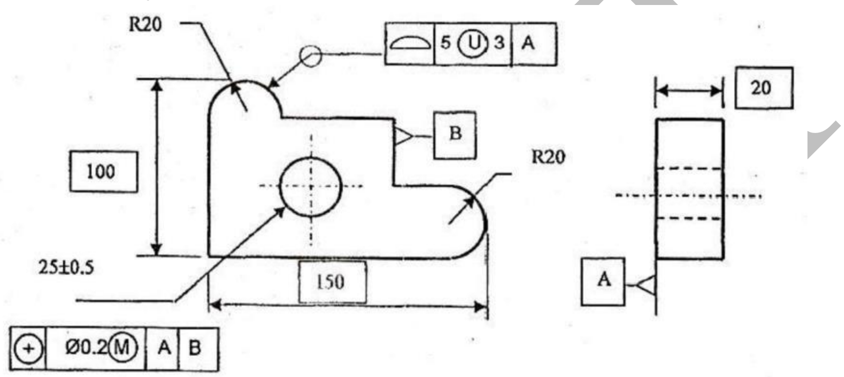
Unit -1 Introduction to Process Planning

Part A

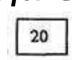
1. What are the details required for process planning? (AU A/M '18)

- Detailed engineering drawings
- Knowledge of materials for manufacture
- Knowledge of manufacturing processes
- Knowledge of jigs and fixtures
- Knowledge of the relative costs of materials, processes and tooling
- Manufacturing parameters (speed, feed etc) and costs
- Knowledge of inspection/QA procedures and specifications

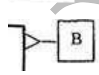
2. Study the drawing shown in fig and interpret any one geometric tolerance symbol (AU A/M '18)



Symbols used for Geometric tolerance



Boxed dimension (theoretically exact)



Datum indication


Circular or cylindrical tolerance

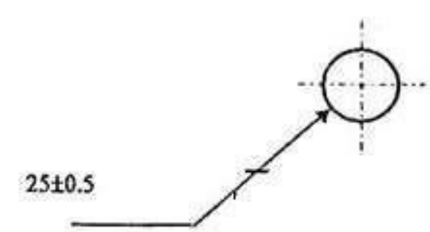

Location (position)

3. List the objectives of process planning (AU N/D '17)

- To manufacture a product that meets its design specification
- The manufacture of the product must be cost-effective, that is, maximize the added value, and meet the agreed deadlines, that is, be completed on time.

4. What is bilateral tolerance? Give examples (AU N/D '17)

Bilateral Tolerances are those when variation in actual dimension of the part can be tolerated to both sides of the given Nominal value .e.g. ϕ 25 (+/- 0.5).



Upper deviation : + 0.5; lower deviation: - 0.5

5. **Define process planning. (AU A/M'17) (AU N/D '16) (AU N/D '15)**

   Process planning is defined as the determination of the processes and the sequence of operations required making the product. It consists of devising, selecting and specifying processes, machine tools and other equipment to transform the raw material into finished product as per the specifications called for by the drawings.

6. **Write any four cutting tool materials (AU A/M'17)**

   Carbon steels, High speed steels, cobalt alloys and carbides.

7. **Write the approaches to process planning (AU N/D '13) (AU M/J '13) (AU M/J '12)**
   - Manual process planning
   - Computer Aided process planning
     - Varient approach
     - Generative approach

8. **List out factors considered on the selection of machinery (AU N/D '13)**
   - Volume of production (Quantity to be produced) *i.e.*, no. of components to be produced.
   - Quality of finished product, and
   - Advantages and disadvantages of the various types of equipment capable of doing the work.

9. **Write the Advantages of computer aided process planning (AU N/D '12)**
   - Efficient processing
   - Standardized procedures
   - Shorter development time
   - Lower hardware costs

10. **Define: Contingency allowance (AU N/D '14)**

    In a shop, there may be small delays due to

    1. Waiting for the inspector.
    2. Consulting the supervisor.
    3. Obtaining special tools etc.

    These delays are of very short duration. The allowance given to compensate these delays is called contingency allowance. Generally 5% of basic time is given as contingency allowance.

<u>Part – B</u>

1. **Why is process planning required to estimate cost? State its advantages. Discuss in detail the methods how computer can be used in cost estimations (13 marks) (AU N/D'18)**

Estimating is the calculation of the costs which are expected to be incurred in manufacturing a component in advance before the component is actually manufactured.

In this rapid developing and competitive age, it is necessary for a factory that the advance information about the cost of a job or a manufacturing order to be put through should be available before taking up the actual production. Estimating which is predetermination of cost is mainly concerned with the factory owner. It helps him to decide about the manufacturing, and selling prices.

Reasons for doing Estimates

Cost estimates are developed for a variety of different reasons. The most important reasons are shown below.

Should the product be produced? When a company designs a new product, a detailed estimate of cost is developed to assist management in making an intelligent decision about producing the product. This detailed estimate of cost includes an estimate of material cost, labour cost, purchased components and assembly cost.

In addition to product cost, many other elements must be estimated. These include all tooling costs. A cost estimate must be developed for jigs, fixtures, tools, dies and gauges. Also, the cost of any capital equipment must be entered into the estimate. These figures are usually supplied through quotation by vendors. An estimate of this nature will include a vast amount of details, because if management approves the project, the estimate now becomes the budget.

Computer Estimating

Use of group technology

GT can be used very efficiently in estimating cost. Assume a company manufactures shaft-type parts. Also arsum there is a computer data base named SHAFT that contains 10-digit code followed by a part number, that is, code part number, and so on. When an estimator must estimate the cost of a new shaft, the process starts by developing a code that describes the characteristics of the part. The first digit in the code might be assigned the part length, while the second digit is assigned the largest diameter and so on. Next, the code is keyed in and the computer finds all the parts that meet the numeric descriptions and points out the part numbers. The best fit is selected to be modified into a new part. All the details of each description are retrieved. These include diameter, length of cut, number of surfaces, and the like. The estimator can alter these features and make the old part into a new one.

Advantages and disadvantages

Shown below are some of the major advantages of computer cost estimating.

Accuracy versus consistency - Computer estimates are very consistent, provided they calculate the detail of an estimate. Because these estimates are consistent, they can be made to be accurate. Through the use of consistent efficiency factors or leaving curves, estimates can be adjusted up or down. This is one of the chief advantages of computer cost estimating.

Levels of details

Some computer estimating systems provide different levels of estimating cost. The level of detail selected by the user depends on the dollar risk. Many estimators produce an estimate in more detail because the computer can calculate speeds and feeds, for example, much faster than an estimator can a hand-held calculators.

Refinements

Some computer estimating systems provide many refinements that would be impossible for the estimator to do in any timely manner. One example is to adjust speeds and feeds for material hardness. Typically, the harder the material the more slowly a part will be turned or bored. Another refinement is the ability to calculate a feed state and adjust it based on the width of a form tool.

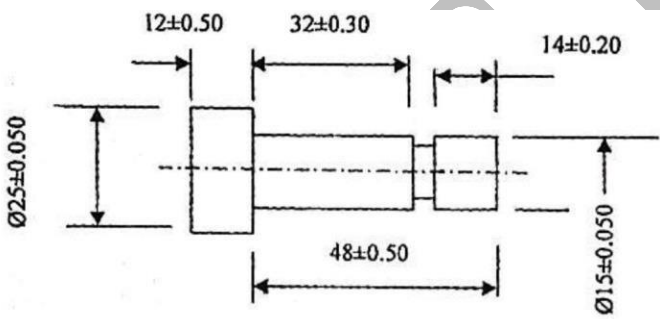
Source code

Some companies offer the source code uncompiled to their users. This is important because it affords the user the opportunity to customize the software. In addition, many companies have written their own software to do something that is not available on the market. If the source code is not compiled, the users can build upon a computer estimating system.

Disadvantages

The chief disadvantage of computer estimating is that no one estimating system can suit everyone's need. This is especially true if the source code is compiled and not customizable. Another problem with computer estimating is that the estimator will, in all probability, have to change some estimating methods. Computer software for estimating cost is seldom written around one method of estimating.

2. **Discuss the production equipment and tool selection for the component shown in fig undercut diameter is 12mm. (13 marks) (AU N/D '18)**



Solution

a. *Evaluation of process and machine selection*. As stated in the problem, the process identified is turning and the machine tool is a small bench lathe. This limits the tools to select from to those we have in machine shop
b. *Analysis of machining operations*. The operations identified are facing, roughing, finishing and parting off. From this, two specific tools can be identified:

    Turning/facing tool- facing, roughing and finishing;

    Parting off tool- parting off
c. *Analysis of workpiece characteristics.* The fact that the workpiece material is brass means that HSS tooling is more than sufficient to carry out all operations. This is due to brass being highly machinable material.

    However, in terms of workpiece and tool geometry, there are two issues to be considered. In terms of the facing and roughing out, a left-handed tool will not be able to completely finish the arc in the middle of the part. There are two options that can be considered. The first is to produce half the arc with the left-handed tool and change to a right-handed tool for the other half. However, it would be much simpler to use a contouring tool for the complete arc. Furthermore, a contouring tool will be required for the 'chamfered groove' to the left-hand end of the part.

    Therefore, it makes sense to use the contouring tool for both features, rake angles permitting, as this uses the least number of tools.
d. *Tooling analysis*. From the above stages, the following tooling list and operation description can be generated:

Facing: left-hand turning tool

Roughing: left-hand turning tool

Finishing: contouring tool

Parting off: parting-off tool

Face the end and rough out the excess material with the left-hand tuming tool. The majority of the finish turning can be carried out with the left-hand turning tool. However, the radius and the chamfered groove will be machined with the contour tool and finally the part will be cut from the billet by the parting off tool.

As the problem is simply to identify the tooting, the problem is basically solved. Therefore, there is no need to go to the stage of selecting a suitable tool holder. It can also be seen from the above example that even fairly simple geometries will require more than one cutting tool.

3. **Explain with neat sketch various methods of process planning(AU N/D '18) (AU N/D '16) (or) Describe various approaches to process planning (AU N/D '15) (or) Explain the use of computers in process planning and cost estimation and list out the advantages of CAPP. (AU N/D '14) (AU N/D '12) (or) How will you distinguish retrieval and generative computer aided planning systems? Which is more effective? State reasons. (AU M/J '16) (16 Marks)**

Approaches of process planning

- Manual Process Planning
- Computer Aided Process Planning

Manual process planning

This type of planning is known as non-variant process planning. It is the commonest type of planning used for production today.

Planning the operations to be used to produce a part requires knowledge of two groups of variables.

(a) The part requirements, and

(b) The available machines and processes and the capabilities of each process.

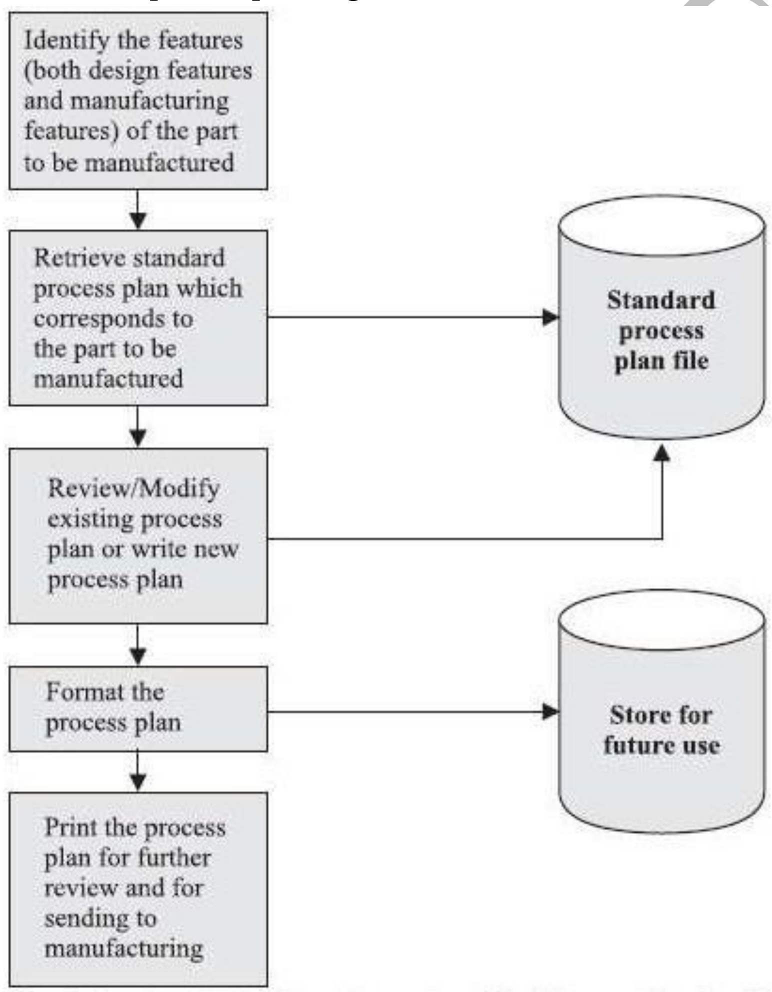
The manual approach to process planning begins when a detailed engineering drawing and data on batch size are issued to a production engineer. This information is used to determine the following:

- The manufacturing processes involved.
- The machine tools required to execute these processes.
- The tools required at each stage of processing.
- The fixtures required at each stage of processing.
- The number and depth of passes in a machining operation.
- The feeds and speeds appropriate to each operation.
- The type of finishing process necessary to achieve the specified tolerances and surface quality.

As a first step, the production engineer examines the part drawing to identify similarities with previously produced parts. If similarities are recognized, a process plan is manually retrieved for the similar item. The process plan is either used without modifications for identical parts or modified to meet the manufacturing requirements of the new part. Although old process plans are used as references for similar parts, there is still significant duplication of effort due to the lack of efficient information retrieval, comparison, and editing techniques. The manual method may also lead to inconsistency in the final plans because it is unlikely that two process planners will generate identical process plans.

It is difficult or impossible to achieve consistent, optimized process plans with the conventional manual method. As a consequence planning and manufacturing costs are increased because of the duplication of effort in the process planning function as well as specification of excessive tooling and material requirements. Production lead times also increase due to redundancies in the planning function.

Computer Aided process planning



Procedure for developing the Retrieval type Computer—Aided Process Planning (CAPP) system

Computer Aided Process Planning represents the link between design and manufacturing in a CAD/CAM system. Process planning is concerned with determining the sequence of processing and assembly steps that must be accomplished to make the product. The processing sequence is documented on a sheet called a route sheet. The route sheet typically lists the production operations, machine tools, work centres or work stations where each operation is performed, jigs, fixtures and tooling required and standard time for each task.

Computer Aided Process Planning (CAPP) Systems are designed with two approaches in mind. These approaches are called:

(a) Retrieval CAPP Systems, and (*b*) Generative CAPP Systems

Variant or Retrieval Method of Process Planning (Retrieval CAPP System)

In this method, the computer makes a search of its storage or a data base or a no. of standard or completed process plans that have been previously developed by the company's process planners.

The development of the data base of these process plans requires substantial knowledge of machining, time and efforts. Using the current design data supplied by the CAD system, (after a component has been designed and dimensioned), it searches for a process plan that was based on a part of similar design. (This search can make effective use of GT, Group Technology, design coding to simplify the search for similar part design).

The process plan **retrieved** is then modified or suitably **varied** (*i.e.*, altered) by the process planner, to suit the exact requirements of the current part design. The use of Computer and Group Technology (GT) to search for the most appropriate or similar part design, and to retrieve the process plan for that design, significantly reduces the work required of the process planners. This also saves considerable amount of time required to develop a process plan for a new part.

The task of process planner becomes one of modifying the existing plan to suit the particular dimensions of the current part. (*i.e.*, the selected process plan is provided to the user for modification and variation). Process planners are required to perform the entire process planning method only in the case of a completely new part design. This approach of process planning is also known as Retrieval CAPP system. This is based on the principles of Group Technology and parts classification and coding. One of the pre-requisites for implementation of this method is that the industries must develop and maintain a large computer data base of standard completed process plans. In addition, the part designs are to be developed using CAD systems.

Generative Method of Process Planning (Generative CAPP System)

The second method of computerized process planning is the generative method. In this method the computer uses the stored manufacturing and design data to generate a complete list of all possible process plans that could be used to manufacture the current part. It then exhaustively searches this list for the one which optimizes the cost function. This method always yields the optimum process plan for manufacturing a particular part.

