/hr say 1.85 m/hr

Filler rod used per metre of weld = 4.5 metres

(i) To find material cost

Filler rod used per 0.6 m of weld = 4.5 × 0.6 = 2.7 m

Volume of filler rod used $= \frac{\pi}{4} d^2 l$

$= \frac{\pi}{4} \times (5 \times 10^{-3})^2 \times 2.7$

$= 5.3 \times 10^{-5}\ m^3$

Weight of filler rod $= (5.3 \times 10^{-5}) \times (11.28 \times 10^3)$

= 0.6 kg

Cost of filler material = Rs. 50 / kg

Actual cost of filler material = 50 × 0.6

= Rs. 30

Rate or Speed of welding = 1.85 m/hr

Time to weld 0.6m length $= \frac{1}{1.85} \times 0.6$

$= 0.324$ hr or 19.44 min

Actual consumption of oxygen $= 1.15\ m^3/hr \times 0.324$ hr

$= 0.3726\ m^3$

Cost of oxygen = Rs. $15/m^3$

Actual cost of oxygen consumed $= 15 \times 0.3726$

= Rs. 5.59

Actual consumption of acetylene $= 1.15 \times 0.324$

$= 0.3726\ m^3$

Cost of acetylene = Rs. $60/m^3$

∴ Actual cost of acetylene consumed $= 60 \times 0.3726$

= Rs. 22.36

Total material cost = Cost of filler material + Cost of O_2 consumed + Cost of C_2H_2 consumed

$= 30 + 5.59 + 22.36$

= Rs. 57.95

(ii) To find labour cost

Time to weld = 19.44 min

Assuming, Edge preparation time = 80 % of time to weld

$$= \frac{80}{100} \times 19.44$$

= 15.55 min

Total labour time = 19.44 + 15.55

= 34.99 min

Labour cost = Rs. 40 / hour

Actual labour cost $= 40 \times \left(\frac{34.99}{60}\right)$

= Rs. 23.33

(iii) To find overheads

Assuming, Overheads = 100% of labour cost

= Rs. 23.33

(iv) To find prime cost

Prime cost = Material cost + Labour cost

= 57.95 + 23.33

= Rs. 81.28

(v) To find factory cost for making 50 tanks:

Factory cost = Material cost + Labour cost + Overheads

$= 57.95 + 23.33 + 23.33$

$=$ Rs. 104.61

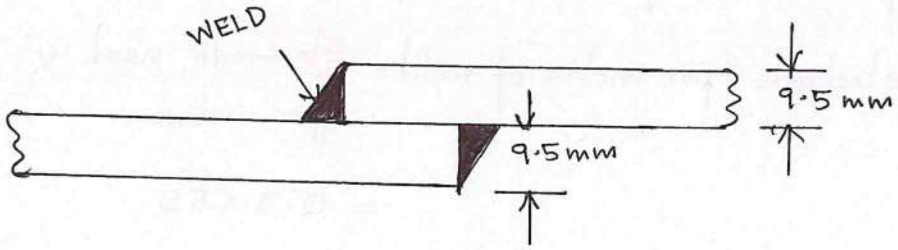
Factory cost for making 50 tanks $= 104.61 \times 50$

$=$ Rs. 5230.50

ESTIMATION OF ELECTRIC ARC WELDING COST

(1) A lap joint is to be prepared in 9.5 mm M.S. sheet using flat welding position and 6 mm electrode. Current used is 250 amperes and voltage is 30V. Welding speed is 12 meters per hour and 0.3 kg of metal is deposited per metre length of joint.

Labour costs Rs. 40 per hour, power Rs. 8 per kWhr and electrode Rs. 55 per kg. Efficiency of machine is 50%. and operating factor is 60%. Calculate the cost of labour, power and electrode per meter of weld.



(i) To find labour cost per metre of weld:

$$\text{Labour cost / Metre of weld} = \frac{1}{\text{Welding speed}} \times \frac{1}{\text{Operation factor}} \times \text{Labour rate}$$

$$= \frac{1}{12} \times \frac{1}{0.6} \times 40$$

$$= \text{Rs. } 5.55$$

(ii) To find cost of power per metre of weld

$$\text{Power cost} = \frac{V \times A}{1000} \times \frac{t}{60} \times \frac{1}{\eta} \times \frac{1}{r} \times C$$

$$t = \text{Welding time in minutes}$$

$$= \frac{1}{\text{Welding speed}} = \frac{1}{12} = 0.083 \text{ hr}$$

$$= 5 \text{ min}$$

$$r = \text{Connecting ratio}$$

Since r is not given, take it as 1

$$\therefore \text{Power cost / metre of weld} = \frac{30 \times 250}{1000} \times \frac{5}{60} \times \frac{1}{0.5} \times \frac{1}{1} \times 8$$

$$= \text{Rs. } 10$$

(iii) To find cost of electrode per metre of weld:

$$\text{Cost of electrode per metre of weld} = \text{Electrode used per metre} \times \text{Electrode rate}$$

$$= 0.3 \times 55$$

$$= \text{Rs. } 16.50$$

ESTIMATION IN FOUNDRY SHOP

Foundry is the process of casting metals into objects of specified shapes. The molten metals or alloys are poured in the moulds and allowed to cool. The object after cooling is known as casting. A mould is a cavity or a matrix formed in a heat resistant material usually sand.

PATTERN

A pattern is a replica of the object to be made by the casting process. The usual pattern materials are wood, metal and plastics.

The most commonly used pattern material is wood, the main reason being the easy availability and the low weight. Also it can be easily shaped and is relatively cheap

PATTERN ALLOWANCES:

(i) Contraction or shrinkage allowance

(ii) Draft allowance

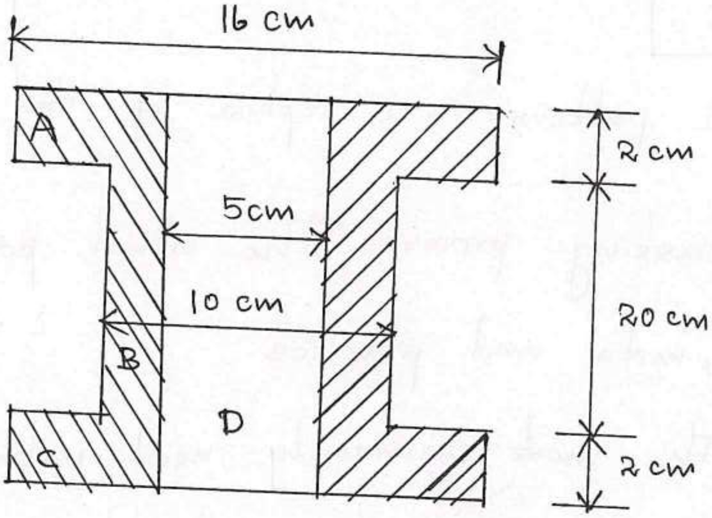
(iii) Machining allowance

(iv) Distortion allowance

(v) Shake allowance

① Estimate the total cost of 20 C.I flanged pipe casting shown in figure, assuming the following data

Cost of C.I = Rs.30/kg; Cost of process scrap = Rs.7/kg; Process scrap = 2% of net weight of casting; Moulding and pouring charges = Rs.15/piece; Casting removal and cleaning = Rs.5/piece; Administrative overheads = 5% factory cost; Selling overheads = 70% administrative overheads.



SOLUTION:

Net volume of cast component = Volume of (A+B+C−D)

$$= \left[\frac{\pi}{4}(160)^2 20\right] + \left[\frac{\pi}{4}(100)^2 200\right] +$$

$$\left[\frac{\pi}{4}(160)^2 20\right] - \left[\frac{\pi}{4}(50)^2 240\right]$$

$$= 1,903,805.15 \text{ mm}^3$$

Assume density of cast iron as 7.2 gm/cc

Net weight of cast component = $1903805.15 \times 7.2 \times 10^{-6}$

$= 13.71$ kg

(i) To find material cost

Process scrap = 2% of net weight of casting

$= \frac{2}{100} \times 13.71$

$= 0.274$ kg

∴ Gross material required = Net weight + Process scrap

$= 13.71 + 0.274$

$= 13.984$ kg

Cost of C.I. = Rs. 30/kg

Cost of 13.984 kgs of C.I. = 30×13.984 = Rs. 419.52

Cost of process scrap = Rs. 7/kg

Cost of 0.274 kg scrap = 7×0.724 = Rs. 1.918

Material cost/piece = Cost of CI − Cost of process scrap

= Rs. 419.52 − Rs. 1.918

= Rs. 417.60

(ii) To find labour cost

Moulding and pouring charges = Rs.15 / piece

Casting removal and cleaning = Rs.5 / piece

∴ Total labour cost per piece = 15 + 5 = Rs.20

(iii) To find overheads:

Factory cost = Material cost + Labour cost + Direct expenses if any

= Rs.417.60 + Rs.20 + 0

= Rs.437.60

Administrative overheads = 5% of factory cost

$= \frac{5}{100} \times Rs.\ 437.60$

= Rs.21.88

Selling overheads = 70% of administrative overheads

$= \frac{70}{100} \times Rs.\ 21.88$

= Rs.15.31

(iv) To find total cost of 20 C.I. flanged pipes

Total costing per piece = Factory cost + Administrative overheads + Selling overheads

= Rs.437.60 + Rs.21.88 + Rs.15.31

= Rs.474.79

Total cost of 20 pipes = Rs. 474·79 X20

= Rs. 9495·80

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(2) 20 numbers of gun metal bevel gear blank shown in figure are to be cast in the factory from the pattern supplied by the customer. Estimate the selling price of each piece from the following data.

(i) Cost of molten gun metal = Rs. 350 per kg

(ii) Scrap return value = Rs. 150 per kg

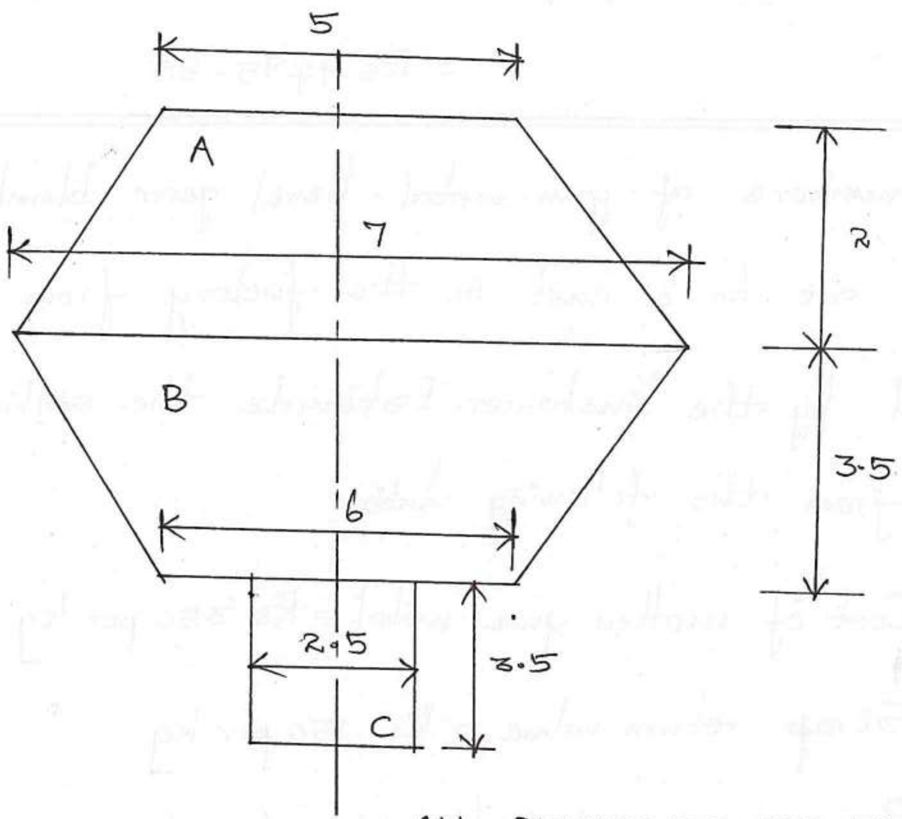
(iii) Process scrap of casting = 10% net weight

(iv) Administrative overheads = Rs. 5 per kg

(v) Profit = 15% of manufacturing cost

(vi) Density of gun metal = 8·73 gm/cc

Process	Time	Labour charges per piece	Work on cost per hour
Moulding and pouring	25 mins.	Rs. 20	Rs. 60
Casting, removal and gate cutting	10 mins.	Rs. 7	Rs. 40
Fettling	3 mins.	Rs. 2	Rs. 40



ALL DIMENSIONS ARE IN cm

Net volume = Volume of (A+B+C)

Vol. of A = Volume of frustum of cone

$$= \frac{H}{3}\left[a_1 + a_2 + \sqrt{a_1 a_2}\right]$$

$$H = 2 \text{ cm}$$

$$a_1 = \frac{\pi}{4}(5)^2 = 19.63 \text{ cm}^2$$

$$a_2 = \frac{\pi}{4}(7)^2 = 38.48 \text{ cm}^2$$

$$\text{Vol. of A} = \frac{2}{3}\left[19.63 + 38.48 + \sqrt{19.63 + 38.48}\right]$$

$$= 57.06 \text{ cm}^3$$

Vol. of B $= \frac{H}{3}\left[a_1 + a_2 + \sqrt{a_1 a_2}\right]$

$H = 3.5$ cm

$a_1 = \frac{\pi}{4}(7)^2 = 38.48\ cm^2$

$a_2 = \frac{\pi}{4}(6)^2 = 28.27\ cm^2$

Vol. of B $= \frac{3.5}{3}\left[38.48 + 28.27 + \sqrt{38.48 * 28.27}\right]$

$= 116.35\ cm^3$

Vol. of C $= \frac{\pi}{4}(2.5)^2\ 3.5 = 17.18\ cm^3$

Net volume $= 57.06 + 116.35 + 17.18 = 190.59\ cm^3$

Net weight = Net volume x Density

$= 190.59 \times 8.73 \times 10^{-3}$

$= 1.664$ kg

Process scrap = 10% of net weight

$= \frac{10}{100} \times 1.664$

$= 0.1664$ kg

Weight of gun metal required $= 1.664 + 0.1664$

$= 1.8304$ kg

(i) To find material cost

Cost of molten gun metal $= 1.8304 \times 350$

$= Rs.\ 640.64$

Scrap return value $= 0.1664 \times 150$

$= Rs.\ 24.96$

Material cost $= 640.64 - 24.96$

$= Rs.\ 615.68$

(ii) To find labour cost

Moulding and pouring charges per piece = Rs. 20

Casting removal and gate cutting charges per piece = Rs. 7

Fettling charges per piece = Rs. 2

Total labour cost $= 20 + 7 + 2 = Rs.\ 29$

(iii) To find overheads

Moulding and pouring factory overhead $= \left(\frac{25}{60}\right) \times 60 = Rs.\ 25$

Casting, removal and gate cutting factory overhead $= \left(\frac{10}{60}\right) \times 40 = Rs.\ 6.67$

Fettling factory overhead $= \left(\frac{3}{60}\right) \times 40 = Rs.\ 2$

$\therefore$ Total factory overheads $= 25 + 6.67 + 2$

$= Rs.\ 33.67$

Administrative overheads = Rs. 5 / kg

∴ Administrative overheads for 1.8304 kg = 5 × 1.8304

= Rs. 9.15

(iv) To find selling price

Manufacturing cost = Material cost + Labour cost + Factory overheads + Administrative overheads

= 615.68 + 29 + 33.67 + 9.15

= Rs. 687.50

Profit = 15% of manufacturing cost

$= \frac{15}{100} \times 687.50$

= Rs. 103.12

∴ Selling price per piece = Manufacturing cost + Profit

= 687.50 + 103.12

= Rs. 790.62

(5)

Administrative overheads = Rs 5/kg

∴ Administrative overheads for 1.984 kg is 5 × 1.984

= Rs 9.92

(iv) To find selling price

Manufacturing cost = Material cost + labour cost + factory overheads + Administrative overheads

= 591.15 + 34 + 22.47 + 9.92

= Rs. 657.54

Profit is 15% of manufacturing cost

$= \frac{15}{100} \times 657.54$

= Rs 98.63

∴ Selling price per piece = Manufacturing cost + Profit

= 657.54 + 98.63

= Rs. 756.17

UNIT V

MACHINING TIME CALCULATION

INTRODUCTION

To estimate the total cost of any product involving machining operations the machining cost is to be estimated primarily. In order to estimate the machining cost one has to calculate the machining time required for these machining operations.