However, it has a very high cost in terms of time and computer processing expenses. The computations required to provide even a single process plan for an arbitrary part design can be enormously complex. To repeat this for every feasible process plan or a part can become very costly. This approach of process planning is also known as **Generative CAPP System.**

Both the approaches viz. Variant (or retrieval) method of process planning and Generative method of process planning involves a systematic development of Code Numbers using Group Technology concepts and principles for the design and manufacture of the part.

Both of these methods of computerized process planning can be enhanced through the application of AI (Artificial Intelligence) in the form of expert systems.

Benefits of CAPP

The benefits derived from computer aided process planning are the following

1. Process rationalization and standardization: Automated process planning leads to more logical and consistent process plans than when process planning is done completely manually.

2. CAPP helps in arriving at standard and consistent process plans : Standard plans tend to result in lower manufacturing costs and higher product quality.

3. Increased productivity of process planners : The systematic approach and the availability of standard process plans in the data files permit more work to be accomplished by the process planners.

4. Reduced lead time for process planning : Process planners working with the CAPP system can provide route sheets in a shorter lead time compared to manual preparation.

5. Improved legibility and readability : Computer prepared route sheets are legible and easier to read than manually prepared route sheets.

6. Incorporation of other application programmes : The CAPP programme can be integrated with other application programmes, such as estimation of standard time, cost estimating and formulation of work standards.

4. **Write down the procedure to be followed during material selection. Discuss the factors that are taken into account in process selection and equipment selection. (AU N/D '16) (10 Marks) (or)**
   What are the factors influencing process selection and write down the process selection parameters (AU N/D '14) (16 marks)

Factors Influencing Process Selection

After a product design is made process selection is to be carried out. There are several factors which influence the process selection, These are :

- Shape requirements
- Size or dimensional requirements
- Tolerance requirements
- Surface finish requirements
- Annual volume requirements (*i.e.*, production quantity required per annum)
- Material characteristics.

Process selection requires a broad and extensive knowledge of various materials and the associated manufacturing processes. A good understanding of the capabilities and limitations of the various processes available is an asset to any process planner. Evaluation of alternative processes can also be carried out simultaneously and a logical decision taken with respect to proper selection of the process. It must be emphasized that the selection of a process is done and evaluated in the context of p**roduct design - material - manufacturing process** in an integrated manner.

Process Selection Parameters

There are several factors which govern the selection of a manufacturing process:

1. Shape requirements of the final product *i.e.,* Geometric Form :

Geometric parameters such as solid shape, hollow shape, flat shape, flanged shape, concave shape, convex shape, cylindrical shape, presence of any part feartures such as groove, threaded shape, hole, chamfer, etc. are considered in the selection of a manufacturing process. Each process has its own capabilities and limitations with respect to the production of the above shapes and part features.

2. Size or Dimensional requirements :

Some processes are capable of handling parts of small sizes and some processes can handle large sized parts economically and effectively.

3. Tolerance requirements :

Each manufacturing process has got its own capability with regard to tolerance or accuracy of parts that can be produced using that process *e.g.* grinding process always gives close tolerances when compared with turning process. Depending upon the tolerance specified on the part drawing, suitable machining process is to be selected.

4. Surface finish requirements:

Each manufacturing process has got its own capability with regard to the surface finish which it can provide on the part machined, *e.g.* reaming process can provide a better surface finish in a hole when compared with drilling process. Similarly cylindrical grinding give a better surface finish, than a plain turning process. Depending on the finish requirements specified on the component drawing, appropriate machining process need to be selected.

5. Production volume requirements:

The economics of any machining process depends on the production volume, *i.e.*, no. of components required on a weekly, monthly or annual basis as the case may be. Existing order quantity as well as any anticipated future orders and their quantity need to be considered in the process selection. Some of the processes and additional cost incurred in the specialized toolings, jigs and fixtures can be justified only when there is a large volume of production.

6. Material requirements:

The hardness and strength characteristics of the material influence the tooling required. To machine hard and tough materials, carbide and ceramic tools are required. If slender or thin materials are machined, proper work holding devices and specially designed jigs and fixtures are required is order to avoid distortion and bending of work pieces during machining. Thus material requirements of the part also influence the appropriate selection of machining process.

Material Selection

Material selection is done by the product designer considering the requirements of the parts designed and the hardness, strength properties and other mechanical characteristics of the material. Cost and availability of the material are also considered. Material should be strong enough and at the same time manufacturing or producibility of the part using the given material and the process are also equally important.

In the initial stages of design, the broad material groups such as ferrous or non-ferrous or other non-metallic materials can be considered. At a later stage specific material in the group can be identified.

In certain products or components specific properties of materials such as fatigue strength, thermal conductivity, electrical properties like conductivity, magnetic permeability and insulation resistance may have to be considered.

Material Selection parameters

(i) Functional requirements:

The primary function of the part for which the material is selected is the foremost consideration. A good knowledge of the product application is important. The properties of materials which have a direct bearing on the functional requirement of the part are : fatigue characteristics, strength, hardness, electrical and thermal properties.

(ii) Reliability:

Reliability of the materials refers to the consistency with which the material will meet all the products requirement throughout its service life. This is important for trouble-free maintenance of the product during its life time.

(iii) Service life durability :

The length of service (years or hours of operation of the product) over which material is able to perform its function satisfactorily.

(iv) Aesthetics and appearance :

Factors like colour, texture, lusture, smoothness and finish play an important role in the aesthetics or appearance of the final product.

(v) Environmental Factors :

Environmental factors such as temperature, humidity, corrosive atmosphere affects the product and its performance. Hence proper materials which can with stand such environmental effects should be selected and they should be given suitable protective coatings.

(vi) Compatibility with other materials during service :

When one type of material is used in combination with another type of material in a product or in an assembly the properties of both types of materials should be compatible and should suit each other. Otherwise deterioration in the performance of the product or assembly such as excessive wear & tear, and corrosion of parts in fitment are likely to take place.

(vii) Producibility or manufacturability: The extent to which the material can be processed effectively and easily using a particular machine tool or process should also be considered in the selection of the material. Machinability of materials for machined components is an important factor.

(viii) Cost: The cost of material is a significant factor in many situations. The availability of the material is equally important. Appropriate material for the product or component is to be selected taking into consideration all the above factors.

5. **Explain how to develop manufacturing logic and knowledge (8 marks) (AU N/D '15) (or) Write short notes on developing manufacturing logic and knowledge (AU M/J '16) (8 marks)**

Developing manufacturing logic and knowledge :

(i) Product : design, (*i.e.*, parts requirements) manufacturing process and materials characteristics all must be considered together in an integrated manner while developing a process plan.

(ii) Identify the datum surface on the component drawings which will form the basis for measurement and inspection of dimensions.

(iii) Adequate attention must be paid so that the component is properly located and clamped. The accuracy of the machined part and the time taken depend on these factors. This will also avoid any distortion that might occur on the machined component. Three point support (locating pins) are suitable for positioning large flat surfaces.

(iv) The no. of settings required to machine a part may be reduced to a minimum. Less no. of settings more is the accuracy of the part machined.

(v) Frequent tool changing can be reduced to a minimum.

(vi) Rough machining operations must be carried out first before finish machining operations.

(vii) Identify critical operations and provide for inspection immediately after critical operations.

(viii) Use appropriate cutting fluid depending on the severity of the operation, the work material and the tool material used.

(ix) Use of jigs and fixtures are justified when the production quantity is large.

6. **What are the factors to be considered in machine selection (8 marks) (AU M/J '13)**

Machine Selection

Product manufacturing requires tools and machines that can produce economically as well as accurately. Economy depends to a large extent on the proper selection of the machine or process for the job that will give a satisfactory finished product. The selection of the machine is influenced, in turn by the quantity of items to be produced. Usually there is one machine best suited for a certain output.

In small lot or jobbing type manufacture, general purpose machines such as the lathe, drill press, and milling machine may prove to be the best type since they are adoptable, have lower initial cost, require less maintenance, and possess the flexibility to meet changing conditions in the shop. However, a special purpose machine should be considered when large quantities of a standard product are to be produced. A machine built for one type of work or operation, such as the grinding of a piston or the machining of a cylinder head, will do the job well, quickly and at a low cost requiring only the service of a semi-skilled operator.

Many of the special-purpose machines or tools differ from the usual standard type in that they have built into them some of the skill of the operator. A simple bolt may be produced on either a lathe or an automatic screw machine. The lathe operator must not only know how to make the bolt but must also be sufficiently skilled to operate the lathe. On the automatic machine the sequence of operations and movements of tools are controlled by cams and stops, and each item produced is identical with the previous one. This "transfer of skill" into the machine makes possible the use of less skillfull operators, but it does requires greater skill in supervision and maintenance. Often it is not economical to make a machine completely automatic, as the cost may become prohibitive.

The selection of the best machine or process for a given product requires knowledge of all possible production methods. Factors that must be considered are:

- Volume of production (Quantity to be produced) *i.e.*, no. of components to be produced.
- Quality of finished product, and
- Advantages and disadvantages of the various types of equipment capable of doing the work.

Too much emphasis cannot be given to the fact that production can be by several methods, but usually there is one way that is most economical.

7. Explain the technological frame work of process planning by using a block diagram. (16 marks) (AU M/J '13)

Process planning

Process planning has been defined as the sub-system responsible for the conversion of design data to work instruction. Process planning can also be defined as the systematic determination of the methods by which a product is to be manufactured economically and competitively. It consists of devising, selecting and specifying processes, machine tools and other equipment to convert raw material into finished and assembled products.

Purpose of Process Planning

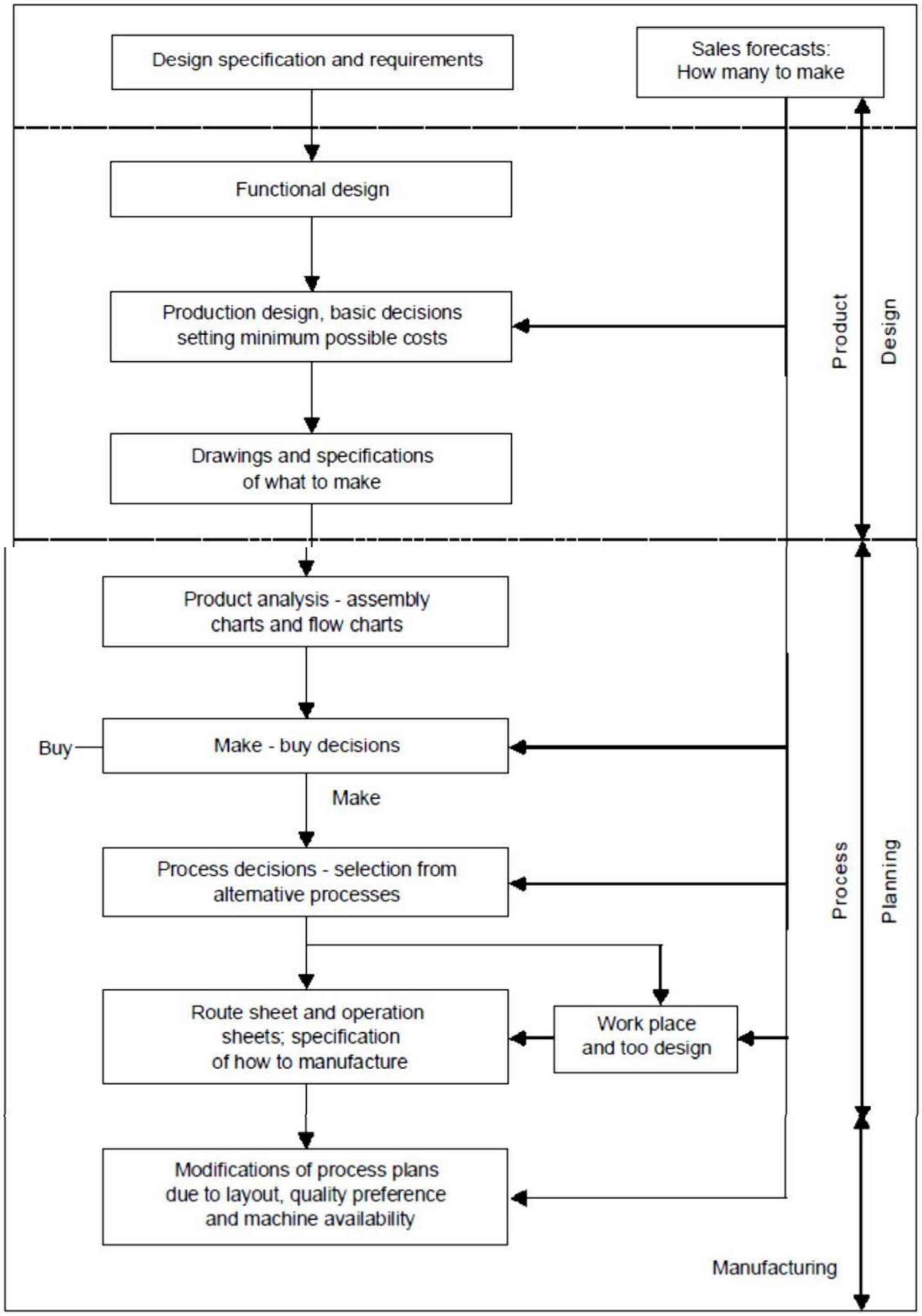
The purpose of process planning is to determine and describe the best process for each job so that,

1. Specific requirements are established for which machines, tools and others equipment can be designed or selected.

2. The efforts of all engaged in manufacturing the product are coordinated.

3. A guide is furnished to show the best way to use the existing or the providing facilities.

Process planning is an intermediate stage between designing the product and manufacturing it (fig).



Where the product design ends, the process planning begins. However, the basic process planning must begin during the product design stages where the selection of materials and initial forms, such as casting, forging and die casting take place. The accepted end point for production design is manifested by the drawing release, which summarizes the exact specifications of what is to be made.

Process planning takes over from this point and develops the broad plan of manufacture for the part of product. Process planning takes as its inputs the drawings or other specifications which indicate what is to be made and how many are to be made.

The drawings are then analysed to determine the overall scope of the project. If it is a complex assembled product, considerable effort may go into exploding the product into its components and subassemblies.

Preliminary decisions about subassembly groupings to determine which parts to make and which to buy, as well as to determine the general level of tooling expenditure, may be made at this point.

Then, for each part, a detailed routing is developed. Here technical knowledge of processes, machines, and their capabilities is required, but of almost equal importance is knowledge of production economics.

In brief, the engineering drawing of the component is interpreted in terms of the manufacturing process to be used. This step is referred to as process planning and it is concerned with the preparation of a route sheet.

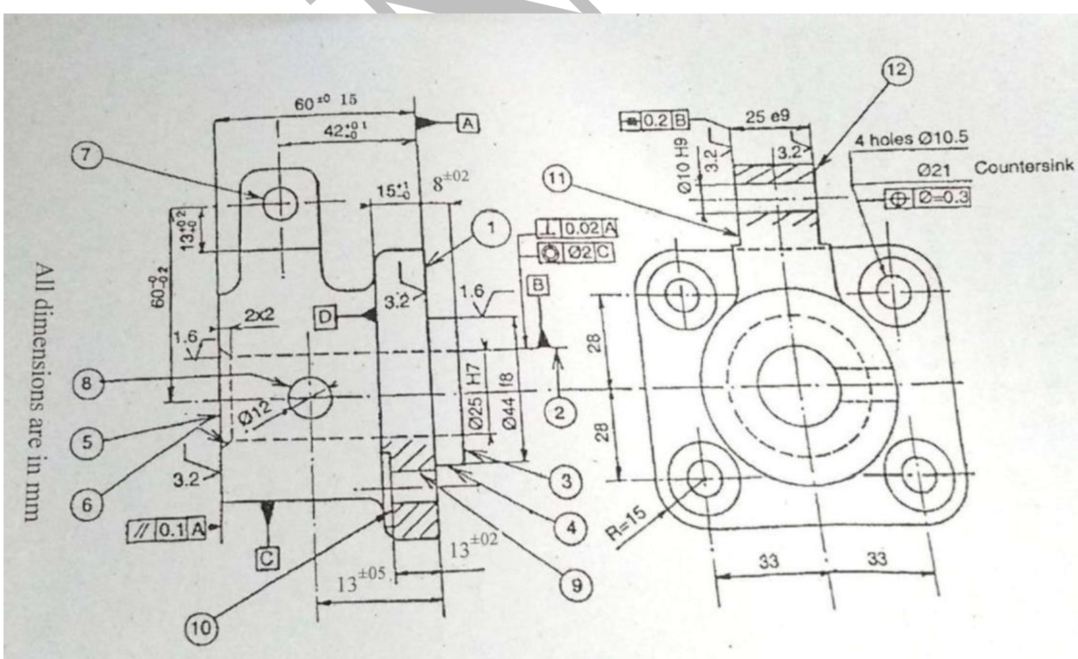
The route sheet is a listing of the sequence of operations which must be performed on the component. It is called a route sheet because it also lists the machines through which the part must be routed in order to accomplish the sequence of operations.