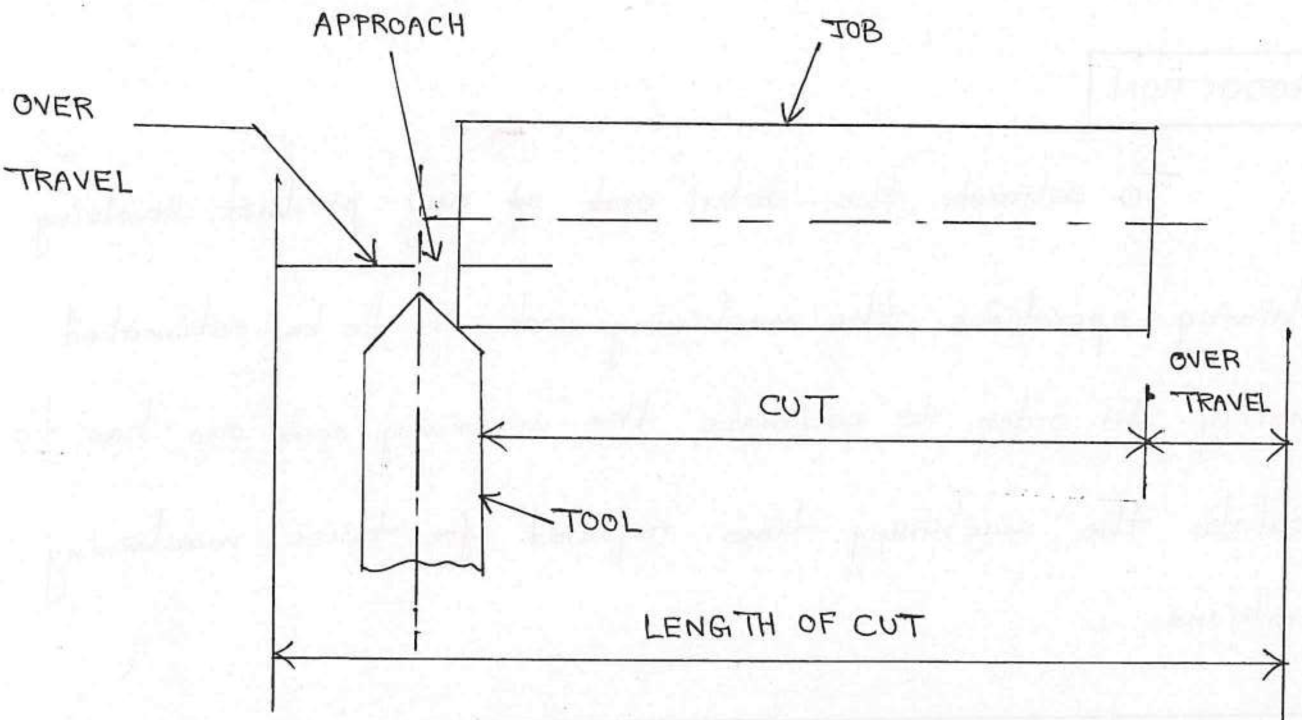
WHAT IS MEANT BY MACHINING TIME?

Machining time is the time for which the machine works on the component, i.e., from the time when the tool touches the work to when the tool leaves the component after completion of operation.

The machining time depends on the type and extent of machining required, material being machined, speed, feed, depth of cut and number of cuts required.

In addition to the actual machining time an estimator has to consider other time elements such as set-up time, handling time, tear down time, down time and allowances to the workers.

TERMS USED IN THE STUDY OF MACHINING TIME



TOTAL TOOL TRAVEL = LENGTH OF JOB + APPROACH + OVER TRAVEL

① LENGTH OF CUT

Length of cut is the distance travelled by the tool to machine the workpiece

Length of cut = Approach Length + Length of workpiece to be machined + Overtravel

APPROACH LENGTH

It is the distance a tool travels from the time it touches the workpiece until it is cutting to full depth.

OVER TRAVEL

It is the distance over which the tool idles before it enters and after it leaves the cut.

② FEED

Feed is the distance through which the tool advances into the workpiece during one revolution of the workpiece or the cutter.

UNIT: It is expressed in millimeters per revolution (mm/rev) or millimeters per stroke (mm/str)

③ 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.

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

(4) CUTTING SPEED

The cutting speed can be defined as the relative speed between the tool and the job.

UNIT : It is expressed in metres per minute (mpm)

FORMULA USED:

$$\text{Cutting speed} = S = \frac{\pi D N}{1000} \text{ m/min}$$

$$N = \frac{1000 \times S}{\pi D} \text{ rpm}$$

The cutting speed depends on the cutting tool material the work piece material and the operation.

CALCULATION OF MACHINING TIME FOR DIFFERENT LATHE OPERATIONS

TURNING OPERATIONS

Turning is the process of removing the excess material from the workpiece by means of a single pointed cutting tool.

$$T = \frac{L}{f \times N}$$

T = Time required for turning in minutes

f = Feed per revolution in mm

L = Length of the job to be turned in mm

N = Revolutions of the job per minute in rpm

$$= \frac{1000 \times S}{\pi \times D}$$

where S = Cutting speed in m/min

D = Diameter of the job to be turned in mm

Considering number of cuts

$$T = \frac{L}{f \times N} \times \text{Number of cuts required}$$

$$\text{Number of cuts} = \frac{\text{Depth of material to be removed}}{\text{Depth of cut}}$$

$$= \frac{D-d}{2 \times \text{Depth of cut}}$$

D = Diameter of the job before turning

d = Diameter of the job after turning

(1) A 80 mm diameter shaft is to be reduced to 60 mm diameter. If the depth of cut is 2.5 mm per pass, calculate the minimum number of passes required

GIVEN DATA:

$D = 80$ mm

$d = 60$ mm

Depth of cut $= 2.5$ mm

TOFIND:

Minimum number of passed required

SOLUTION:

$$\text{No. of passes} = \frac{\text{Depth of material to be removed}}{\text{Depth of cut}}$$

$$= \frac{D-d}{2 \times \text{Depth of cut}}$$

$$= \frac{80-60}{2 \times 2.5}$$

$= 4$ passes.

(2) Estimate the machining time to turn a 3 cm diameter mild steel bar 10 cm long, down to 2.5cm diameter in a single cut, using high speed steel tool. Assume the cutting speed of the tool to be 30 m/min and a feed of 0.4mm per revolution.

GIVEN DATA:

$D = 3 cm = 30 mm$

$L = 10 cm = 100 mm$

$d = 2.5 cm = 25 mm$

Single cut

$S = 30 m/min$

$f = 0.4 mm/rev$

TOFIND:

Machining Time to turn

SOLUTION:

$$T = \frac{L}{f \times N}$$

$$N = \frac{1000 \times S}{\pi \times D}$$

$$= \frac{1000 \times 30}{\pi \times 30}$$

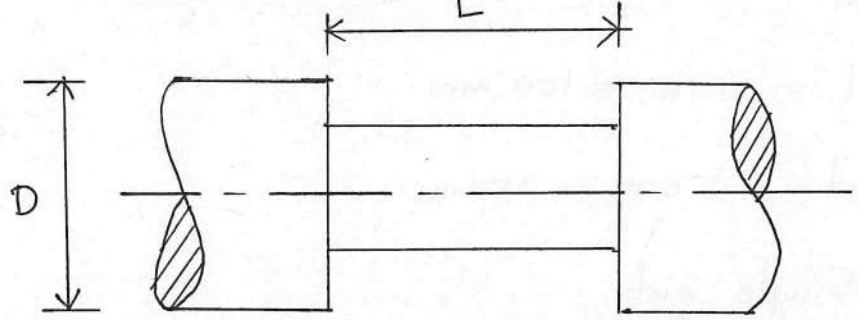
$$N = 318.31 \text{ rpm}$$

$$T = \frac{L}{f \times N}$$

$$= \frac{100}{0.4 \times 318.31}$$

$$T = 0.785 \text{ min}$$

EXTERNAL RELIEF TURNING



EXTERNAL RELIEF

An external relief operation is the removal of material from a previously turned surface along the same axis and within the limits of turned area.

$$T = \frac{L}{f \times N} \times \text{Number of cuts.}$$

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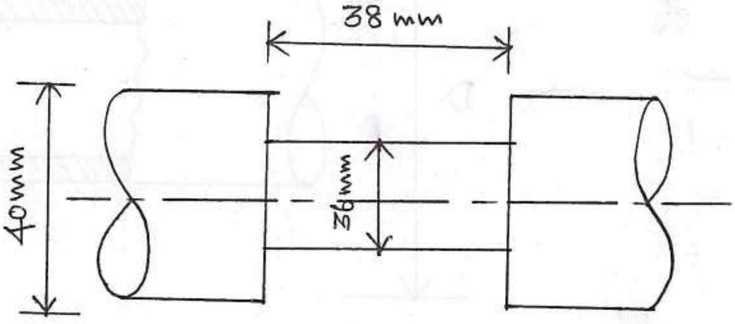
1. Find the time to turn the external relief shown in figure. The material is mild steel, cutting speed 60 m/min., and the feed is 0.2 mm/rev



GIVEN DATA:

$S = 60$ m/min

$f = 0.2$ mm/rev

TOFIND

Time to turn the external relief

SOLUTION

$$N = \frac{1000 \times S}{\pi \times D}$$

$$= \frac{1000 \times 60}{\pi \times 40}$$

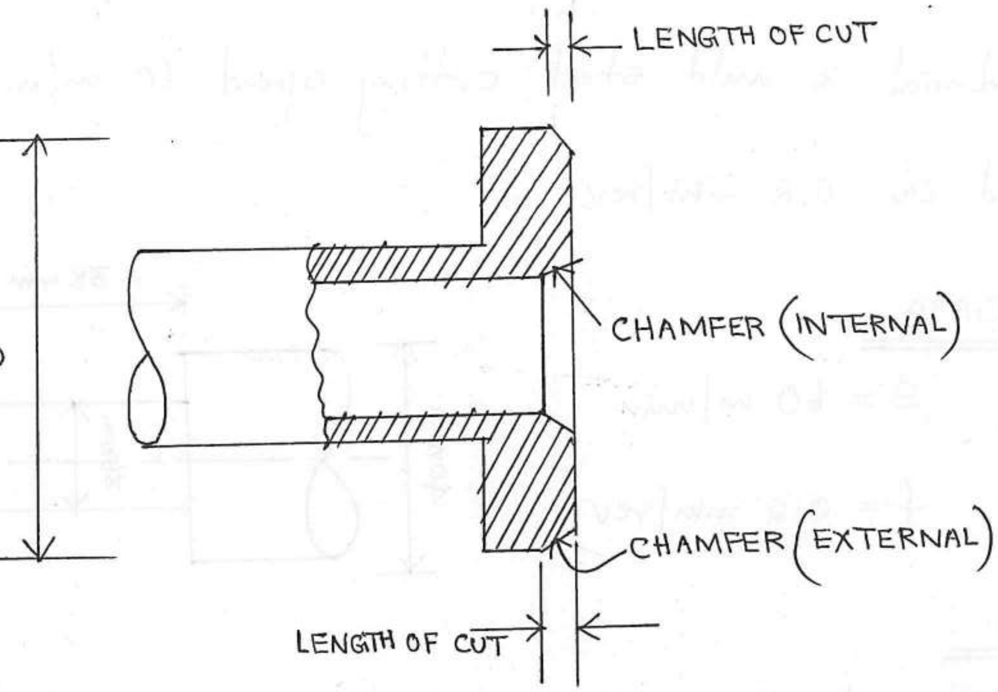
$$N = 477.46 \text{ rpm}$$

$$T = \frac{L}{f \times N}$$

$$= \frac{38}{0.2 \times 477.46}$$

$$T = 0.398 \text{ min}$$

CHAMFERING



CHAMFER (EXTERNAL AND INTERNAL)

Chamfering is the operation of removing material from the edges of external or internal diameters.

$$T = \frac{L}{f \times N}$$

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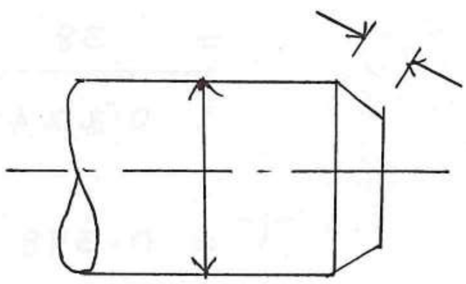
① A 25cm diameter bar is revolving at 65 rpm. How much time it will take to machine a 45° by 3.125 mm chamfer as shown in figure. and feed is 0.3 mm

GIVEN DATA:



$D = 250 \text{ mm}$

$N = 65 \text{ rpm}$

$L = 3.125 \text{ mm}$

$f = 0.3 \text{ mm}$

TO FIND:

T

SOLUTION:

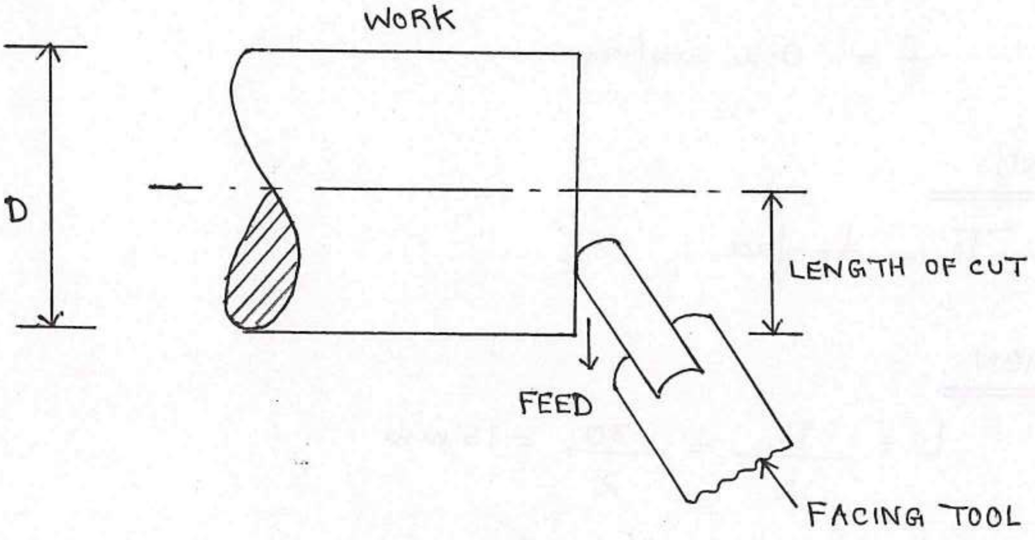
$$T = \frac{L}{f \times N}$$

$$= \frac{3.125}{0.3 \times 65}$$

$$T = 0.16 \text{ min}$$

FACING

Facing is the process of removing material from the ends of the job by moving the tool perpendicular to the axis of the job.



FACING

$$\text{Time for facing} = \frac{L}{f \times N}$$

L = Length of job or length of cut

$= \frac{1}{2} \times$ Diameter of job, for solid jobs

$= \frac{1}{2}(D-d)$, for hollow jobs

---

① Estimate the machining time to face both ends of a workpiece of 30 mm steel rod in one cut, if the cutting speed is 30 m/min and cross feed as 0.2 mm/rev.

GIVEN DATA:

D = 30 mm

S = 30 m/min

f = 0.2 mm/rev

TO FIND:

Time to face

SOLUTION

$$L = \frac{D}{2} = \frac{30}{2} = 15 \text{ mm}$$

$$N = \frac{1000\,S}{\pi D}$$

$$= \frac{1000 \times 30}{\pi \times 30}$$

N = 318.31 rpm

$$T = \frac{L}{f \times N}$$

$$= \frac{15}{0.2 \times 318.31}$$

$$= 0.2356 \text{ min}$$

Time taken to face both ends $= 0.2356 \times 2$

$= 0.471$ min

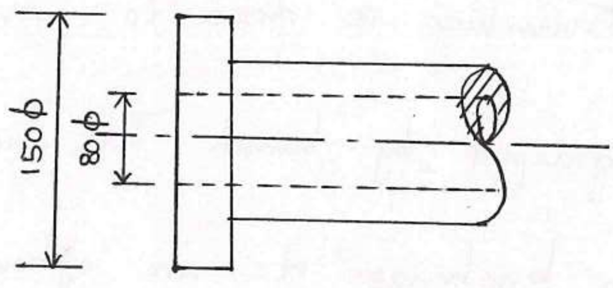
---

(2) Calculate the machining time to face on a cast iron flange as shown in figure. Assume speed of rotation of the job as 80 rpm and cross feed as 0.6 mm/rev

GIVEN DATA:

$N = 80$ rpm

$f = 0.6$ mm/rev



ALL DIMENSIONS ARE IN mm

TOFIND:

Time to face

SOLUTION:

$$L = \frac{1}{2}(D-d)$$

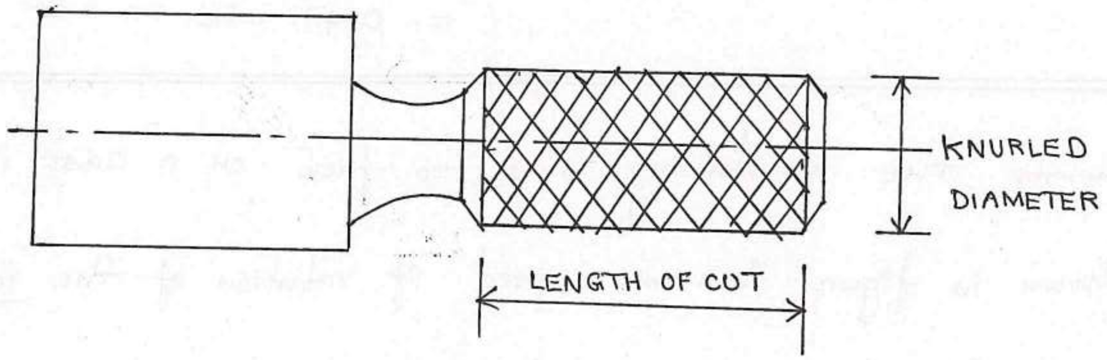
$$= \frac{1}{2}(150-80) = 35 \text{ mm}$$

$$T = \frac{L}{f \times N} = \frac{35}{0.6 \times 80}$$

$$T = 0.729 \text{ min}$$

KNURLING

Knurling is the operation of upsetting material so as to produce diamond-shaped or straight-lined patterns on the surface of the material



KNURLING

Knurling is done to provide gripping when the job is grasped by hand. The handles of gauges, hand screws, slip bushings etc are often knurled.

The knurling is obtained with the help of tools called 'knurls' and the operation may be performed either from cross slide or from turret of a lathe.

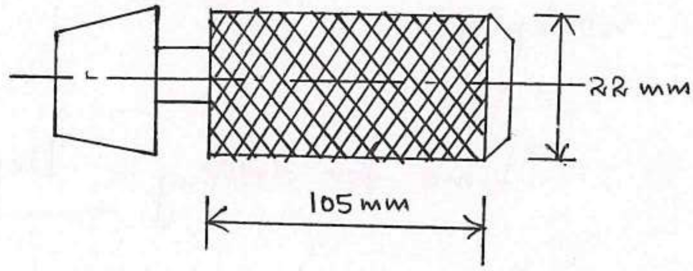
$$T = \frac{\text{Length of cut}}{(\text{feed})\ (\text{rpm})} = \frac{L}{f \times N}$$

(1) A taper gauge as shown in figure is to be knurled by a high speed knurling tool. Assuming cutting speed of 25 m/min and a feed of 0.3 mm/rev., find the time required for knurling

GIVEN DATA:

$S = 25$ m/min

$f = 0.3$ mm/rev



TO FIND:

Time for knurling

SOLUTION:

$$\text{Time } T = \frac{L}{f \times N}$$

$$N = \frac{1000 \times S}{\pi \times D} = \frac{1000 \times 25}{\pi \times 22} = 361.71 \text{ rpm}$$

$L = 105$ mm

$$T = \frac{L}{f \times N}$$

$$= \frac{105}{0.3 \times 361.71}$$

$$= 0.9676 \text{ min}$$

$$T = 0.9676 \times 60 = 58 \text{ sec.}$$

DRILLING

Drilling is the process of producing holes in the material.

The drilling operation is done on the lathe by holding the drill in tail stock and forcing it into the rotating workpiece.

$$\text{Time for drilling} = \frac{\text{Depth of hole to be produced}}{(\text{Feed}/\text{rev}) \times (\text{rpm})}$$

$$= \frac{L}{f \times N}$$

---

(1) A 100 mm thick laminated plate used in pressure vessels consists of 80 mm thick steel plate cladded with titanium plate of thickness 20 mm. A 10 mm diameter hole is to be drilled through this composite plate. Estimate the time taken for drilling this hole if, cutting speed of steel and titanium are 25 mm/min and 10 mm/min respectively. Also the feed of drill for steel and titanium are 0.25 mm/rev and 0.20 mm/rev respectively.

GIVEN DATA

$L = 100\ mm$

$L_1 = 80\ mm$

$L_2 = 20\ mm$

$D = 10\ mm$

$S_{steel} = 25\ m/min$

$S_{titanium} = 10\ m/min$

$f_{steel} = 0.25\ mm/rev$

$f_{titanium} = 0.2\ mm/rev$

TOFIND:

Total time taken for drilling

SOLUTION:

$$N_{steel} = \frac{1000 \times S_{steel}}{\pi \times D}$$

$$= \frac{1000 \times 25}{\pi \times 10}$$

$$N_{steel} = 795.77\ rpm$$

$$N_{titanium} = \frac{1000 \times S_{titanium}}{\pi \times D}$$

$$= \frac{1000 \times 10}{\pi \times 10}$$

$$N_{titanium} = 318.31\ rpm$$

∴ Drilling operation should be carried out at 318.31 rpm

$$T_1 = \frac{L_1}{f_{steel} \times N}$$

$$= \frac{80}{0.25 \times 318.31}$$

$$T_1 = 1.005 \text{ min}$$

$$T_2 = \frac{L_2}{f_{titanium} \times N}$$

$$= \frac{20}{0.2 \times 318.31}$$

$$T_2 = 0.314 \text{ min}$$

$$\text{Total time} = T_1 + T_2 = 1.005 + 0.314 = 1.319 \text{ min}$$

$$= 79.14 \text{ sec}$$

BORING

Boring is the operation of enlarging or finishing an internal hole which has been previously drilled

$$\text{Time for boring} = \frac{\text{Length or depth to be bored}}{(\text{Feed}/\text{rev}) \times (\text{rpm})}$$

---

(1) A hollow spindle is bored to enlarge its hole diameter from 15 mm to 20 mm upto 80 mm depth in single cut. Estimate the boring time if cutting speed is 20 m/min., and feed is 0.25 mm/rev.

GIVEN DATA:

$L = 80$ mm

$S = 20$ m/min

$f = 0.25$ mm/rev ; $D = 15$ mm

TOFIND:

Boring Time

SOLUTION:

$$N = \frac{1000 \times S}{\pi \times D}$$

$$= \frac{1000 \times 20}{\pi \times 15}$$

$$N = 424.41 \text{ rpm}$$

$$T = \frac{L}{f \times N}$$

$$= \frac{80}{0.25 \times 424.41}$$

$$T = 0.754 \text{ min or } 45.24 \text{ Sec}$$

REAMING

Reaming is the process of removing a small amount of material from a previously drilled or bored hole for perfecting the hole.

Reaming is carried out by using a tool known as reamer.

$$T = \frac{\text{Length of cut}}{(\text{Feed / rev}) \times (\text{rpm})}$$

---

(1) Estimate the time for reaming a 18 mm diameter hole having 26mm depth to make it 18·3 mm diameter hole. Take the cutting speed as 15 m/min and feed 0·3 mm/rev.

GIVEN DATA:

$D = 18$ mm ; $L = 26$ mm ; $S = 15$ m/min

$f = 0{\cdot}3$ mm/rev.

TO FIND:

Time for reaming

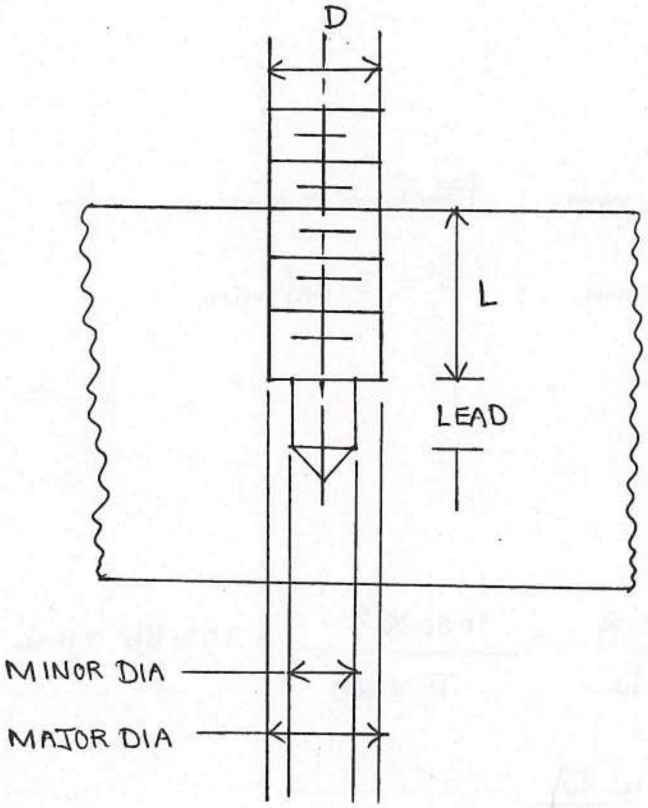
SOLUTION:

$$N = \frac{1000 \times S}{\pi \times D} = \frac{1000 \times 15}{\pi \times 18} = 265{\cdot}26 \text{ rpm}$$

$$T = \frac{L}{f \times N} = \frac{26}{0{\cdot}3 \times 265{\cdot}26} = 0{\cdot}327 \text{ min or } 19{\cdot}6 \text{ sec}$$

TAPPING:

Tapping is the operation of cutting internal threads with the help of a tool called tap



$$\text{Time taken for tapping} = \frac{\text{Length travelled by tap}}{(\text{Feed/rev}) \times (\text{rpm})}$$

$$= \frac{\left(L + \frac{D}{2}\right)}{\text{Pitch} \times \text{rpm}}$$

Pitch = Feed / rev

$$\text{Actual Tapped length} = L + \frac{D}{2}$$

① Estimate the time required for tapping a hole with 25 mm tap (3mm pitch tap) to a length of 50 mm. For return stroke the speed is 1½ times the cutting speed. Take the cutting speed as 8 m/min.