8. In the figure, interpret the meaning of any two

a. Dimensional tolerance symbols (4 marks)

b. Form tolerance feature control frames (8 marks)

c. Surface finish symbols (4 marks) **(AU A/M'17)**



a. <u>Dimensional tolerance symbols</u>

<u>Parallelism</u>

//	**0.1**	**A**

Position

⌖	Ó = 0.3

Perpendicularity

⊥	0.02	A

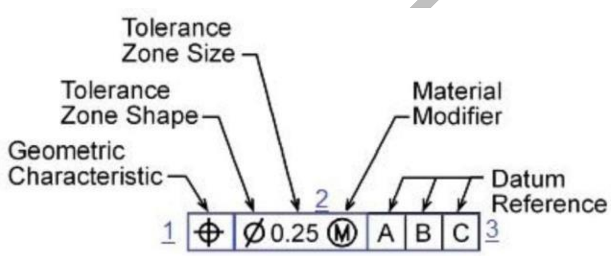
Symmetry

═	0.2	B

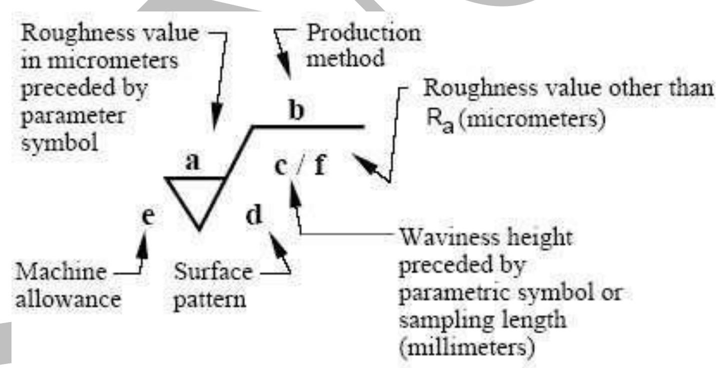
Concentricity

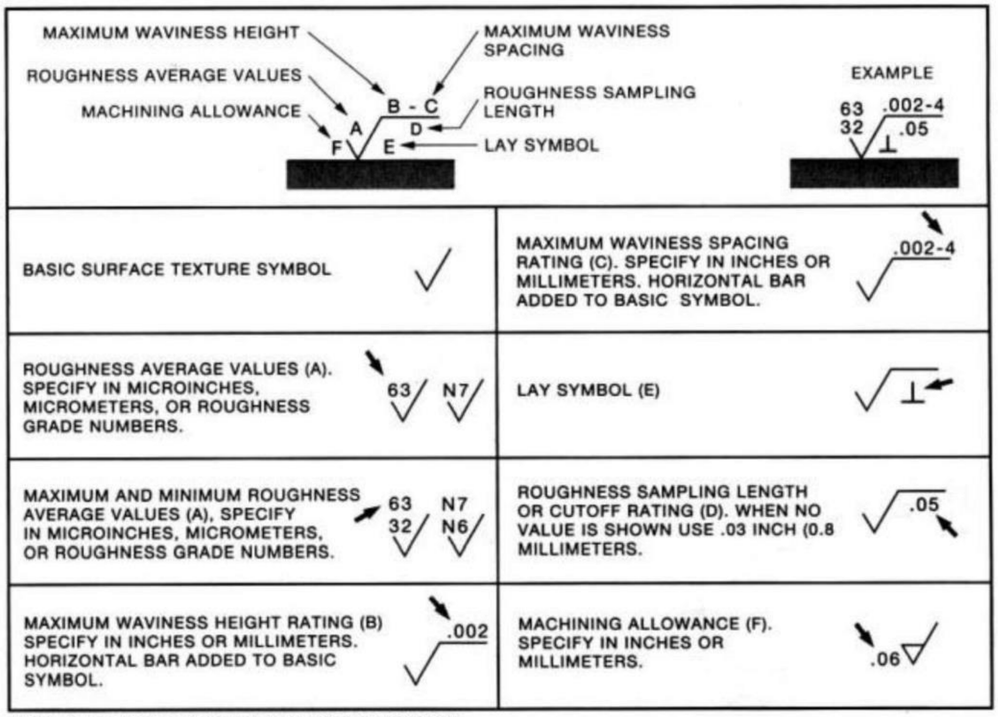
◎	Ó 2	C

b. Form tolerance feature control frame



b. Surface finish symbols





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Unit -2 Process Planning Activities

Part A

11. **What is activity based costing? (AU A/M '18)**

Activity-based costing (ABC) is a costing methodology that identifies activities in an organization and assigns the cost of each activity with resources to all products and services according to the actual consumption by each. This model assigns more indirect costs (overhead) into direct costs compared to conventional costing.

12. **What are the main reasons for using jigs and fixtures? (AU N/D '17)**

The main purpose of any work holding device is to position and hold a work piece in a precise location while manufacturing operation is being performed

13. **What are the most influential factors in terms of tool performance? (AU N/D '17)**

Factors affecting tool performance

- Cutting tool materials
- Cutting tool geometry
- Cutting fluids

14. **What are the factors to be considered during the selection of a process? (AU N/D '16)**

- Quality of work to be completed
- Availability of equipments, tools and personnels
- Sequence in which operations will be performed on the raw material
- Standard time for each operation

15. **Enumerate the documents required for process planning (AU N/D '15) (AU N/D '12) (AU M/J '13)**

- Product design and the engineering drawings pertaining to all the components of the product.
- Machining/Machinability Data Handbook
- Catalogues of various cutting tools and tool inserts.
- Specifications of various machine tools available in the shop/catalogues of machine tools in the shop
- Sizes of standard materials commercially available in the market.
- Machine Hr. cost of all equipment available in the shop.
- Design Data Handbook.
- Charts of Limits, Fits & Tolerances.
- Tables showing tolerances and surface finish obtainable for different machining processes.
- Tables of standard cost.
- Table of allowances (such as Personal Allowance, Fatigue Allowance etc. in % of standard time followed by the company).

16. **State the parameters involved in material selection (AU N/D '14) (AU M/J '16)**

(i) Functional requirements

(ii) Reliability

(iii) Service life durability

(iv) Aesthetics and appearance

(v) Environmental Factors

(vi) Compatibility with other materials during service

(vii) Producibility or manufacturability

(viii) Cost

17. What are the activities associated with process planning? (AU M/J '12)

- Analyse the part requirements
- Determine operation sequence
- Select the equipment
- Calculate processing times
- Select inspection methods
- Estimate manufacturing cost
- Document process plan
- Communicate to manufacturing engineer

18. State the procedure to select cost optimal process (AU N/D'11)

- Break even point
- Break even chart
- Break even analysis

19. What is the difference between routing sheet and operations list? (AU A/M'17)

A route sheet determines the sequence or order of arrangement of various departments in a facility. Thus, a route sheet is a document which has information and data inputs and a step wise listing of all the processes or transactions performed. It also contains details such as date and time, remarks, log in/out, point of contact etc.

It is a list of operations has to be performed in a process without sequence.

20. What is the relation between tolerance and surface finish? (AU A/M'17)

Components must fit together and function properly in a predicted dimension is defined as tolerance, whereas surface finish is the depth of irregularities and vertical deviations of a surface resulting from the manufacturing process used to produce it.

21. What is the purpose of a work holding device?

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

22. List the types of work holding devices.

- General work holding devices
  - Vices
  - Clamps
  - Mandrels
  - Chucks
- Specialist work holding devices
  - Jigs
  - Fixtures

23. What is meant by Statistical Quality Control (SQC)?

SQC is about employing inspection methodologies derived from statistical sampling theory to ensure conformance to requirements

24. List seven statistical tools of quality that are used in quality control

(i) Flowchart
(ii) Cause and effect diagram
(iii) Check sheet
(iv) Scatter diagram
(v) Histogram
(vi) Control chart
(vii) Pareto diagram

25. What is meant by break even analysis (BEA)?

BEA also known as cost volume profit analysis is the study of inter-relationships among a firms sales, costs and operating profit at various levels of output.

Part – B

1. Describe the basic method employed for the selection of cutting tools. (AU N/D '17)

(i) ***Evaluation of process and machine selections***- Provided the selection of processes and machines is satisfactory, the range of tools that can be used should be limited to those suitable for the processes and machines selected. Therefore, this limits the initial list of possible suitable tooling.

(ii) ***Analysis of machining operations***- A specific machine will carry out every operation required. Each machine tool to be used will have specific tool types to carry out certain operations. Therefore, this analysis should enable the identification of specific tool types for specific operations.

(iii) ***Analysis of workpiece characteristics*** - The focus of the workpiece analysis is on the workpiece material and geometry and the capability in terms of dimensional and geometric accuracy and surface finish. The analysis of the first two characteristics enables suitable tool materials and geometry (in terms of size and shape) to be identified. The third characteristic allows the tool type and geometry to be refined further to suit the operations.

(iv) ***Tooling analysis***- Using the tooling data available, the general tooling specifications generated at the third stage can be translated into a statement of tooling requirements for the job, that is, a tooling list. This will obviously reflect whatever tooling is actually available for the operations required.

(v) ***Selection of tooling*** - There are two routes that the tool selection can take at this point. If single-piece tooling is being used, then a suitable toolholder should be selected before fully defining the tool geometry and material. However, if insert-type tooling is being used then the following steps should be followed:

i. select clamping system;
ii. select toolholder type and size;
iii. select insert shape;
iv. select insert size;
v. determine tool edge radius;
vi. select insert type;

vii. select tool material.

Once all of the above is completed, the machining parameters can be calculated. These will be the speeds, feeds and machining times for each operation. All of the above factors will have a significant influence on the determination of these parameters.

2. **Explain the process planning procedure and List out the information required for process planning. (16 marks) (AU N/D '16) (AU M/J '13) (or)**

What are the Set of documents required for process planning? (16 marks) (AU N/D '17) (10 marks) (AU N/D '13) (or)

Explain the steps involved in process planning. (16 marks) (AU N/D '17) (8 marks) (AU N/D '13)(AU M/J '12)

Set of documents required for process planning

(i) Product design and the engineering drawings pertaining to all the components of the product. (*i.e.*, components drawings, specifications and a bill of materials that defines how many of each component go into the product).

(ii) Machining/Machinability Data Handbook (Tables of cutting speeds, depth of cut, feeds for different processes and for different work materials).

(iii) Catalogues of various cutting tools and tool inserts.

(iv) Specifications of various machine tools available in the shop/catalogues of machine tools in the shop (speeds, feeds, capacity/power rating of motors, spindle size, table sizes etc.).

(v) Sizes of standard materials commercially available in the market.

(vi) Machine Hr. cost of all equipment available in the shop.

(vii) Design Data Handbook.

(viii) Charts of Limits, Fits & Tolerances.

(ix) Tables showing tolerances and surface finish obtainable for different machining processes.

(x) Tables of standard cost.

(xi) Table of allowances (such as Personal Allowance, Fatigue Allowance etc. in % of standard time followed by the company).

(xii) Process plans of certain standard components such as shafts, bushings, flanges etc.

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

Steps in process planning

(i) Required operations must be determined by examining the design data and employing basic machining data such as :

(a) Holes can be made conveniently on drilling machines.

(b) Flat surfaces can be machined easily on milling machines.

(c) Cylindrical parts can be made using lathe. Design data can be obtained from the part-drawing or from the finished part design file from the CAD system.

(ii) The machines required for each operation must be determined. This selection depends on knowledge of machine factors, such as availability of the machine, specifications of machine tools available in the shop, accuracy grade of the m/c, table size, spindle size, speed and feed ranges available, torque, power, machining rate and other size limitations.

(iii) The required tools for each identified machine or process must be determined. For selection of specialized tools knowledge and prior experience of process planner will be useful.

(iv) The optimum cutting parameters for each selected tool must be determined. These parameters include cutting speed, feed rate, depth of cut, and type of coolant/lubricant to be used. This determination depends on design data, such as work material, tool material, surface finish specifications and behaviour of cutting tool. Again expertise knowledge and prior experience of process planner and methods engineer will be useful in this regard. Machining data handbooks can also be referred.

(v) Finally an optimum combination of these machining processes must be determined. The best process plan is the one which minimizes manufacturing time and cost. This provides a detailed plan for the economical manufacturing of the part.

(vi) The results of each of these five basic steps can be seen in the final form of the process plan

3. What are the factors that influence process planning? Discuss (8 marks) (AU N/D '12) (AU M/J '13) (or)

Explain the steps in process selection with suitable example (16 marks) (AU N/D '17)

Practices of Process Planning

The practices of process planning vary widely in modern industry, depending on such factors as :

- Type of product
- The equipment available, and
- The volume of production (*i.e.*, production quantity)

The individual responsible for carrying out process planning / process analysis is the Process Engineer also known as process planner, process analyst or methods engineer. To be effective on his or her job, the process analyst must be familiar with material characteristics and manufacturing processes. Knowledge of the nature, types, and properties of standard materials and new materials will assist the process analyst in selecting the most appropriate process, equipment and methods for manufacturing a particular product. The process analyst must also be familiar with engineering drawings and product design. Drawings provide the part configuration and the dimensional tolerances and specifications that need to be met by the manufacturing process selected

In addition, the process planner must be familiar with the operating characteristics and costs of the production and tooling equipment, either available in the plant or to be purchased.

Process Planning starts with a careful examination of the drawing or design of the part. The process planner must be able to analyze the engineering drawing and visualize the three dimensional part configuration. The part configuration must then be analyzed to determine its basic geometric components. Identifying these basic geometric elements assists the process planner in selecting the most appropriate process to manufacture the product.

Process Selection

Consideration should be given to the following factors in selecting a particular process

(a) Nature of part, including materials, tolerances, desired surface finish and operation required.
(b) Method of fabrication including machining or assembling of similar parts or components.
(c) Limitation of facilities including the plant and equipment available.
(d) Possibility of likely product design changes to facilitate manufacturability or cost reduction.
(e) In-plant and outside materials handling systems.
(f) Inherent process to produce specified shape, surface, finish to give desired mechanical properties.
(g) Available skill level of operators for the production. Sometimes the following additional factors affect the selection of a particular process.
(a) Proposed or anticipated production requirements, including volume requirements, production rates and short- term or long- term production runs.
(b) Total end-product costs.
(c) Time available for tooling-up.
(d) Materials receipt, storage, handling and transportation. Careful consideration of these factors will result in the selection of the most appropriate process for the manufacture of a particular product. Selection of an appropriate manufacturing process depends on many factors and requires considerable knowledge, skill and competence of the process planner or process analyst.

Machine Selection

Product manufacturing requires tools and machines that can produce economically as well as accurately. Economy depends to a large extent on the proper selection of the machine or process for the job that will give a satisfactory finished product. The selection of the machine is influenced, in turn by the quantity of items to be produced. Usually there is one machine best suited for a certain output.

In small lot or jobbing type manufacture, general purpose machines such as the lathe, drill press, and milling machine may prove to be the best type since they are adoptable, have lower initial cost, require less maintenance, and possess the flexibility to meet changing conditions in the shop. However, a special purpose machine should be considered when large quantities of a standard product are to be produced. A machine built for one type of work or operation, such as the grinding of a piston or the machining of a cylinder head, will do the job well, quickly and at a low cost requiring only the service of a semi-skilled operator.

Many of the special-purpose machines or tools differ from the usual standard type in that they have built into them some of the skill of the operator. A simple bolt may be produced on either a lathe or an automatic screw machine. The lathe operator must not only know how to make the bolt but must also be sufficiently skilled to operate the lathe. On the automatic machine the sequence of operations and movements of tools are controlled by cams and stops, and each item produced is identical with the previous one. This "transfer of skill" into the machine makes possible the use of less skillfull operators, but it does requires greater skill in supervision and maintenance. Often it is not economical to make a machine completely automatic, as the cost may become prohibitive.