GIVEN DATA:

$$D = 25 \text{ mm} \; ; \; \text{Pitch} = 3 \text{ mm}$$

$$L = 50 \text{ mm} \; ; \; S = 8 \text{ m/min}$$

TO FIND:

T

SOLUTION:

$$N = \frac{1000\,S}{\pi D} = \frac{1000 \times 8}{\pi \times 25} = 101.86 \text{ rpm}$$

$$T_1 = \frac{L + \frac{D}{2}}{\text{Pitch} \times \text{rpm}}$$

$$= \frac{50 + \left(\frac{25}{2}\right)}{3 \times 101.86} = 0.2045 \text{ min}$$

Given that Return speed = 1½ × Cutting speed

$$\text{Return Time } T_2 = \frac{2}{3} \times \text{Tapping Time}$$

$$= \frac{2}{3} \times 0.2045 = 0.1363 \text{ min}$$

$$\text{Total time for tapping} = T_1 + T_2$$

$$= 0.2045 + 0.1363$$

$$= 0.3408 \text{ min}$$

$$= 20.45 \text{ sec}$$

THREADING OR SCREW CUTTING

Threading is the process of removing material to produce helix on external or internal circular surface for fastening process

$$\text{Time for threading} = \frac{\text{Length of cut}}{(\text{Pitch or lead}) \times (\text{rpm})} \times \{\text{No. of cuts}\}$$

$$\text{No. of cuts} = \frac{25}{\text{Threads per cm}}, \text{ for external threads}$$

$$= \frac{32}{\text{Threads per cm}} \text{ for internal threads}$$

---

(1) Estimate the time required for cutting 3 mm pitch threads on a mild steel bar of 2.8 cm dia and 8 cm long. Assume the cutting speed for threading as 15 m/min

$$N = \frac{1000\,S}{\pi \times D}$$

$$= \frac{1000 \times 15}{\pi \times 28}$$

$$N = 170.52 \text{ rpm}$$

$$\text{Threads per cm} = \frac{1}{\text{Pitch}}$$

$$= \frac{1}{0.3}$$

$$= 3.333$$

$$\text{No. of cuts} = \frac{25}{\text{Threads per cm}}, \text{ for external threads}$$

$$= \frac{25}{3.333} = 7.5 \text{ say } 8$$

$$T = \frac{L}{\text{Pitch} \times N}$$

$$= \frac{80}{3 \times 170.52}$$

$$= 0.156 \text{ min}$$

Time for 8 cuts = 0.156 × 8 = 1.25 min or 75 sec

ESTIMATION OF MACHINING TIME FOR SHAPING, PLANNING AND SLOTTING OPERATIONS

① Effective cutting speed (c)

$$C = \frac{L}{1000} \times N \text{ m/min}$$

L = Length of forward stroke in mm (including clearance on each ends)

N = Number of forward strokes/min

(2) Cutting Speed (S)

If $K = \frac{\text{Time for return stroke}}{\text{Time for forward stroke}}$

Then cutting speed is given by

$$S = \frac{L(1+k)}{1000} \times N \quad m/min$$

(3) Total time for one cut (T)

Time taken by cutting stroke $= \frac{L}{S \times 1000}$

Time taken by return stroke $= K \times$ Cutting stroke time

$$= \frac{L \times K}{S \times 1000}$$

$$T = \frac{L}{S \times 1000} + \frac{L \times k}{S \times 1000}$$

$$= \frac{L(1+k)}{S \times 1000}$$

Now if W = Width of the job in mm

f = Feed per stroke

Then, number of double strokes required to complete one cut on full width $= \frac{w}{f}$

Total time for completing one cut $= \frac{L(1+k)}{S \times 1000} \times \frac{w}{f}$

(4) Total time required

If p = Number of cuts (or passes) required, then

$$T = \frac{L(1+k)}{S \times 1000} \times \frac{w}{f} \times p$$

---

(1) Find the time required on the shaper to complete one cut on a plate 600 x 900 mm if the cutting speed is 6 m/min. The return time to cutting time ratio is 1:4 and the feed is 2 mm/stroke. The clearance at each end along the length is 75 mm

GIVEN DATA:

Plate size = 600 × 900 mm

$S = 6$ m/min

$$k = \frac{\text{Return time}}{\text{Cutting time}} = \frac{1}{4} = 0.25$$

$f = 2$ mm/stroke

clearance at each end $= 75$ mm

TOFIND:

T

SOLUTION

Length of stroke = Length of plate + Clearance on both sides

$= 900 + 2 \times 75 = 1050$ mm

Time to complete one cut on full width

$$T = \frac{L(1+k)}{S \times 1000} \times \frac{w}{f}$$

$$= \frac{1050(1+0.25)}{6 \times 1000} \times \frac{600}{2}$$

$$T = 65.625 \text{ min}$$

---

(2) Estimate the time required for planing a surface of 900 X 300 mm size. The cutting speed is 12 m/min and feed is 1.2 mm/stroke. Assume suitable tool clearances

GIVEN DATA

Surface size = 900 X 300 mm

$S = 12$ m/min

$f = 1.2$ mm/stroke

TO FIND:

T

SOLUTION:

Length L = Length + Approach + Over-run

$= 900 + 25 + 25$

$= 950$ mm

Crossfeed W = Width + Approach + Over-run

$= 300 + 5 + 5$

$= 310$ mm

Assume $k = \frac{3}{5} = 0.6$

$$T = \frac{L(1+k)}{(1000 \times S)} \times \frac{W}{f}$$

$$= \frac{950(1+0.6)}{(1000 \times 12)} \times \frac{310}{1.2}$$

$$T = 32.72 \text{ min}$$

ESTIMATION OF TIME FOR MILLING OPERATIONS

Milling is the operation of removing material from a surface by using a rotary multipoint tool called cutter

$$T = \frac{\text{Length of cut}}{(\text{Feed / rev}) \times (\text{rpm})}$$

$$= \frac{L}{f \times N}$$

$$N = \frac{1000 \times S}{\pi \times D}$$

S = Cutting speed in m/min

D = Cutter diameter in mm

Feed per revolution = Feed per tooth x No. of cutter teeth

$$\text{Time taken per cut} = \frac{\text{Length of cut (Total table travel)}}{(\text{Feed / rev}) \times (\text{rpm of cutter})}$$

Total table travel = Length of job + Added table travel

Added table travel = Cutter approach + Over travel

Total table travel = Length of job + Cutter approach + Over-travel

$$\text{Time taken per cut} = \frac{\text{Length of job + Added table travel}}{(\text{Feed / rev}) \times (\text{rpm})}$$

Added table travel $= \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right]$

D = Cutter diameter

W = width of workpiece

CASE I

If cutter diameter is same as width of workpiece

$D = W$

Approach $= \frac{D}{2}$

CASE II

If cutter diameter is less than width of workpiece

$D < W$

Approach $= 0.5\,D$

CASE III

If cutter diameter is greater than width of work piece $D > W$

Approach $= \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right]$

---

(1) A face milling cutter of 150 mm diameter is used to give a cut on a block 500 mm × 250 mm. The cutting speed is 50 m/min and feed 0.2 mm/revolution. Calculate the time required to complete one cut.

GIVEN DATA:

$D = 150$ mm

Block size $= 500$ mm $\times$ 250 mm

$S = 50$ m/min

$f = 0.2$ mm/rev

TO FIND:

T

SOLUTION:

$$N = \frac{1000\,S}{\pi D}$$

$$= \frac{1000 \times 50}{\pi \times 150}$$

$N = 106.1$ rpm

$L = 500$ mm

$W = 250$ mm

The cutter diameter (D) is less than the width of the job (w) $D < W$

Approach $= 0.5\,D$

$= 0.5 \times 150$

Approach $= 75$ mm

Over travel $= 7$ mm

$\therefore$ Added table travel = Approach + Over-travel

$= 75 + 7$

$= 82$ mm

$$\text{Milling time / cut} = \frac{\text{Length of the job + Added table travel}}{(\text{Feed / rev}) \times (\text{rpm})}$$

$$= \frac{500 + 82}{0.2 \times 106.1}$$

$$T = 27.43 \text{ min}$$

ESTIMATION OF TIME FOR GRINDING OPERATIONS

Grinding is the process of metal removal by abrasion. The grinding machine employs a multipoint cutting tool called grinding wheel. Generally grinding is a finishing operation which removes comparatively very small amount of material.

$$\text{Grinding Time / cut} = \frac{\text{Length of cut}}{\text{Feed / rev} \times \text{rpm}}$$

$$L = \underset{(L_0)}{\text{Length of workpiece}} - \underset{\text{wheel }(w)}{\text{Width of grinding}} + \underset{\text{length}}{\text{Approach}}$$

$$L = L_0 - w + 5$$

where Approach length = 5 mm

$$\text{Feed / rev} = \frac{w}{2} \text{ for rough grinding}$$

$$= \frac{w}{4} \text{ for finish grinding}$$

w = width of the grinding wheel

$$\text{Grinding time / cut} = \frac{L_0 - w + 5}{\left(\frac{w}{2} \text{ or } \frac{w}{4}\right) \times N}$$

$$\text{Total grinding time} = \frac{L_0 - w + 5}{\left(\frac{w}{2} \text{ or } \frac{w}{4}\right) \times N} \times \text{No. of cuts required}$$

$$N = \frac{1000\,S}{\pi D}$$

S = Cutting speed of work in m/min

D = Diameter of workpiece in mm

$$\text{Number of passes } (n) = \frac{\text{Depth of stock to be removed } (d)}{\text{Depth / cut } (t)}$$

$$n = \frac{d}{t}$$

---

① Find the time required for doing rough grinding of a 15 cm long steel shaft to reduce its dia. from 4 to 3.8 cm with the grinding wheel of 2 cm face width. Assume cutting speed as 15 m/min and depth of cut as 0.25 mm.