The selection of the best machine or process for a given product requires knowledge of all possible production methods. Factors that must be considered are:

- Volume of production (Quantity to be produced) *i.e.*, no. of components to be produced.
- Quality of finished product, and
- Advantages and disadvantages of the various types of equipment capable of doing the work.

Too much emphasis cannot be given to the fact that production can be by several methods, but usually there is one way that is most economical.

Material selection

Material selection is done by the product designer considering the requirements of the parts designed and the hardness, strength properties and other mechanical characteristics of the material. Cost and availability of the material are also considered. Material should be strong enough and at the same time manufacturing or producibility of the part using the given material and the process are also equally important.

In the initial stages of design, the broad material groups such as ferrous or non-ferrous or other non-metallic materials can be considered. At a later stage specific material in the group can be identified.

In certain products or components specific properties of materials such as fatigue strength, thermal conductivity, electrical properties like conductivity, magnetic permeability and insulation resistance may have to be considered.

Material Selection parameters

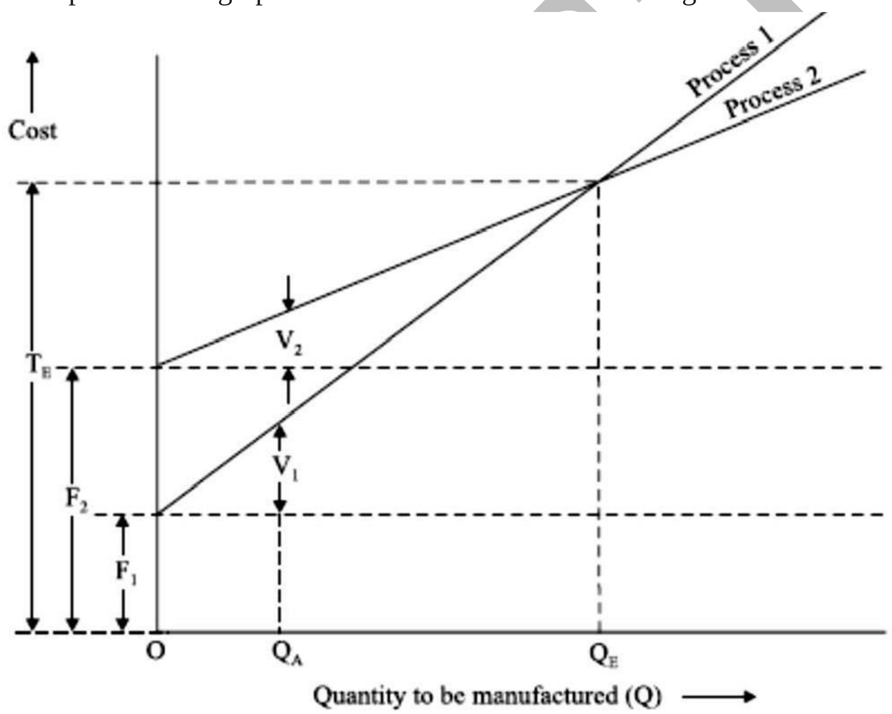
- Functional requirements
- Reliability

- Service life durability
- Aesthetics and appearance
- Environmental Factors
- Compatibility with other materials during service
- Producibility or manufacturability
- Cost

4. Write notes on selection of cost for optimal processes. (or) write notes on economics of process planning (8 marks) (AU M/J '16) (AU A/M '18)

Two different types of processes can be used for the same job. The processes can be compared and optimum process selected with the help of break-even charts.

Break-even charts: Break-even charts give the production engineer a powerful tool by which feasible alternative processes can be compared and the process which gives minimum cost can be selected. The fixed and variable costs for two alternative processes are plotted on a graph to a suitable scale as shown in Fig.



F_1 = Fixed costs for process (1)
F_2 = Fixed costs for process (2)
V_1 = Variable costs for process (1)
V_2 = Variable costs for process (2)
Q_E = Break-even quantity at quantity Q_A
T_E = Total costs of manufacture at quantity Q_E

For each process generally the variable cost is a linear function of the quantity manufactured. Therefore, once the fixed costs have been plotted, only one value for the variable costs is required at some value Q_A and the total cost lines can be drawn. Where these lines intersect is known as the break-even point, *i.e.*, the point where the total cost of manufacture of quantity Q_E is same for both process (1) and process (2). The break-even chart tells us to :

Use process (1) if the quantity to be manufactured $\leq Q_E$

≥

The value of QE can be scaled directly from the chart with sufficient accuracy, although it can also easily be calculated.

5. **A component can be produced with equal ease on either a capstan lathe or on a single spindle cam operated automatic lathe. Find the break-even quantity Q_E if the following information is known. (8 marks)(AU N/D '15)**

		Capstan Lathe	*Automatic Lathe*
(*a*)	Tooling cost	Rs. 30.00	Rs. 30.00
(*b*)	Cost of cams	—	Rs. 150.00
(*c*)	Material cost/Component	Rs. 0.25	Rs. 0.25
(*d*)	Operating labour cost	Rs. 2.50/hour	Rs. 1.00/hour
(*e*)	Cycle time/Component	5 minutes	1 minute
(*f*)	Setting up labour cost	Rs. 4.00/hour	Rs. 4.00/hour
(*g*)	Setting up time	1 hour	8 hours
(*h*)	Machine overheads (setting and operating)	300 % of (d)	1000 % of (d)

Capstan lathe :

$$\text{Overheads} = \frac{300}{100} \times 2.50 = \text{Rs. } 7.50/\text{hour}$$

$$\text{Fixed Costs} = \text{tooling cost} + \text{setting-up cost}$$
$$= 30.00 + 1(4.00 + 7.50)$$
$$= 30.00 + 11.50 = \text{Rs. } 41.50$$
$$= \text{Rs. } 42$$

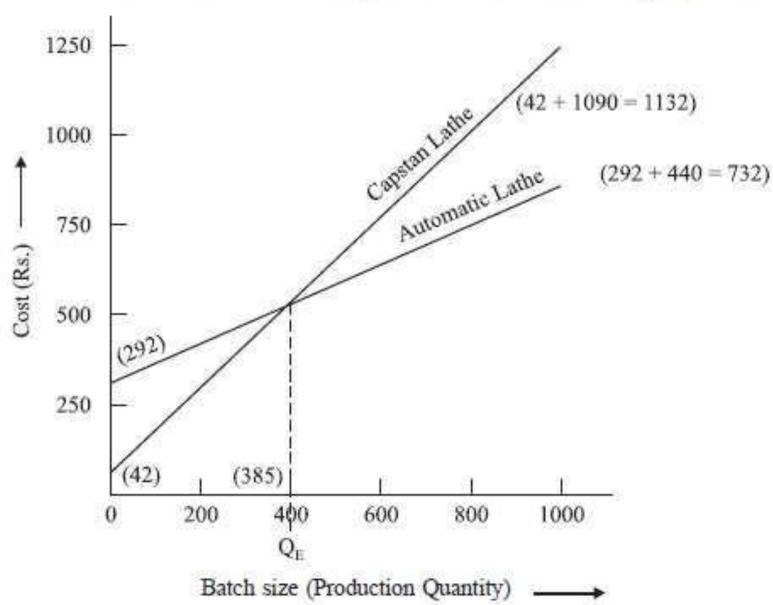
$$\text{Variable costs/Component} = \left(2.50 \times \frac{5}{60}\right) + 0.25 + \left(7.50 \times \frac{5}{60}\right)$$
$$= 0.21 + 0.25 + 0.63 = \text{Rs. } 1.09$$

$$\text{Variable costs/1000 components} = \text{Rs. } 1090.00$$

Automatic lathe :

$$\text{Overheads} = \frac{1000}{100} \times 1.00 = \text{Rs. } 10.00/\text{h}$$

$$\text{Fixed costs} = \text{tooling cost} + \text{cam cost} + \text{setting-up cost}$$



= 30.00 + 150.00 + 8 (4.00 + 10.00)
= 180.00 + 112.00
= Rs. 292.00

$$\text{Variable costs/Component} = \left(1.00 \times \frac{1}{60}\right) + 0.25 + \left(10.00 \times \frac{1}{60}\right)$$

= 0.02 + 0.25 + 0.17
= Rs. 0.44

Variable costs/1000 components = Rs. 440.00.

These costs can now be plotted on a break-even chat (Fig.) to find the value of Q_E. Q_E is scaled from the break-even chart (Fig.) and found to be 385. If the batch size to be manufactured is equal to or less than 385 use the capstan lathe.

If the batch size to be manufactured is equal to or greater than 385 use the automatic lathe. The above is the graphical method of determining Break-even Quantity.

6. What is Inspection? Write briefly about the different methods of inspections followed in industries.(AU A/M'17)

Inspection is the function by which the product quality is maintained

The objectives of the Inspection are

(i) To sort out confirm and non-conforming product
(ii) To initiate means to determine variations during manufacture
(iii)To provide means to discover inefficiency during manufacture

Stages of Inspection

Inspection of incoming materials

It consists of inspecting and checking all the purchased raw materials and parts that are supplied before they are taken on to stock or used in actual manufacturing.

This inspection performed either at supplier's place or at manufacturer dispatch or gate.

Inspection of production process

The inspection is done in parallel while the production is in processing. Inspection can be done at different work centers and at the critical production points.

This has the advantages of minimize the wastage of time and money on defective units and preventing delays in assembly.

Inspection of finished goods

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

Methods of inspection

There are two methods of inspection. They are:

i) 100% inspection, and

ii) Sampling inspection,

A. 100% inspection

100% or cent percent inspection is quite common when the number of parts to be inspection is relatively small.

Here every part is examined as per the specification or standard established and acceptance or rejection of the part depend on the examination.

B. Sampling inspection

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

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

Types of inspection

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

1. Inspection of variable, and
2. Inspection of attributes.

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

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

Measurement instruments

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

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

(i) Dimensions/size,

(ii) Physical properties,

(iii) Functionality, and

(iv) Appearance.

7. Discuss about factors to be considered in the selection of jigs and fixtures for cost reduction (8 Marks) (AU A/M '18)

Function of work holders

The main purpose of any Work holding device is to position and hold a workpiece in a precise location while the manufacturing operation is being performed. In order to perform this function adequately, all work holders consist of four basic elements:

Locating elements - that allow the work piece to be positioned correctly

Structural elements- that can withstand the forces applied during the manufacturing operation.

Clamping elements - that can withstand the forces applied during the manufacturing operation and maintain the position of the work piece.

Fixing elements - that attach the work holder to the machine; There are many devices that adhere to the above definition that can be classified as general work holding devices as opposed to specialist work holding devices, that is, jigs and fixtures. General work holding devices can be classified as:

- Vices
- Clamps and abutments
- Chucks
- Collets
- Centers
- Mandrels
- Face plates

The entire above are sometimes referred to as low-cost jigs and fixtures.

Use of jigs and fixtures

For many machining and assembly operations, general-purpose work holding devices may not be sufficient. In these instances, these special work holding requirements are generally satisfied by designing and building special-purpose work holding devices known as jigs and fixtures. The design of special jigs, fixtures and tools is considered as one of three essential activities for facilitating interchangeable manufacture, along with process planning and the design of suitable limit gauges and gauging equipment. Consequently, the main reasons for the use of jigs and fixtures are:

- Components can be produced quicker;
- Greater interchangeability is obtained due to repeatability of manufacture which subsequently reduces assembly time;
- Accuracy can be easily obtained and maintained;
- Unskilled or semi-skilled labour may be used on a machine, resulting in reduced manufacturing costs.

Jigs:

A jig is a work holding device. However, jigs have a further important function and that is determining the location dimensions of specific features. In order to fully understand this function, the distinction between location and size dimensions must be defined. Strictly speaking, not all jigs provide guidance for tools. This is because in many assembly processes, such as welding, the jig merely holds the parts together in the correct orientation with respect to each other while the tool carries out the joining process.

However, in the case of jigs being used with machining processes, they generally always provide guidance for the cutting tool. In summary, a jig is a specially designed and built work holding device, usually made of metal, and performs three basic functions

- holding the component;
- providing guidance for the cutting tools to determine the location dimension for the machining of a feature;
- Positively locating the component so that subsequent components are machined in the same manner.

Jigs can usually be generally classified as either drilling jigs or boring jigs and are used for operations such as drilling, reaming, tapping, chamfering, counterboring, countersinking and boring operations.

Fixture:

A fixture is similar to a jig and can be defined as a special-purpose workholding device used during machining or assembly. However, fixtures are generally of heavier construction than jigs and also usually fixed to the machine table. The main function of a fixture is to positively locate the workpiece. However, unlike a jig, no guidance is provided for cutting tools. Fixtures are used in a variety of processes including milling, broaching, planing, grinding and turning.

8. Explain the importance of selection of the right quality assurance method during manufacturing. (13 marks) (AU A/M '18)

All manufacturing organizations have the common goal of making a profit. The basic model of added value previously presented focuses on the main input of materials undergoing some transformation process and value being added to that material. A profit is made if the value added is greater than the cost to process the material. However, a profit will only be made if the customer is satisfied with the product. In the globally competitive market, this is where the factor of product quality is seen to be important.

The transformation processes mentioned above in this instance are obviously manufacturing processes. However, all manufacturing processes have some degree of inherent variability, even highly automated processes such as CNC milling. Therefore, steps must be taken to ensure that the product specification is adhered to in spite of this variability. The starting point for this is the establishment of the capability of the processes being used.

However, except in the case of the introduction of new processes, the capability of available processes should be known. These data should be documented and available to the process planner if required.

Based on the capability of the process being employed, the process planner will determine which are the most appropriate quality assurance (QA) tools and techniques to employ. These will range from basic measurement tools such as callipers, micrometers and gauges to the use of coordinate measuring machines (CMMs). Also covered will be the application of statistical process control (SPC) methods. Although SPC and process capability studies will most probably be designed and carried out by quality engineering, it is essential that the process planner has an understanding of these in order to enter into meaningful dialogue with regards to process capability. In fact, the process planner will have to liaise closely with the quality function on a number of issues with regards to the process plan. These include:

- identifying inspection locations;
- identifying appropriate inspection and testing methods;
- the frequency of inspection and testing;
- evaluation of inspection and test data;
- Identifying corrective action where appropriate.

All of the above will influence the processes, equipment, tools and manufacturing parameters to be used for a given job, particularly in the case where corrective action involves changing any of these. Therefore, the process planner requires a knowledge and understanding of all of these aspects of product quality.