GIVEN DATA:

$L_o = 150$ mm

$D = 40$ mm

$W = 20$ mm

$S = 15$ m/min

$t = 0.25$ mm per pass

TO FIND:

Grinding Time (T)

SOLUTION:

For rough cut

$$\text{Feed} = \frac{W}{2} = \frac{20}{2} = 10 \text{ mm/rev}$$

$$N = \frac{1000 \times S}{\pi D}$$

$$= \frac{1000 \times 15}{\pi \times 40}$$

$$N = 119.37 \text{ rpm}$$

$$\text{No. of passes required} = \frac{\text{Depth of stock to be removed}}{\text{Depth / cut } (t)}$$

$$= \frac{(40-38)/2}{0.25}$$

$$= 4$$

$$\text{Length of cut } L = L_0 - w + 5$$

$$= 150 - 20 + 5$$

$$= 135 \text{ mm}$$

$$\text{Total grinding time} = \frac{\text{Length of cut}}{(\text{Feed / rev}) \times (\text{rpm})} \times \text{No. of passes}$$

$$= \frac{135}{10 \times 119.37} \times 4$$

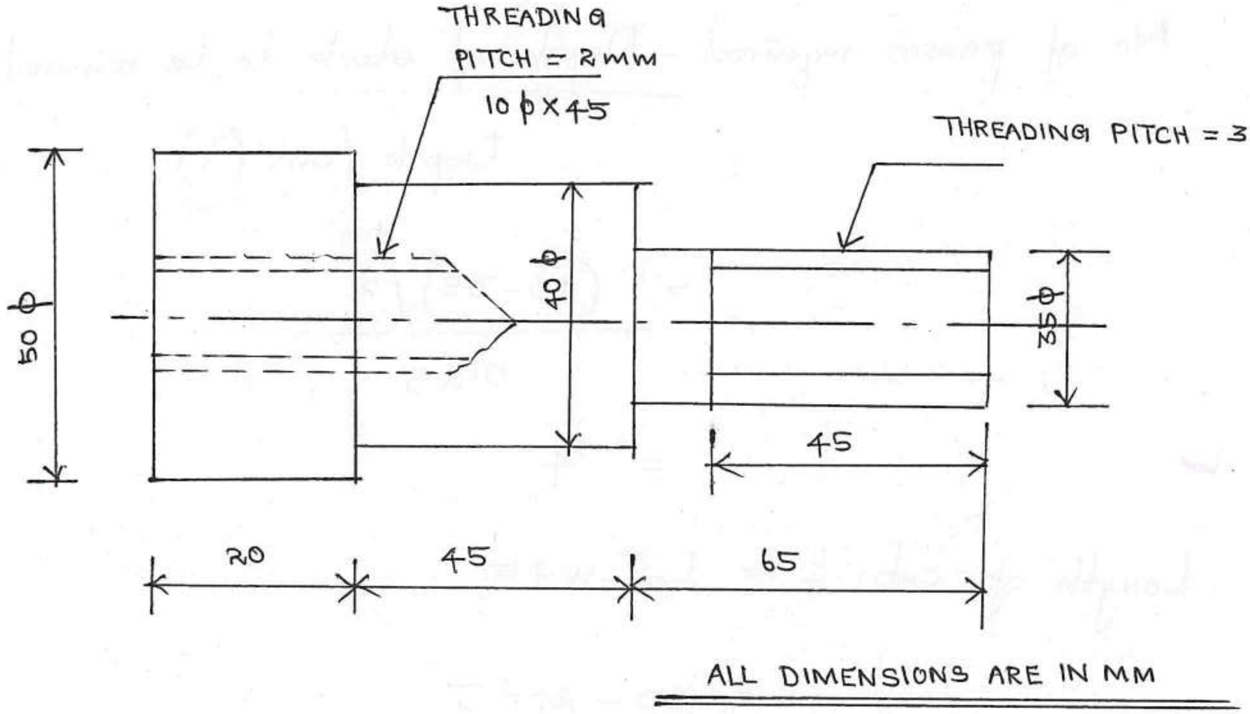
$$T = 0.452 \text{ min}$$

Find the machining time to complete the job as shown in figure. from the basic material of 60 mm diameter and 130 mm length.

Assume Cutting speed for turning = 28 m/min; Feed = 1 mm/rev;

Depth of cut = 3 mm; Cutting speed for thread cutting = 10 m/min;

Cutting speed for drilling = 30 m/min; Feed for drilling = 0.25 mm/rev



TO FIND:

Machining Time to complete the job

SOLUTION:

FIRST OPERATION: Turning from 60 mm ϕ to 35 mm ϕ

STEP I : Turning from 60 mm ϕ to 50 mm ϕ

S = 28 m/min ; L = 130 mm; f = 1 mm/rev

Depth of cut = 3 mm

$$N = \frac{1000\,S}{\pi D} = \frac{1000 \times 28}{\pi \times 60} = 148.54 \text{ rpm}$$

$$\text{Number of cuts} = \frac{D-d}{2 \times \text{Depth of cut}}$$

$$= \frac{60-50}{2 \times 3} = 1.66 \text{ say } 2$$

$$\text{Time for turning } T_1 = \frac{L}{f \times N} \times \text{Number of cuts}$$

$$= \frac{130}{1 \times 148.54} \times 2 = 1.75 \text{ min}$$

STEP II: Turning from 50 mm ϕ to 40 mm ϕ

$$L = 45 + 65 = 110 \text{ mm},\ D = 50 \text{ mm}$$

$$N = \frac{1000 \times 28}{\pi \times 50} = 178.25 \text{ rpm}$$

$$\text{Number of cuts} = \frac{50-40}{2 \times 3} = 1.66 \text{ say } 2$$

$$\text{Time for turning } T_2 = \frac{110}{1 \times 178.25} \times 2 = 1.234 \text{ min}$$

STEP III: Turning from 40 mm ϕ to 35 mm ϕ

$$L = 65 \text{ mm};\ D = 40 \text{ mm};\ \text{Number of cut} = 1$$

$$N = \frac{1000 \times 28}{\pi \times 40} = 222.82 \text{ rpm}$$

$$\text{Time for turning } T_3 = \frac{65}{1 \times 222.82} = 0.292 \text{ min}$$

SECOND OPERATION: Drilling a 10 mm ϕ hole for a 45 mm length

$S = 30$ m/min ; $f = 0.25$ mm/rev , $L = 45$ mm

$D = 10$ mm

$$N = \frac{1000 \times 30}{\pi \times 10} = 954.93 \text{ rpm}$$

$$\text{Time for drilling } T_4 = \frac{45}{0.25 \times 954.93} = 0.188 \text{ min}$$

THIRD OPERATION: Internal threading

$L = 45$ mm ; $D = 10$ mm ; $S = 10$ m/min

$f = \text{Pitch} = 2$ mm

$$N = \frac{1000 \times 10}{\pi \times 10} = 318.31 \text{ rpm}$$

$$\text{Threads per cm} = \frac{1}{\text{Pitch}} = \frac{1}{0.2} = 5$$

$$\text{Number of cuts} = \frac{32}{\text{Threads per cm}} \text{ for internal threading}$$

$$= \frac{32}{5} = 6.4 \text{ say } 7$$

$$\text{Time for threading } T_5 = \frac{45}{2 \times 318.31} \times 7$$

$$= 0.495 \text{ min}$$

FOURTH OPERATION: External threading

$L = 45$ mm ; $f =$ Pitch $= 3$ mm ; $D = 35$ mm

$S = 10$ m/min

$$N = \frac{1000 \times 10}{\pi \times 35} = 90.95 \text{ rpm}$$

$$\text{Threads per cm} = \frac{1}{\text{Pitch}} = \frac{1}{0.3} = 3.333$$

$$\text{Number of cuts} = \frac{25}{\text{Threads per cm}} \text{ for external threading}$$