9. Explain the factors to be considered in selection of process parameters (13 marks) (AU A/M '18)

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

- Cutting Speed
- Feed Rate
- Depth of Cut

Cutting Speed:

Cutting speed is known as surface cutting speed or surface speed, can be defined as Relative speed between the tool and the work piece

Unit: meteres per minute

Factors affecting the selection of cutting speed

- Nature of the cut
  - Continuous cut like turning, boring are done at higher cutting speed
  - Shock initiated cuts in shaping, planning, slotting machine are done at lower cutting speed.
  - Intermittent cuts as in milling, hobbing are done at quite lower speed for dynamic loading
- Work material
  - Harder and stronger materials are machined at lower cutting speed
  - Soft, non-sticky materials can be machined at higher cutting speed
- Cutting tool material
- Cutting fluid application
- Purpose of machining
  - Rough machining (lower cutting speed)
  - Finish machining (higher cutting speed)
- Kind of machining operation
- Capacity of machine tool
- Condition of machine tool

Feed and feed rate

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

Feed rate is the speed at which the cutting tool penetrates the work piece

Unit: millimeters per minute

Factors affecting feed rate:

- Nature of the cut
- Work material
- Cutting tool material
- Cutting fluid application
- Purpose of machining
- Kind of machining operation
- Capacity of machine tool

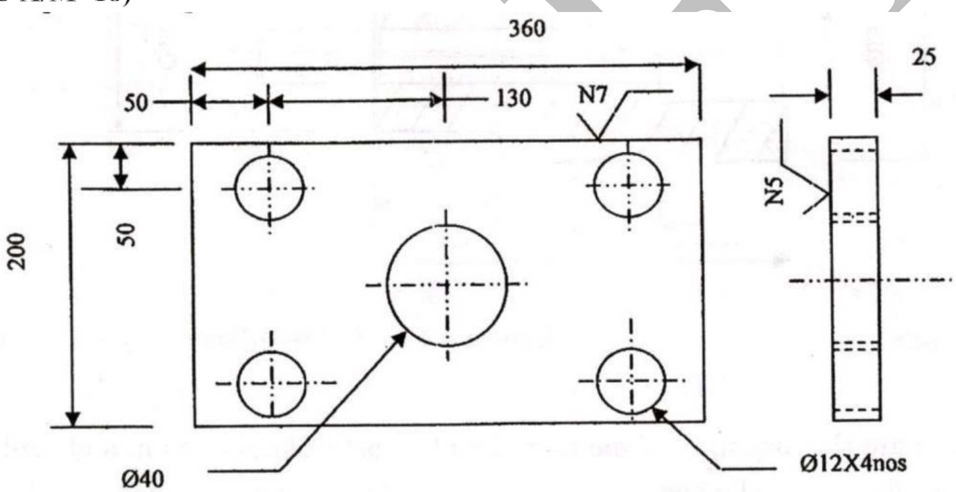
Depth of cut:

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

Unit : millimeter

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

10. Prepare the operation and route sheet for the component shown in fig (15 marks) (AU A/M '18)



Solution

Operation Sheet:

Comp Procedure	**A.R.C**	**Inc: Part Name**	**Drill Plate**		**Prepared by**		
		Drilling	**Part No :18**		**Date**		
Operation No.	*Operation Description*	*Machine Type*	*Tool*	*Dept*	*Set up Time (m)*	*Operation Time (min)*	*Material /Part*
01	Cutting	Cutter	Cutting Wheel	Machine Shop	30	20	Steel Plate
02	Surface Grinding	Grinder	Grinding Wheel	Machine Shop	15	30	Steel Plate
03	Drilling 4 Nos	Drilling Machine	Drill tool -12mm	Machine Shop	15	20	Steel Plate
04	Drilling	Drilling Machine	Drill tool -40 mm	Machine Shop	15	20	Steel Plate

Rout Sheet

Routing sheet		
Part name	Part no	Drg no
Quantity	Material	Planner
Date	Page 1 of 1	Order no
Operation no	Description	Machine tool
01	Cut off 200x360 mm bar to 25 mm thick	Hor. Bandsaw
02	Drill 40 mm dia.	Drill press no 1
03	Drill 12 mm dia x 4 nos	Drill press no 2
04	Surface Grind 5 micro meter	Grinding machine no 1

Unit – 3 Introduction to Cost Estimation

Part – A

1. **Classify the allowances considered in cost estimation (AU N/D '17)**
   - Relaxation Allowance
     - Fatigue allowance
     - Personal need allowance
   - Process allowance
   - Interference allowance
   - Contingency allowance
   - Special allowance
2. **What do you meant by cost accounting? (AU N/D '16) (AU N/D '15) (AU N/D '13) (AU N/D '12) (AU M/J '13)**

   Costing may be defined as a system of accounts which systematically and accurately records every expenditure in order to determine the cost of a product after knowing the different expenses incurred in various department.
3. **Define overhead cost. (AU N/D '16) (AU N/D '14) (AU M/J '12)**

   Overhead is the sum of indirect labour cost, indirect material cost and other expenses including service which cannot be conveniently charged to specific cost unit. These can be further classified as
   - Production expenses/Factory expenses.
   - Administrative expenses.
   - Selling expenses.
   - Distribution expenses.
4. **Distinguish between cost estimation and cost accounting (AU N/D '15) (AU A/M '17) (AU N/D '17)**

S.No	Point of comparison	Cost estimating	Cost accounting
1.	Type of cost	It gives an expected cost of the product based on the calculations by means of standard formulae or certain established rules.	It gives actual cost of the product cost based on the data collected from the different expenditures actually done

5. **List the types of estimates (AU N/D '15)**
   - Guesstimates
   - Budgetary
   - Using Past History
   - Estimating in Some Detail
   - Estimating in Complete Detail
   - Parametric Estimating
   - Project Estimating
6. **What are the sources of for cost estimation? (AU N/D '15)**
   - Cost of design.
   - Cost of drafting.

- Cost of research and development.
- Cost of raw materials.
- Cost of labour.
- Cost of inspection.
- Cost of tools, jigs and fixtures.
- Overhead cost.

7. Brief about the procedure to calculate material cost (AU N/D '15)

- Study the drawing carefully and break up the component into simple geometrical shapes. (Cubes, prisms, cylinders, etc.)
- Add the necessary machining allowances on all sides which are to be machined.
- Determine the volume of each part by applying the formulae of mensuration.
- Add the volumes of all the simple components to get total volume of the product.
- Multiply the total volume of the product by the density of the material to get the weight of the material.
- Find out the cost of the material by multiplying the cost per unit weight to the total weight of the material.

8. Define: Under estimate (AU N/D '14)

The estimated cost is below the actual cost of product, then the firm will face huge financial loss which may cause utter failure or closure of the firm. This estimation is called under estimate.

9. Define: Contingency Allowance (AU N/D '14)

Contingency Allowance: This is a small allowance of time which may be included in the standard time to meet unforeseen items of work, or delays (*e.g.* waiting for raw materials, tools). Contingency allowance is 5% (maximum) or Normal Time.

10. What is meant by conceptual cost estimating? (AU N/D '14)

In the conceptual design stage, the geometry of parts and materials has not been specified, unless they dictate essential product functions. In the conceptual design stage, the costs associated with a change in the design are low. In the conceptual design stage, the incurred costs are only 5 to 7% of the total cost whereas the committed costs are 75 to 85% of the total cost.

The accuracy of the conceptual cost estimate depends on the accuracy of the data base. The accuracy of conceptual cost estimating is approximately –30% to + 50%. Accuracy in conceptual cost estimating is important since at the conceptual design stage only significant cost savings can occur.

11. List the elements of prime cost (AU N/D '13)

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

12. What is the need to include allowances in cost estimation? (AU N/D '13)

A worker cannot work for 8 hours continuously without rest. Also efficiency decreases as the time passes due to fatigue etc. He also requires for tool sharpening, checking measurements and personal calls. All these allowances come under this category. These allowances generally consumes 15 to 20% of total time.

13. Give the methods of costing. (AU N/D '13)

- Process costing.
- Job costing.

- Batch costing.
- Hybrid costing systems.

14. List the various elements of cost. (AU M/J '16) (AU A/M '18)

- Material cost,
- Labour cost and
- Other expenses

15. What shall be the effect of overestimate (AU M/J '16)

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 losses the order to its competitors.

16. Mention any two functions of estimating. (AU M/J '16) (AU M/J '13) (AU M/J '12)

- To calculate the cost of new material needed to manufacture a product.
- To find the cost of parts to be purchased from outside vendors.
- To find the cost of equipment, machinery, tools, jigs and fixtures etc. required to be purchased to make the product.
- To calculate the direct and indirect labour cost associated with the manufacture of the product, based upon work study.
- To calculate various overhead charges associated with the product.
- To decide about the profit to be charged, taking into consideration other manufacturers of same product in the market.
- To calculate the selling price of the product.
- To maintain records of previous estimating activities of the company for future references.
- To decide the most economical method of making the product.
- To submit cost estimates with the competent authority for further action.

17. Differentiate direct and indirect overheads. (AU M/J '16)

Direct expenses: Direct expenses include all that expenditure which can be directly allocated and charged to a particular job. The direct expenses include cost of special jigs or fixtures, patterns, tooling made for job, or cost of research and development work done for that specific job.

Indirect expenses: Except direct expenses, all other indirect expenditure incurred by the manufacturer is called indirect expenses. The indirect expenses are also called overhead expenses or on-cost.

The indirect expenses are further classified as:

(i) Factory expenses.
(ii) Administrative expenses.
(iii) Selling and distribution expenses.

18. What is meant by direct material? Give example. (AU M/J '13) (AU M/J '12)

It is the cost of those materials which are directly used for the manufacture of the product and become a part of the finished product. This expenditure can be directly allocated and charged to the manufacture of a specific product or job and includes the scrap and waste that has been cut away from original bar or casting.

19. What is meant by direct labour cost? (AU M/J '13) (AU M/J '12)

Direct labourer is one who actually works and processes the materials to convert it into the final shape. The cost associated with direct labour is called direct labour cost. The direct labour cost can be identified and allocated to the manufacture of a specific product. Examples of the direct labour are the workers operating lathes, milling machines or welders, or assemblers in assembly shop. The direct labour cost may be allocated to a product or job on the basis of time spent by a worker on a job.

20. What is fatigue allowance? (AU M/J '13)

The efficiency of the worker decreases due to fatigue (or) working at a stretch and also due to working conditions such as poor lighting, heating (or) ventilation. The efficiency is also affected by the psychology of the worker. It may be due to domestic worries, job securities etc. For normal work, the allowance for fatigue is about 5% of the total time. This allowance can be increased depending upon the type and nature of work and working conditions.

21. What do you meant by realistic estimate? (AU M/J '12) (AU N/D '12) (AU M/J '13)

Both over-estimate and under-estimate may prove to be dangerous and harmful for a concern. Assume that on the basis of an estimate, the concern has to fill up a tender enquiry. The overestimate means the concern will quote a higher rate and thus will not get the job or contract. In case of an under-estimate, the concern will get the contract but it will not be able to complete the work within that small quoted amount and hence will suffer heavy losses. This emphasizes the importance of making realistic estimates. Realistic estimates are very essential for the survival and growth of a concern.

Part – B

1. Discuss various methods of costing in detail. (8 marks) (AU N/D '16) (AU M/J '12) (AU M/J '16) (AU M/J '13)

Methods of Costing

(a) Process costing.
(b) Job costing.
(c) Batch costing.
(d) Hybrid costing systems.

(a) Process costing

This method is employed when a standard product is being made which involves a number of distinct processes performed in a definite sequence.

- In oil refining, chemical manufacture, paper making, flour milling, and cement manufacturing etc., this method is used.
- The object i.e., record and trace cots for each distinct stage.
- While costing, the by-products of each process should be considered.
- This method indicates the cost of a product at different stages as it passes through various processes.

- The total time spent and materials used on each process, as well as services such as power, light and heating are all charged. For this purpose cost sheet may be employed.

The process cost sheet is a summary of all operations for the month. The current operating charges are entered on the sheet showing
1. The transfer cost from the previous operation.
2. The costs incurred by each operation showing materials, labour and overhead in separate columns.

This separation of transfer cost and conversion cost is extremely important for the charges incurred by a department are its measures of efficiency.
The sheet can be used as a basis for:
1. Closing entries at the end of each month.
2. Operating statements, without need to look up the ledger accounts.

Within the cost ledger an account is kept for each process. The direct material, direct labour and factory overhead costs are transferred from the process cost sheet. There are debited to the process account, and then any completed units are credited to cover the transfer to the next process. The balance on the account represents the work-in-progress at the end of the period, which, of course, becomes the opening balance for the next period.

(b) Job costing or order costing

- Job costing is concerned with finding the cost of each individual job or contract. Examples are to be found in general (job order) engineering industries, ship building, building contracts, etc.
- The main features of the system is that each job has to be planned and costed separately.
- Overhead costs may be absorbed on jobs on the basis of actual costs incurred or on predetermined costs.
- The process of determining in advance what a job or order will cost is known as estimating.

It involves consideration of the following factors for each job/order:
1. Materials requirements and prices to arrive at the direct material cost.
2. Labour hours and rates to determine labour costs.
3. Overhead costs.
4. Percentage added to total cost to cover profit.

A record of above costs per unit time is kept in separate cost sheets.

(c) Batch costing

Batch costing is a form of job costing. Instead of costing each component separately, each batch of components are taken together and treated as a job.

Thus, for example, if 100 units of a component, say a reflector are to be manufactured, then the costing would be as far a single job. The unit price would be ascertained by dividing the cost by 100.

Besides maintaining job cost sheets it may also be necessary to keep summary sheets on which the cost of each component can be transferred and the cost of the finished product can be calculated. This applies in general engineering where many hundreds of components may go towards making the finished machine or other product.

(d) Hybrid costing systems

- Many costing systems do not fall nearly into the category of either job costing or process costing. Often systems use some features of both main costing systems.
- Many engineering companies use batch costing, which treats each batch of components as a job and then finds the average cost of a single unit.
- Another variation is multiple costing, used when many different finished products are made. Many components are made which are subsequently assembled into the completed article, which may be bicycles, cars, etc. Costs have to be ascertained for operations, processes, units and jobs, building together until the total cost is found.
- Different names may be used to describe either process costing or job costing. Thus, for example, unit costing is the name given to one system where there is a natural unit, such as sack of flour, a barrel of beer etc.
- In unit costing method, the expenses on various items are charged per unit quantity or production.
- Operation costing is a variation of unit costing, and is used when production is carried out on a large scale, popularly known as mass production.
- Operation costing is the term applied to describe the system used to find the cost of performing a utility service such as transport, gas, water or electricity.
- In this method, the cost per unit is found on the basis of operating expenses incurred on various items of expenditure.
- Unit costing, operation costing and operating costing are variations of process costing.
- Contract or terminal costing is the name given to job costing employed by builders and constructional engineers.
- All these methods ascertain the actual cost.

2. Explain the procedure followed for estimating the cost of an individual product. (8 marks) (AU N/D '16) (AU N/D '14) (AU N/D '13) (AU M/J '12)

The basic steps in the cost estimation of any product are given below:

- Make thorough study of cost estimation request to understand it fully.
- Make an analysis of the product and prepare a bill of materials.
- Make separate lists of parts to be purchased from the market and parts to be manufactured in plant.

- Determine the cost of parts to be purchased from outside.
- Estimate the material cost for the parts/components to be manufactured in plant.
- Make manufacturing process plan for the parts to be manufactured in plant.
- Estimate the machining time for each operation listed in the manufacturing process plan.
- Multiply each operation time by the labour wage rate and add them up to find direct labour cost.
- Add the estimate of step 4, 5, and 8 to get prime cost of component.
- Apply overhead costs to get the total cost of the component.

3. Discuss the objectives of the cost estimation (10 marks) (AU N/D '15)

The main purpose or objectives of estimating are

- To establish the selling price of a product.
- To ascertain whether a proposed product can be manufactured and marketed profitably.
- To determine how much must be invested in equipment.
- To find whether parts or assemblies can be more cheaply fabricated or purchased from outside (make or buy decision).
- To determine the most economical process, tooling or material for making a product.
- To establish a standard of performance at the start of project.
- For feasibility studies on possible new products.
- To assist in long term financial planning.
- To prepare production budget.
- To help in responding to tender enquiries.
- To evaluate alternate designs of a product.
- To set a standard estimate of costs.
- To initiate programs of cost reduction that result in economics due to the use of new materials, which produce lower scrap losses and which create savings due to revisions in methods of tooling and processing, and
- To control actual operating costs by incorporating these estimates into the general plan of cost accounting.

4. Describe the classification and elements of cost. (16 marks) (AU N/D '15) (AU M/J '13)

Elements of cost

For the purpose of calculations, the total cost of the product is divided into the following:
(A) Material cost, (B) Labour cost, (C) Other expenses.

(A) Material Cost

Material cost consists of the cost of materials which are used in the manufacture of product. It is divided into the following

(a) Direct material cost: It is the cost of those materials which are directly used for the manufacture of the product and become a part of the finished product. This expenditure can be directly allocated and charged to the manufacture of a specific product or job and includes the scrap and waste that has been cut away from original bar or casting. The procedure for calculating the direct material cost is as follows:

- **(i)** From the product drawing, make a list of all the components required to make the final product.
- **(ii)** Calculate the volume of each component from the drawing dimensions after adding machining allowances, where ever necessary.
- **(iii)** The volume of component multiplied by the density of material used gives the weight of the material per component.
- **(iv)** Add process rejection and other allowances like cutting allowance to get the gross weight per component.
- **(v)** Multiply the gross weight by the cost of material per unit weight to get the cost of raw material per component.
- **(vi)** The cost of raw material for all the components is, similarly, calculated and added up which gives the cost of direct material for the product.