$$= \frac{25}{3.333} = 7.5 \text{ say } 8$$

$$\text{Time for threading } T_6 = \frac{45}{3 \times 90.95} \times 8$$

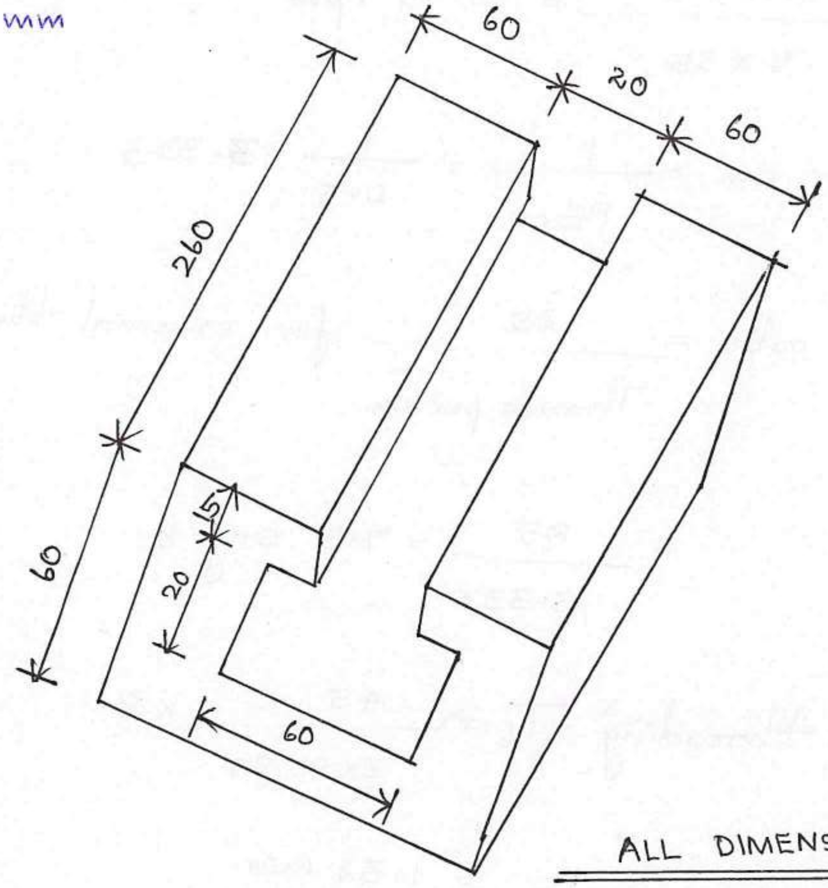
$$= 1.32 \text{ min}$$

$$\text{Total time for machining} = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

$$= 1.75 + 1.234 + 0.292 + 0.188 + 0.495 + 1.32$$

$$= 5.279 \text{ min}$$

A T-slot is to be cut in a C.I. slab as shown in figure. Estimate the machining time. Take cutting speed 25 m/min, feed is 0.25 mm/rev. Diameter of cutter for channel milling is 80 mm



ALL DIMENSIONS ARE IN mm

GIVEN DATA:

$S = 25$ m/min

$f = 0.25$ mm/rev

Diameter of cutter $D = 80$ mm

TOFIND:

Machining time to cut T-slot

SOLUTION:

STEP I: Cutting a channel of 20mm wide and 35 mm [= 15mm + 20mm] deep along the 260 mm length

For slot milling, Added table travel = $\sqrt{Dd - d^2}$

$D = 80$ mm (Dia. of cutter)

$d = 15 + 20 = 35$ mm (Depth of cut)

Added tool / table travel = $\sqrt{(80 \times 35) - (35)^2} = 39.68$ mm

Total tool / table travel = Length of job + Added tool / table travel

$= 260 + 39.68$

$= 299.68$ mm

rpm of cutter $N = \frac{1000 \times S}{\pi \times D} = \frac{1000 \times 25}{\pi \times 80}$

$= 100$ rpm

Time for cutting slot $T_1 = \frac{\text{Total table travel}}{\text{Feed / rev} \times \text{rpm}}$

$= \frac{299.68}{0.25 \times 100} = 11.987$ min

STEP II: Cutting T-slot of dimensions 60 X 20 mm with a T-slot cutter

Diameter of cutter = 60 mm

rpm of cutter $N = \frac{1000 \times S}{\pi \times D} = \frac{1000 \times 25}{\pi \times 60} = 132.63$ rpm

Since diameter of cutter = width of slot therefore

Over-travel of tool = 0.5 X Diameter of cutter

= 0.5 X 60

= 30 mm

Total tool / table travel = 260 + 30 = 290 mm

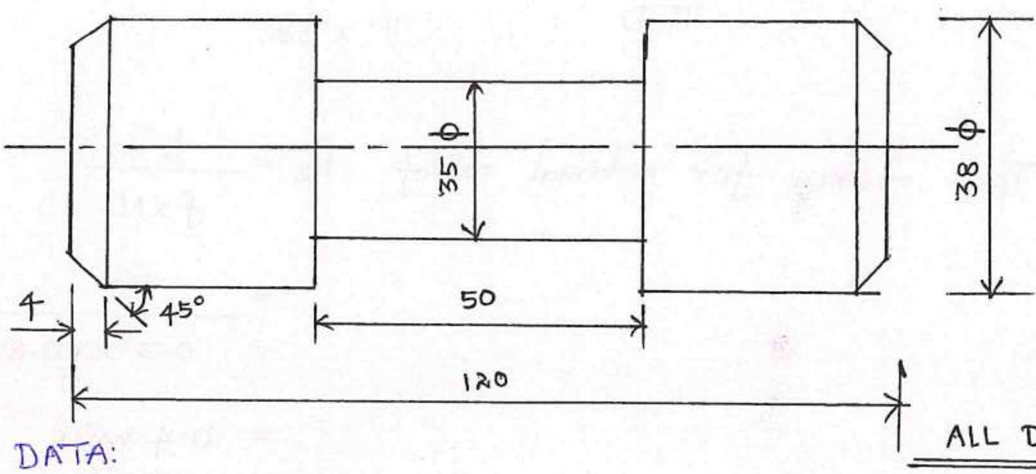
Time taken $T_2 = \frac{290}{0.25 \times 132.63} = 8.746$ min

∴ Total time to cut the T-slot $T = T_1 + T_2$

$= 11.987 + 8.746$

$= 20.733$ min

A mild steel bar 120mm long and 40mm in diameter is turned to 38mm diameter and was again turned to a diameter of 35mm over a length of 50mm as shown in figure. The bar was chamfered at both the ends to give a chamfer of $45^\circ \times 4$mm after facing. Calculate the machining time. Assume cutting speed of 50 m/min and feed 0.3 mm/rev. The depth of cut is not to exceed 3mm in any operation



ALL DIMENSIONS ARE IN mm

GIVEN DATA:

$S = 50$ m/min ; $f = 0.3$ mm/rev

Depth of cut = 3 mm

TO FIND:

Total machining time

SOLUTION:

FIRST OPERATION: Turning from 40mm ϕ to 38 mm ϕ and 120 mm long

$$N = \frac{1000\,S}{\pi D} = \frac{1000 \times 50}{\pi \times 40} = 397.89 \text{ rpm}$$

Time taken for turning $T_1 = \frac{L}{f \times N}$

$$= \frac{120}{0.3 \times 397.89} = 1.005 \text{ min}$$

SECOND OPERATION: External relief from 38mm ϕ to 35mm ϕ and 50mm long

$$N = \frac{1000\, S}{\pi D} = \frac{1000 \times 50}{\pi \times 38} = 418.83 \text{ rpm}$$

Time taken for external relief $T_2 = \frac{L}{f \times N}$

$$= \frac{50}{0.3 \times 418.83}$$

$$= 0.4 \text{ min}$$

THIRD OPERATION: Facing of both ends

$$L = \text{Length of cut} = \frac{38}{2} = 19 \text{ mm}$$

$$D = 38 \text{ mm} \quad S = 50 \text{ m/min}$$

$$N = \frac{1000\, S}{\pi D}$$

$$= \frac{1000 \times 50}{\pi \times 38}$$

$$N = 418.83 \text{ rpm}$$

Time for facing one end $= \dfrac{L}{f \times N}$

$= \dfrac{19}{0.3 \times 418.83}$

$= 0.1512$ min

Time for facing both ends $T_3 = 0.1512 \times 2 = 0.302$ min

FOURTH OPERATION: Chamfering $45^\circ \times 4$ mm on both sides

Length of cut $= 4$ mm

$D = 38$ mm

$S = 50$ m/min

$$N = \frac{1000\,S}{\pi D} = \frac{1000 \times 50}{\pi \times 38}$$

$= 418.83$ rpm

Time for chamfering on one side $= \dfrac{L}{f \times N}$

$= \dfrac{4}{0.3 \times 418.83}$

$= 0.032$ min

Time for chamfering on both sides $T_4 = 0.032 \times 2$

$= 0.064$ min

MACHINING TIME:

Total machining time $= T = T_1 + T_2 + T_3 + T_4$

$= 1.005 + 0.4 + 0.302 + 0.064$

$= 1.771$ min $= 106.26$ sec