(b) Indirect material cost: In addition to direct materials a number of other materials are necessary to help in the conversion of direct materials into final shape. Though these materials are consumed in the production, they don't become a part of the finished product and their cost cannot be directly booked to the manufacture of a specific product. Such materials are called indirect materials. The indirect materials include oils, general tools, grease, sand papers, coolants, cotton waste etc. The cost associated with indirect materials is called indirect material cost.

In some cases certain direct materials like nails, screws, glue, putty etc., are used in such small quantity that it is not considered worthwhile to identify and charge them as direct materials. In such cases these materials are also charged as indirect materials.

Depending upon the product manufactured, the same may be direct materials for one concern and indirect materials for others.

(B) Labour Cost

It is the expenditure made on the salaries, wages, overtime, bonuses, etc. of the employees of the enterprise. It can be classified as :

(a) Direct labour cost: Direct labourer is one who actually works and processes the materials to convert it into the final shape. The cost associated with direct labour is called direct labour cost. The direct labour cost can be identified and allocated to the manufacture of a specific product. Examples of the direct labour are the workers operating lathes, milling machines or welders, or assemblers in assembly shop. The direct labour cost may be allocated to a product or job on the basis of time spent by a worker on a job.

(b) Indirect labour cost: Indirect labourer is one who is not directly employed in the manufacturing of the product but his services are used in some indirect manner. The indirect labour includes supervisors, inspectors, foreman, storekeeper, gatekeeper, maintenance staff, crane driver etc. The cost associated with indirect labour is called indirect labour cost. The indirect labour costs cannot be identified with a particular job or product but are charged on the total number of products made during a particular period in a plant.

To make the concept of direct and indirect labour cost clear, consider an operator working on a drilling machine. The operator in this case is direct labour whereas the man supervising the job, inspector and store man supplying the material are indirect labour.

(C) Other Expenses

In addition to the material cost and labour cost, several other expenses such as rent of building, depreciation of plant and machinery, cost of packing materials, transport and distribution expenses, wages and salaries of administrative staff and executives are also incurred by the manufacturer. All this expenditure including the indirect material cost and indirect labour cost is called other expenses. We can say that except direct material and direct labour costs all other expenditure incurred by the manufacturer is known as "Other Expenses". Expenses are further classified as:

(a) Direct expenses: Direct expenses include all that expenditure which can be directly allocated and charged to a particular job. The direct expenses include cost of special jigs or fixtures, patterns, tooling made for job, or cost of research and development work done for that specific job.

(b) Indirect expenses: Except direct expenses, all other indirect expenditure incurred by the manufacturer is called indirect expenses. The indirect expenses are also called overhead expenses or on-cost.
The indirect expenses are further classified as:

- Factory expenses.
- Administrative expenses.
- Selling and distribution expenses.

(i) Factory expenses: Factory expenses comprise of the indirect expenses incurred from the receipt of the order to the completion of production. In addition to indirect material and indirect labour cost it includes rent of factory building, licence fee, electricity and telephone bills of factory, insurance charges etc. Factory expenses are also called "Works expenses", or "Factory or Works overhead".

(ii) Administrative expenses: Administrative expenses or office expenses include the expenditure incurred on control and administration of the factory. It includes the salaries of office and administrative staff, rent of office building, postage and telephone charges, water and electricity charges for office, Director's fee, legal and audit charges etc. Administrative expenses are also known as 'Administrative overheads'.

(c) Selling and distribution expenses: This is the expenditure incurred on Sales Department for selling the product, *i.e.,* wages, salaries, commission and travelling allowances of salesmen and officers in Sales Department, cost of advertisement, packing, delivery and distribution expenses, rent of warehouses etc.

5. Discuss various types of estimates (10 marks) (AU N/D '15) (AU M/J '13)

Types of Estimate

Estimates can be developed in a variety of different ways depending upon the use of the estimates and the amount of detail provided to the estimator. Every estimator should understand every estimating method and when to apply each, because no one estimating method will solve all estimating problems.

Guesstimates

Guesstimate is a slang term used to describe as estimate than lacks detail. This type of estimate relies on the estimators experience and judgment. There are many reasons why some estimates are developed using his method. One example can be found in the tool and die industry. Usually, the tool and die estimator is estimating tool cost without any tool or die drawings. The estimator typically works from a piece part drawing and must visualize what the tool or die looks like. Some estimators develop some level of detail in their estimate. Material cost, for example, is usually priced out in some detail, and this brings greater accuracy to the estimator by reducing error. If the material part of the estimate has an estimating error of plus or minus 5 per cent and the reminder of the estimate has an estimating error of plus or minus 10 per cent, the overall error is reduced.

Budgetary

The budgetary estimate can also be a guesstimate but is used for a different purpose. The budgetary estimate is used for planning the cost of a piece part, assembly, or project. This type of estimate is typically on the high side because the estimator understands that a low estimate could create real problems.

Using Past History

Using past history is a very popular way of developing estimates for new work. Some companies go to great lengths to ensure that estimates are developed in the same way actual cost is conducted. This provides a way past history in developing new estimates. New advancements in group technology now provide a way for the microcomputer to assist in this effort.

Estimating in Some Detail

Some estimators vary the amount of detail in an estimate depending on the risk and dollar amount of the estimate. This is true in most contract shops. This level of detail might be at the operation level where operation 10 might be a turning operation and the estimator would estimate the setup time at 0.5 hours and the run time at 5.00 minutes. The material part of the estimate is usually calculated out in detail to reduce estimating error.

Estimating in Complete Detail

When the risk of being wrong is high or the dollar amount of the estimate is high, the estimator will develop the estimate in as much detail as possible. Detailed estimates for machinery operations, for example, would include calculations for speeds, feeds, cutting times, load and unload times and even machine manipulations factors. These time values are calculated as standard time and adjusted with an efficiency factor to predict actual performance.

Parametric Estimating

Parametric estimating is an estimating method developed and used by trade associations. New housing constructions can be estimated on the basis of cost per square. There would be different figures for wood construction as compared with brick and for single strong construction as compared with multilevel construction. Some heat-beating companies price work on a cost per pound basis and have different cost curves for different heat-treating methods.

Project Estimating

Project estimating is by far the most complex of all estimating tasks. This is especially true if the project is a lengthy one. A good example of project estimating is the time and cost of developing a new missile. The project might take 5 years and cost millions of dollars. The actual manufacturing cost of the missile might be a fraction of the total cost. Major projects of this nature will have a PERT network to keep track of the many complexities of the project. A team of people with a project leader is usually required to develop a project estimate.

6. Explain the data requirements for cost estimation (6 marks) (AU N/D '15) (AU N/D '14) (AU M/J '12) (AU M/J '16) (AU M/J '13)

1. Man-hour cost (Labour rate) *i.e.*, hourly cost of skilled, semi-skilled and unskilled labours of the company.
2. Machine-hour cost for different types of equipment and machinery available in the company.
3. Material cost in respect of commercially available materials in the market :
   - Cost in Rs. per kg for different categories of materials like ferrous, non-ferrous, special steel etc., for rods of different diameters and for different thicknesses in respect of flats/sheet metals.
4. Scarp rates *i.e.*, scarp values of different materials in Rs. per kg.
5. In respect of welding operations, information such as electrode cost, gas cost, flux cost, power cost, etc.
6. Set-up time for different processes.
7. % allowances to be added for computing standard time, relaxation allowance, process allowance, special allowance as % of normal time as per the policy of the management.
8. Standard time for different types of jobs, if available.
9. Overhead charges in terms of % direct labour cost or overhead rate in Rs. per hr.
10. Life in years permitted for various types of equipment and machines available in the plant for calculation of depreciation, for cost recovery and for calculation of machine-hour rate.
11. Data base of cost calculations carried out by the company in respect of earlier products or jobs (Historical cost data).
12. Cost data of products available in the market similar to the ones manufactured by the company.

13. Budget estimates prepared by the company for new projects/products.
14. Journals or Data sheets of Professional Associations dealing with Costs and Accounting.

7. Describe different methods of estimates (10 marks) (AU N/D '15) (AU M/J '16)

Methods of Estimates

Computer Estimating

Computer estimating has become very popular in recent years primarily because of the advent of the microcomputer. Early efforts of computer estimating date back to the early 1970s but were cumbersome to use because they were on a mainframe and were card-driven. No less than 15 U.S. companies now offer estimating software for a microcomputer. Because the computer estimating industry is new, there are no real standards for estimating programs. Some programs are nothing more than a way to organize the calculations of an estimate, while others calculate all the details of the estimate.

Advantages and disadvantages

Shown below are some of the major advantages of computer cost estimating.

Accuracy versus consistency

Computer estimates are very consistent, provided they calculate the detail of an estimate. Because these estimates are consistent, they can be made to be accurate. Through the use of consistent efficiency factors or leaving curves, estimates can be adjusted up or down. This is one of the chief advantages of computer cost estimating.

Levels of details

Some computer estimating systems provide different levels of estimating cost. The level of detail selected by the user depends on the dollar risk. Many estimators produce an estimate in more detail because the computer can calculate speeds and feeds, for example, much faster than an estimator can a hand-held calculators.

Refinements

Some computer estimating systems provide many refinements that would be impossible for the estimator to do in any timely manner. One example is to adjust speeds and feeds for material hardness. Typically, the harder the material the more slowly a part will be turned or bored. Another refinement is the ability to calculate a feed state and adjust it based on the width of a form tool.

Source code

Some companies offer the source code uncompiled to their users. This is important because it affords the user the opportunity to customize the software. In addition, many companies have written their own software to do something that is not available on the market. If the source code is not compiled, the users can build upon a computer estimating system.

Disadvantages

The chief disadvantage of computer estimating is that no one estimating system can suit everyone's need. This is especially true if the source code is compiled and not customizable.

Another problem with computer estimating is that the estimator will, in all probability, have to change some estimating methods. Computer software for estimating cost is seldom written around one method of estimating.

Group Technology

Group technology is not new. It was invented by a Russian engineer over 30 years ago. Unfortunately the subject is not taught in many of our colleges and universities. Group technology (GT) is a coding system to describe something.

Several proprietary systems are on the market. One such system, the MICAPP system, uses four code lengths, a 10-, 15-, 20-, 25- digit code. The code length selected is based on the complexity of the piece part or tool being described.

Use for group technology

Shown below are several uses for group technology along with several examples of use both internally and externally.

Cost estimating

GT can be used very efficiently in estimating cost. Assume a company manufactures shaft-type parts. Also arsum there is a computer data base named SHAFT that contains 10-digit code followed by a part number, that is, code part number, and so on. When an estimator must estimate the cost of a new shaft, the process starts by developing a code that describes the characteristics of the part. The first digit in the code might be assigned the part length, while the second digit is assigned the largest diameter and so on. Next, the code is keyed in and the computer finds all the parts that meet the numeric descriptions and points out the part numbers. The best fit is selected to be modified into a new part. All the details of each description are retrieved. These include diameter, length of cut, number of surfaces, and the like. The estimator can alter these features and make the old part into a new one.

Actual performance

As the part is being produced, the estimated information is updated with actual performance and refined. This gives the estimator the ability to improve estimating accuracy, because the next time, the computer finds that part as one to be modified into a new one, the estimator is working with actual performance.

Parametric Estimating

Parametric estimating is the act of estimating cost or time by the application of mathematical formulas. These formulas can be as simple as multiplices or as complex as regression models.

Parametric estimating, sometimes refused as statistical modeling, was first documented by the Rard Corporation in the early 1950's in an attempt to predict military hardware cost.

Use of parametric estimating

Many companies use some form of parametric estimating to develop sales forecasting. The four examples cited below will give the reader a good feel of how parametric estimating is used in a variety of different industries.

Construction industry

In developing a cost estimate for residential buildings, some cost estimators use a dollar value per square foot. The estimator constitutes curves based on different construction such as wood on brick buildings and single or multi-storey dwellings. These numbers can then be multiplied by the number of square feet in the building.

Some construction companies have refined this process to provide additional detail carpeting, for example, could have a separate multiplier.

Heat treating

Most commercial heat-treating companies price their work based on a cost per pound and heat treating method. Heat-treating costs are very difficult to define because many times more than one type of part is in the heat-treating furnace at the same time. It is difficult to think of a more effective way to estimate cost for this type of industry.

Statistical Estimating

The analysis of data through the use of statistical methods has been used for centuries. These data can be cost versus other information that leads to cost development. The practitioner must have a well-founded background in the use and application of statistical methods because an endless array of methods is available, several of which are described below.

Parametric estimating

Statistical estimating is another form of parametric estimating. The parametric methods made industry oriented whereas the methods discussed below are universal.

Regression analysis

They form most popular of regression analysis are simple regression, multiple regression, log-linear regression and curvilinear regression. Each math model is different and is designed for a specific use.

8. Explain the allowances in estimation (6 marks) (AU N/D '15) (AU M/J '12) (AU M/J '16)

Allowances in estimation

Normal Time = Observed time × Rating factor

Observed time and rating factor are obtained during the time study of an operation or a job.

Various allowances are considered in estimating the standard time for a job. These allowances are always expressed as % of Normal Time and are added to Normal Time to compute the Standard Time.

Standard Time = Normal Time + Allowances

Standard Time is time required to complete one cycle of operation (usually expressed in minutes).

Standard Time for a job is the basis for determining the standard output of the operator in one day or shift.

Need for Allowances

Any operator will not be able to carry out his work throughout the day without any interruptions. The operator requires some time for his personal needs and rest, and hence such time should be included in standard time. There are different types of allowances, and they can be classified as follows :

1. **Relaxation Allowance :** This is also known as **Rest Allowance**. This allowance is given to enable the operator to recover from the physiological and psychological effects (Fatigue) of carrying out the specified work and to attend to personal needs. Relaxation allowance consists of :

(i) Fatigue allowance, and

(ii) Personal needs allowance.

(i) Fatigue allowance is intended to cater for the physiological and psychological effects of carrying out the work.

This time allowance is provided to enable to operator to overcome the effect of fatigue which occurs due to continuous doing of the work (monotony etc.).

Relaxation allowance (Fatigue allowance and Personal needs allowance put together) is commonly 5% to 10% (of normal time).

(ii) Personal needs allowance: This allowance is provided to enable the operator to attend to his personal needs (*e.g.* going to toilet, rest room, etc.).

2. **Process Allowance:** It is an allowance to compensate for enforced idleness of the worker.

During the process, it may be likely that the operator is forced to be idle due to certain reasons, such as:

- When the process is carried out on automatic machines, (the operator is idle after loading the job on the machine).
- When the operator is running more than one machine (as in the case of cellular manufacturing)

Process allowance varies from one manufacturing situation to another depending on factors such as hazardous working conditions, handling of heavy loads, strain involved, mental alertness required etc. Generally 5% of the normal time is provided towards process allowance.

Interference Allowance : This allowance is provided where in a cycle of operation, there are certain elements which are machine controlled. The operator cannot speed up those elemental operations.

This allowance is also provided when one worker is working on several machines.

4. Contingency Allowance : This is a small allowance of time which may be included in the standard time to meet unforeseen items of work, or delays (*e.g.* waiting for raw materials, tools). Contingency allowance is 5% (maximum) or Normal Time.

5. Special Allowances : These allowances are a policy matter of the management, *e.g.* when the job is newly introduced or when a new machine or new method is introduced, because worker takes some time to learn the new method or job; Special allowance is also provided depending on the working conditions such as noise, dust, etc.

Once the normal time is obtained, the standard time can be estimated or obtained by adding all the allowances to normal time.

Standard time = Normal time + Allowances

9. Write the difference between cost accounting and cost estimation (8 marks) (AU N/D '14) (AU N/D '13) (AU M/J '12) (AU M/J '13)

Points of comparison	Cost estimating	Cost accounting
1.Types of	It gives an expected cost of the	It gives actual cost of the product

cost	product based on the calculations by means of standard formula.	based on the data collected from the different expenditures actually done for a product.
2.Duration of process	It is generally carried out before actual production of a product Due to certain unexpected expenses coming to light at a later stage, estimates may be modified or revised.	It usually starts with the issue of order for production of a product and ends after the product is dispatched for sale. For sale commitments like free repair or replacement, the process continuous up to the expiry period of guarantee because the overhead expenses incurred in the above case will be included in the production cost.
3.Nature of quality	A qualified technical person or engineer having a thorough knowledge of the drawings and manufacturing process is required.	It can be done by a person qualified for accounts instead of a technical person. Thus, this work instead of being of technical nature is more of a clerical work

10. What are the methods used in conceptual cost estimation? Explain (8 marks) (AU N/D '14) (AU A/M '17)

There are different methods of estimates of cost. These are in addition to conventional method of estimating of cost such as calculating material cost, labour cost, factory expenses and overhead expenses and adding all these cost elements.

The methods of estimates are :

1. Conceptual Cost Estimating

It is estimating during the conceptual design stage. In the conceptual design stage, the geometry of parts and materials have not been specified, unless they dictate essential product functions. In the conceptual design stage, the costs associated with a change in the design are low. In the conceptual design stage, the incurred costs are only 5 to 7% of the total cost whereas the committed costs are 75 to 85% of the total cost.

The accuracy of the conceptual cost estimate depends on the accuracy of the data base. The accuracy of conceptual cost estimating is approximately − 30% to + 50%. Accuracy in conceptual cost estimating is important since at the conceptual design stage only significant cost savings can occur.

Conceptual cost estimating methods include :

(a) Expert opinion,

(b) Analogy methods, and

(c) Formula based methods.

(a) Conceptual Method Based on Expert Opinion

If back-up and/or historical cost data are not available, getting expert opinion is the only way for estimating cost.

The disadvantages of this method are

i. The estimate is subjected to bias.
ii. The estimate can't be quantified accurately.
iii. The estimate may not reflect the complexity of the product or project.
iv. Reliable data base for future estimates are not possible.

In spite of these disadvantages, the expert opinion is useful when historical data base is not available. It is also useful to verify cost estimate arrived at using other methods of conceptual estimating (like analogy methods and formula based methods).

(b) Conceptual Method Based on Analogy

Analogy estimating derives the cost of a new product based on past cost data of similar products. Cost adjustments are made depending on the differences between the new and previous product/system. Analogy estimating requires that the products be analogous or similar and products manufactured using similar facilities or technology. If the technology changes, the analogy estimating relationship has to changed to reflect the changes in technology. Another limitation of this method is that analogy estimates often omit important details that makes cost considerably higher than the original cost estimates.

(c) Conceptual Method Based on Formula

There are formula based methods that are primarily used in the conceptual cost estimating. These are :

(i) Factor method,
(ii) Material cost method,
(iii) Function method, and
(iv) Cost-size relationship.

These methods are known as **Global cost estimation methods** and they generally use one of the above methods only.

(i) Factor method

This is the simplest method, but it can give reliable estimates if the data are kept up- to-date, taking into consideration factors such as inflation, and environmental issues which tend to increase the cost.

(ii) Material cost method

Material cost method is justified since the material cost is the largest cost item in the prime cost of many manufacturing companies.

According to this method :

$$\text{Estimated cost of an item} = \frac{\text{material cost of the item being estimated}}{\text{material cost share of item being estimated (in \%)}}$$

(iii) Function method

In function method more variables are used and the expressions are non-linear. The function is basically a mathematical expression with constants and variables that provides a mathematical function for the cost estimate. One expression is given below:

Cost of turbo fan engine development, (in Rs. Lakhs)

$$= 41.2 \times a^{0.74} \times b^{0.08}$$

where a = Maximum engine thrust, in kg

and b = No. of engines produced

11. Discuss about determination of material and labour cost. (8 marks) (AU N/D '13)

Determination of Material Cost

To calculate the material cost of the product the first step is to study drawing of the product and split it into simple standard geometrical shapes and to find the volume of the material in the product and then to find the weight. The volume is multiplied by density of the metal used in the product.

The exact procedure to find the material cost is like this:

1. Study the drawing carefully and break up the component into simple geometrical shapes. (Cubes, prisms, cylinders, etc.)
2. Add the necessary machining allowances on all sides which are to be machined.
3. Determine the volume of each part by applying the formulae of mensuration.
4. Add the volumes of all the simple components to get total volume of the product.
5. Multiply the total volume of the product by the density of the material to get the weight of the material.
6. Find out the cost of the material by multiplying the cost per unit weight to the total weight of the material.

12. Discuss in detail about the computation of price of a product using the ladder of cost with appropriate example. (16 marks)(AU N/D '13)

The elements of cost can be combined to give following types of cost:

				Profit (or) Loss	
			Selling + Distribution expenses		
		Administrative expenses	Office cost (or) production	Total (or) selling cost	Selling price (or) Market price
	Factory expenses	Factory cost (or)	(or) Manufacturing cost	(or)	Catalogue price
Direct material	Prime cost (or)	Works cost	(or)		
Direct labour	Direct cost				
Direct expense					

1. Prime cost: It consists of direct material cost, direct labour cost and direct expenses.

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

Prime cost is also called as direct cost.

2. Factory cost: It consists of prime cost and factory expenses.

Factory cost = prime cost + factory expenses.

Factory cost is also named as works cost.

3. Office cost: It consists of factory cost and administrative expenses.

Office cost = Factory cost + Administrative expenses

It is also named as manufacturing cost (or) cost of production.

4. Total cost: It includes manufacturing cost and selling and distribution expenses.

Total cost = Manufacturing cost + selling and distribution expenses.

Selling price

If the profit is added in the total cost of the product, it is called selling price. The customers get the articles by paying the price which is named as selling price.

Selling price = Total cost + Profit

= Total cost – Loss

Making price (or) catalogue price: Some percentage of discount allowed to the distributors of product is added into the selling price. The result obtained is called the market price (or) catalogue price (figure).

13. Explain the various methods used in an industry for allocation of overheads with an example. (16 marks) (AU M/J '16) (AU N/D '12)

After estimating the total on-cost, next step is the allocation of this on-cost over the production. To run the business in economical way, it is necessary to know, the variation of on-cost with the variation of production. Several methods are available for the allocation of on-cost. The choice of a particular method depends upon the nature of work, type of organisation and types of machine used, etc.

Following are the different methods of on-cost allocation:

- Percentage on direct material cost.
- Percentage on direct labour cost.
- Percentage on prime cost.
- Manhour method.
- Machine hour method.
- Combination of man hour and machine hour method.
- Unit of production method.
- Space rate method.

These methods for estimation the overheads are discussed below:

Percentage on Direct Material Cost

This method is based on the theory that the overhead expense is incurred in proportion to the value of the direct materials consumed. This method is simple, but does not allow for the usual situation where in some of the materials is fabricated without the use of much equipment whereas other material in the same plant requires extensive machinery, requiring considerably more labour, power, maintenance and floor space.

However, for the allocation of material expenses such as purchasing, storage and handling, this method is useful. This method is also useful when major part of the cost is of material line foundries and mines.

$$\text{Overhead rate} = \frac{\text{Total overhead expenses}}{\text{Total direct material cost}}$$

Percentage on Direct Labour Cost

In this method, allocation of on-cost depends upon the wages paid to the direct labour. This method is very reasonable and simple in calculation. Therefore, this method is very popular. It is the ratio of the total overhead to the direct labour cost for a particular period.

$$\text{Overhead rate} = \frac{\text{Total overhead for a period}}{\text{Total direct labour for that period}}$$

It is also called as labour burden rate. It is the ratio of the annual total overheads to the annual direct labour cost.

Overhead cost = Overhead rate X Direct labour cost/unit.

This is very suitable where production is mainly carried out by hand. It may not be an accurate indicator where machines of greatly different capacity and sizes are operated. Also if two products take the same time but labour rate for both is different then this method will give less overhead cost where labour is cheap and high overhead cost where labour is costly. Therefore, this method increases the cost of a component which has already higher labour cost. Also, in many case it gives very approximate results because sometimes of overhead such as depreciation and taxes have very little relationship to labour costs.

Percentage on Prime Cost

This is a very simple method. So it has gained popularity. This method is suitable, where labour and material both play equal role. This method will give the same overhead cost for two products with equal prime cost, even though their labour and material costs will be different. This will be useful where only one type of product is being manufactured and when direct labour and direct materials costs are nearly equal.

$$\text{Overhead rate} = \frac{\text{Total overhead over a period}}{\text{Prime cost over a period}} \times 100$$

Then, overhead cost/unit = Overhead rate X Prime cost/unit.

Man-Hour Rate

This method is very similar to the percentage on direct labour cost method. The difference in the two methods is that in which the basis of allocation was the total direct labour cost, whereas in this basis of the total hours spent by the direct labour and not the wages paid to them. This is an important method over the direct labour cost method.

$$\text{Man-hour rate} = \frac{\text{Total overheads}}{\text{Total direct man hour spent}}$$

Unit Rate Method

This is also known as production unit basis method. In this, on-cost is allocated on the basis of unit of production. Unit of production is generally piece, kilogram, tonne, litres, metre, etc. This method is mostly used where only one type of production is carried out. This method cannot be used in factories, where different kinds of products are manufactured. Unit rate is the overheads for one unit. It can be calculated as the ratio of total overheads to the quantity of production during a particular period.

$$\text{Overhead/Unit} = \frac{\text{Total overheads}}{\text{Quantity of production}}$$

Space Rate Method

The amount of space occupied by a machine has a relationship to certain overhead expenses. For example, building expense, heat, light, ventilation and service equipment such as cranes and conveyors

Space rate/m^2 for a department is

$$\text{Rs.} = \frac{\text{Total overhead assigned to a department}}{\text{Total area of the production department in square metre}}$$

∴ Space charges to the individual machine for the defined period of time = Space rate × Total area with which the machine should be charged.

14. A factory has 15 lathes of same make and capacity and 5 shapers of same make and capacity. Lathes occupy 30 m^2 area while shapers occupy 15 m^2. During one calender year, factory expenses for this section area are as follows:

(i) **Building rent and depreciation**	**Rs. 5000**
(ii) **Indirect labour and material**	**Rs. 15000**
(iii) **Insurance**	**Rs. 2000**
(iv) **Depreciation charges of lathes**	**Rs. 5000**
(v) **Depreciation charges of shapers**	**Rs. 3000**
(vi) **Power consumption for the lathes**	**Rs. 2000**
(vii) **Power consumption for the shapers**	**Rs. 1000**

Find out the machine hour rate for lathes and shapers work for 25000 hours and 8000 hours respectively. (16 marks) (AU N/D '12) (AU A/M '18)

Solution

(a) Lathe section

Total overheads for the lathe section will be as follows:

(i) Building rent and depreciation (charged on the basis of floor area occupied)
= (5000 × 30) / (30 + 15)
= Rs. 3333.33

(ii) Indirect labour and material = (15000 × 30) / (30 + 15)
= Rs.10000

(iii) Insurance = (2000 × 30) / (30 + 15)
= Rs. 1333.33

(iv) Depreciation = Rs. 5000

(v) Power = Rs. 2000

∴ Total overheads = Rs. 21666.66

∴ Machine hour rate for lathes = 21666.66 / 25000
= Rs. 0.87

(b) Shaper section

Total overhead for the shaper section will be as follows

(i) Building rent and depreciation = (5000 ×15) / (30+15)
= Rs. 1666.66

(ii) Indirect labour and material = (15000×15) / (30+15)
= Rs.5000

(iii) Insurance = (2000 ×15) / (30+15)
= Rs. 666.66
(iv) Power consumption = Rs. 1000.00
(v) Depreciation = Rs. 3000.00
Total overheads = Rs. 11332.32
∴ Machine hour rate for shapers = 11332.32/ 8000
= Rs. 1.42

15. Calculate prime cost, factory cost, production cost, total cost and selling price per item from the data given below for the year 2003-04.

Cost of raw material in stock as on 1-04-2003	**Rs. 25,000**
Raw material purchased	**Rs. 40,000**
Direct labour cost	**Rs. 14,000**
Direct expenses	**Rs. 1,000**
Factory/Works overhead	**Rs. 9,750**
Administrative expenditure	**Rs. 6,500**
Selling and distribution expenses	**Rs. 3,250**
No. of items produced	**Rs. 650**
Cost of raw material in stock as on 31-03-2004	**Rs. 15,000**

Net profit/item is 10 percent of total cost of the product.

(16 marks) (AU N/D '14)

Solution :

For 650 units produced during 2003-04

(i) Direct material used = Stock of raw material on 1-04-2003 + raw material purchased – stock of raw material on 31-03-2004
= 25,000 + 40,000 – 15,000
= Rs. 50,000

(ii) Direct labour = Rs. 14,000
(iii) Direct expenses = Rs. 1,000
Prime cost = 50,000 + 14,000 + 1,000
= Rs. 65,000

Factory cost = Prime cost + Factory expenses
= 65,000 + 9,750
= Rs. 74,750

Production cost = Factory cost + Administrative expenses
= 74,750 + 6,500
= Rs. 81,250

Total cost = Production cost + Selling expenses
= 81,250 + 3,250
= Rs. 84,500

Selling price = 84,500 + 10 percent of 84,500
= 84,500 × 1.10 = Rs. 92,950

$$\text{Prime cost/item} = \frac{65,000}{650} = \text{Rs. } 100$$

$$\text{Factory cost/item} = \frac{74,750}{650} = \text{Rs. } 115$$

$$\text{Production cost/item} = \frac{81,250}{650} = \text{Rs. } 125$$

$$\text{Total cost/item} = \frac{84,500}{650} = \text{Rs. } 130$$

$$\text{Selling price/item} = \frac{92,950}{650} = \text{Rs. } 143$$

16. From the following data for a sewing machine manufacturer, prepare a statement showing prime cost, Works/factory cost, production cost, total cost and profit.

	Rs.
Value of stock of material as on 1-04-2003	**26,000**
Material purchased	**2,74,000**
Wages to labour	**1,20,000**
Depreciation of plant and machinery	**8,000**
Depreciation of office equipment	**2,000**
Rent, taxes and insurance of factory	**16,000**
General administrative expenses	**3,400**
Water, power and telephone bills of factory	**9,600**
Water, lighting and telephone bills of office	**2,500**
Material transportation in factory	**2,000**
Insurance and rent of office building	**2,000**
Direct expenses	**5,000**
Commission and pay of salesman	**10,500**
Repair and maintenance of plant	**1,000**
Works Manager salary	**30,000**
Salary of office staff	**60,000**
Value of stock of material as on 31-03-2004	**36,000**
Sale of products	**6,36,000**

(16 marks) (AU N/D '13)

Solution :

(*i*) Material cost = Opening stock value + Material purchases – Closing balance
= 26,000 + 2,74,000 – 36,000
= Rs. 2,64,000

Prime cost = Direct material cost + Direct labour cost + Direct expenses
= 2,64,000 + 1,20,000 + 5,000
= Rs. 3,89,000

(*ii*) Factory overheads are :

	Rs.
Rent, taxes and insurance of factory	16,000
Depreciation of plant and machinery	8,000
Water, power and telephone bill of factory	9,600
Material transportation in factory	2,000
Repair and maintenance of plant	1,000

Work Manager salary	30,000
Factory overheads or Factory cost	**66,600**

Factory cost = Prime cost + Factory expenses
= 3,89,000 + 66,600
= Rs. 4,55,600

(*iii*) Administrative/office expenses are :

	Rs.
Depreciation of office equipment	2,000
General administrative expenses	3,400
Water, lighting and telephone bills of office	2,500
Rent, insurance and taxes on office building	2,000
Salary of office staff	60,000
Total	**69,900**

Production cost = Factory cost + Office expenses
= Rs. 4,55,600 + Rs. 69,900
= Rs. 5,25,500

(iv) Selling overheads are :

Commission and pay to salesmen = Rs. 10,500

Total cost = Production cost + Selling expenses
= 5,25,500 + 10,500
= Rs. 5,36,000

(v) Profit = Sales – Total cost
= 6,36,000 – 5,36,000
= Rs. 1,00,000

17. In a manual operation, observed time for a cycle of operation is 0.5 minute and the rating factor as observed by the time study engineer is 125%. All allowances put together is 15% of N.T. (Normal Time). Estimate the Standard Time.

(8marks) (AU N/D '2014)

Solution :

Observed time for a cycle = 0.5 min.
Rating factor = 125%
Normal time = Observed time × Rating factor
= 0.5 × 1.25
= 0.625 min.
Allowances = 15% of Normal Time
Standard Time = Normal Time + Allowances
= 0.625 min. + (0.15 × 0.625) min.
= 0.625 min. + 0.094 min.
= 0.719 min.
= 0.72 min.

18. In a manufacturing process, the observed time for 1 cycle of operation is 0.75 min. The rating factor is 110%. The following are the various allowances as % of normal time :

Personal allowance = 3%
Relaxation allowance = 10%
Delay allowance = 2%

Estimate the standard time. (8 marks) (AU N/D '2014)

Solution :

Basic time or normal time = Observed time × Rating factor
= 0.75 min × 110%
= 0.75 × 1.1
= 0.825 min.

Standard time = Normal time + All allowances
= Normal time + [3% + 10% + 2%] of normal time
= 0.825 min. + (0.15 × 0.825) min.
= 0.825 min. + 0.124 min.
= 0.949 min.
= 0.95 min.

Standard time is the basis for calculation of standard output (*i.e.*, no. of components produced) in 1 day or in 1 shift (of 8 hours). Incentive schemes are based on the standard output.

19. From the records of an oil mill, the following data are available,

***(a)* Raw materials**

Opening stock	**= Rs. 1,40,000**
Closing stock	**= Rs. 1,00,000**
Total purchases during the year	**= Rs. 2,00,000**

***(b)* Finished goods**

Opening stock	**= Rs. 20,000**
Closing stock	**= Rs. 30,000**
Sales	**= Rs. 6,00,000**

***(c)* Direct wages**	**= Rs. 1,00,000**
***(d)* Factory expenses**	**= Rs. 1,00,000**
***(e)* Non-manufacturing expenses**	**= Rs. 85,500**

Find out what price should be quoted for a product involving an expenditure of Rs. 35,000 in material and Rs. 45,000 wages. Factory expenses to labour cost is 100%. (16marks) (AU M/J '2012)

Solution

Direct material cost = Opening stock + Total purchases – Closing stock
= 1,40,000 + 2,00,000 – 1,00,000
= Rs. 2,40,000

Direct material cost = Rs. 2,40,000

Direct wages = Rs. 1,00,000

Factory expenses = Rs. 1,00,000

Factory cost = Direct material + Direct labour + Factory overheads

= 2,40,000 + 1,00,000 + 1,00,000

= Rs. 4,40,000/-

Non-manufacturing expenses = Rs. 85,000

Total cost = Factory cost + Non-manufacturing expenses

= 4,40,000 + 85,000

= Rs. 5,25,000/-

Factory expenses of direct labour cost = 100%

Non-manufacturing expenses = 85000/4, 40,000 = 19.31%

Cost of finished goods = Opening stock + cost of goods – Closing stock

= 20,000 + 5,25,000 – 30,000

= 5,15,000

Cost of finished goods = Rs. 5,15,000/-

Total sales = Rs. 6,00,000

Profit = Rs. 6,00,000 – 5,15,000

Profit to sales cost = 85,000/5,15,000 = 16.5%

The cost of the product to be quoted is listed down as follows:

Direct material cost = Rs. 35,000

Direct labour cost = Rs. 45,000

Factory expenses = 100% of wages

= Rs. 45,000

Factory cost = Direct material cost + Labour cost + Factory expenses

= 35000 + 45000 + 45000 = 1,25,000

Factory cost = Rs. 1,25,000

Administrative and selling expenses = Non-manufacturing expenses

= 19.31% of factory cost

= Rs. 24,137.50

Total cost = 1,25,000 + 24137.50

= Rs. 1,49,137.50

Total cost = Rs. 1,49,137.50

Profit = 16.5% total cost

= Rs. 24,607.68

Profit = Rs. 24,607,68/-

Quotation price = 1,49,137.50 + 24,607.68 = 1,73,745.1875

Quotation price = Rs. 1,73,745.1875/-

Selling price = Total cost + Profit

= 3410 + 682 = Rs. 4092/-

Cost per unit = 4092 / Number of units

= 4092 / 50

= Rs. 81.84

List price = Selling price + Discount

= Selling price + 20% list price

Let us assume 'list price' be ('x/-Rs.')

Now, x = 81.84 + (20x/100)

x = 81.84 + 0.2 x

0.8 x = 81.84

x = 102.30

List price = Rs. 102.30.

20. Calculate the selling price per unit from the following data :

Direct material cost = Rs. 8,000

Direct labour cost = 60 percent of direct material cost

Direct expenses = 5 percent of direct labour cost

Factory expenses = 120 percent of direct labour cost

Administrative expenses = 80 percent direct labour cost

Sales & distribution expenses = 10 percent of direct labour cost

Profit = 8 percent of total cost

No. of pieces produced = 200 (16 marks) (AU A/M '17) (AU N/D 17)

Solution :

Direct material cost = Rs. 8,000

Direct labour cost = 60 percent of direct material cost

$$= \frac{60 \times 8{,}000}{100} = \text{Rs. } 4{,}800$$

Direct expenses = 5 percent of direct labour cost

$$= \frac{4{,}800 \times 5}{100} = \text{Rs. } 240$$

Prime cost = 8,000 + 4,800 + 240

= Rs. 13,040

Factory expenses = 120 percent of direct labour cost

$$= \frac{4{,}800 \times 120}{100} = \text{Rs. } 5{,}760$$

Administration Expenses = 80 percent of direct labour cost

$$= \frac{4{,}800 \times 80}{100} = \text{Rs. } 3{,}840$$

Sales and distribution expenses = 10 percent of direct labour cost

$$= \frac{10 \times 4{,}800}{100} = \text{Rs. } 480$$

Total cost = Prime cost + Factory expenses + Office expenses + Sales and distribution expenses

= 13,040 + 5,760 + 3,840 + 480

= Rs. 23,120

Profit = 8 percent of Total cost

$$= \frac{23,120 \times 8}{100} = \text{Rs. } 1,849.60$$

= Rs. 1,850 (say)

Selling price = Total cost + Profit
= 23,120 + 1,850
= Rs. 24,970

$$\text{Selling price 1 unit} = \frac{24,970}{200} = \text{Rs. } 124.85$$

$$= \text{Rs. } 125$$

21. Describe the various components of job estimate. (16 marks) (AU N/D '17)

Components of a cost estimate or job estimate

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

1. Cost of design.
2. Cost of drafting.
3. Cost of research and development.
4. Cost of raw materials.
5. Cost of labour.
6. Cost of inspection.
7. Cost of tools, jigs and fixtures.
8. Overhead cost.

1. Cost of Design

The cost of design of a component or product is estimated by ascertaining the expected time for the design of that component. This may be done on the basis of similar job previously manufactured but for new and complicated jobs the estimator has to consult the designer who gives the estimated time of design. The estimate design time multiplied by the salary of designer per unit time gives the estimated cost of design. If the design of the component is done by some outside agency, the total amount paid to outside agency gives the cost of design.

2. Cost of Drafting

Once the design of the component is complete, its drawings have to be prepared by draftsman. The expected time to be spent in drawing or drafting is estimated and is then multiplied by the standard drafting rate or by the salary of the draftsman per unit time to get estimated cost of drafting.

3. Cost of Research and Development Work

Before taking up the manufacturing of actual components/parts considerable time and money has to be spent on research and development. The research may be theoretical, experimental or developmental research. The cost of R and D can be estimated by considering various items of expenditure incurred during R and D work which include :

(i) Cost of labour involved.
(ii) Cost of material used.
(iii) Cost of special equipment used or fabricated for the prototype.

(iv) Depreciation, repair and maintenance cost of experimental set-up.

(v) Cost of services of highly qualified and trained personnel needed for experimentation.

(vi) Cost of preparing Test Reports, if any.

In some cases the cost of R and D may be estimated on the basis of research involved in similar products produced in the past.

4. Cost of Raw Material

The estimation of cost of materials used in production of a component/product consists of following steps:

(i) A list of all the materials used in the manufacture of the product is made which includes the direct as well as indirect materials.

(ii) The quantity (weight or volume) of all the material expected to be used in the manufacture of the product is estimated. The allowance for material wastage, spoilage and scarp are also added for each component/part.

(iii) Cost of each material is estimated by multiplying the estimated quantity of each material with its estimated future price. The estimate of future price of a material is made keeping in view of present prices and general trends and variations.

(iv) Estimated cost of all the materials is added to get the overall estimated material cost.

5. Cost of Labour

The cost of labour involved in the manufacture of a product is estimated by estimating the labour time needed to manufacture the product and multiplying it by cost of labour per hour. In order to estimate the labour time expected to be spent on a job, one must have thorough knowledge of the various operations to be performed, machines to be used, sequence of operations, tools to be used and labour rates. For this purpose, the estimator may consult engineers, supervisors or foremen from production or industrial engineering departments.

6. Cost of Inspection

A product being manufactured is inspected at various stages during its manufacture. It may be inspection of raw material or in-process inspection or inspection of finished goods. The cost of inspection equipment, gauges and consumable involved in the inspection and testing are taken into account while estimating the cost of the product.

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, fixtures and dies required in the production. The cost of tools, jigs, fixtures etc., is estimated considering their present prices, market trend and the number of times a particular tool can be used during its life-time. The estimated cost divided by the number of jobs, it can make, gives the tool cost per unit produced.

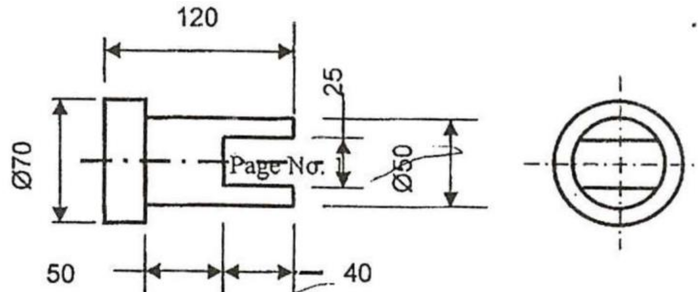
8. Overhead Costs

Overhead or indirect costs are those which are not incurred specifically for any one order or product and these cannot be charged directly to a specific order or product. The overhead costs may be estimated by referring to the records of overhead costs in similar items produced in past. The overhead cost per unit varies considerably with the volume of production *i.e.* number of components produced.

Unit – 4 Production Cost Estimation

Part – A

1. **Estimate the weight of the component shown in fig. the material is CI (AU A/M '18)**



Volume of the component = volume of A + Volume of B – Volume of C

$= (\frac{\pi}{4}d^2l) + (\frac{\pi}{4}d^2l) - (b \times l)$

$= \left(\frac{\pi}{4} \times 70^2 \times 30\right) + \left(\frac{\pi}{4} \times 50^2 \times 90\right) - (50 \times 25)$

= 115454 + 176715 +1250

= 290919 cm^3

Weight of the component = Volume x Density

Assume density of CI = 7.2 g/cc

Weight of the component = 290919 x 7.2

= 2094617 g = 2094.62 kg

2. **What are the causes of depreciation? (AU A/M '18)**

Depreciation due to physical condition

- Wear and tear
- Physical decay
- Accident
- Poor maintenance of equipment

Depreciation due to functional conditions

- Inadequacy
- Obsolescence

3. **Give the formula for calculating the cost of power consumed in arc welding (AU N/D '17)**

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

V = voltage in volts

A = current in amperes

t = welding time in minutes

η = efficiency of the welding machine

r = ratio of operating time to connecting time taken by operator

C = rate of electricity per kWhr in Rs

4. **Define roll forging (AU N/D '17)**

Roll forging is used to draw out sections of bar stock, *i.e.*, reducing the cross-section and increasing the length. Special roll forging machines, with dies of decreasing cross-section are used for roll forging.

5. **List the losses to be considered in estimating the gross weight of a forging component? (AU M/J '16) (AU N/D '16) (AU N/D '14) (AU N/D '13) (AU A/M '17)**
   - Scale loss
   - Flash loss
   - Tonghold loss
   - Sprue loss
   - Shear loss
6. **Differentiate leftward and rightward welding. (AU N/D '16) (AU A/M '18)**

   Leftward welding: In this method, welding is started from right hand side of the joint and proceeds towards left. This method is used for welding plates upto 5 mm thick. No edge preparation is required in case of the plates of thickness upto 3 mm.

   Rightward welding: This method is adopted for welding thicker plates. Welding proceeds from left to right. The flame is directed towards the deposited metal and rate of cooling is very slow.
7. **Brief about the procedure to calculate material cost. (AU N/D '15)**

   Direct material cost = Gross weight × Price/kg.

   Gross weight = Net weight + Material loss in the process.

   Net weight = Volume of forging × Density of metal.
8. **How can you calculate the labour cost for a turning process in lathe? (AU N/D '13)**

   Direct labour cost = $t \times l$

   Where t = Time for truning process per piece (in hrs)

   l = Labour rate per hour
9. **Define Flash loss (AU N/D '13)**

   There is a certain quantity of metal which comes between the flat surfaces of the two dies after the die cavity has been filled in. This material equal to the area of the flat surface is wastage. For finding the flash loss, the circumference is determined which multiplied by cross-sectional area of flash will give the volume of the flash. The volume multiplied by material density gives the flash loss. Generally, it is taken as 3 mm thick and 2 mm wide all round the circumference.
10. **What are the various elements considered while calculating the cost of a welded joint? (AU N/D '12)**

    The total cost of welding consists of the following elements :
    - Direct material cost.
    - Direct labour cost.
    - Direct other expenses.
    - Overheads.
11. **State any four pattern allowances. (AU N/D '12)**

    (i) Shrinkage Allowance

    (ii) Machining Allowance

    (iii) Draft Allowance

    (iv) Distortion Allowance

12. Define production cost (AU A/M '17)

Prime cost = Direct material cost + Direct labour cost + Direct expenses (if any)

Factory cost = Prime cost + Factory overheads

Cost of production = Factory cost + Administrative overheads + Miscellaneous overheads (if any)

13.What are overhead costs? (AU A/M '17)

Overhead expenses include all expenditure incurred by the manufacturer on the product except the direct material cost, direct labour cost and direct chargeable expenses.

(a) Indirect material expenses.

(b) Indirect labour expenses.(supervisors, inspectors, foremen, store-keeper, gatekeepers, repair and maintenance staff, crane drivers, sweepers, administrative office staff and sales and distribution staff, etc.)

(c) Other indirect.(water and electricity charges, rent of factory building, licence fee, insurance premia stationery, legal expenses, audit fee etc.

Part – B

1. **Market price of a CNC lathe is Rs. 50,000 and discount is 20% of market price. Here factory cost is 4 times selling cost and 1 : 4 : 2 is ratio of material, labour and overhead charges. Material cost is Rs. 4000. What is profit value?(16 marks) (AU M/J '16)**

Solution

Material cost	= 4000
From ratio, Labour cost	= 16,000/-
Overheat charges	= 8000/-
Factory cost	= 4000 + 16000 + 8000
	= Rs. 28000/-
Now selling price	= 28000 / 4
Total cost	= 28000 + 7000
	= Rs. 35000/-
Selling price	= Market rate – Discount
Profit	= Selling price – Total cost
	= 40000 – 35000
	= 5000

Company incurs Rs. 5000/- as profit.

2. **Explain the different items involved in the estimation of arc welding cost of job. (6 marks) (AU M/J '16) (AU N/D '16)**

Estimation of Cost in Welding

The total cost of welding consists of the following elements:

1. Direct material cost.
2. Direct labour cost.
3. Direct other expenses.
4. Overheads.

1. Direct Material Cost

The direct material cost in a welded component consists of the following :

- Cost of base materials to be welded *i.e.*, sheet, plate, rolled section, casting or forging. This cost is calculated separately.
- Cost of electrodes/filler material used. The electrode consumption can be estimated by using the charts supplied by the suppliers. Another way to find the actual weight of weld metal deposited is to weigh the component before and after the welding and making allowance for stub end and other losses during welding.

Also the weight of weld metal = Volume of weld × Density of weld material

2. Direct Labour Cost

The direct labour cost is the cost of labour for preparation, welding and finishing operations. Preparation or pre-welding labour cost is the cost associated with preparation of job for welding, *i.e.*, the edge preparation, machining the sections to be welded etc. If gas is used in cutting/preparation of edges, its cost is also taken care of.

Cost of labour in actual welding operation is calculated considering the time in which arc is actually in operation.

The cost of labour for finishing operation is the cost of labour involved in grinding, machining, sand or shot blasting, heat treatment or painting of welded joints.

3. Direct Other Expenses

The direct other expenses include the cost of power consumed, cost of fixtures used for a particular job etc.

Cost of power : The cost of power consumed in arc welding can be calculated from the

following formula :

$$\text{Power cost} = \frac{V \times A}{1{,}000} \times \frac{t}{60} \times \frac{1}{E} \times \frac{1}{r} \times C$$

Where V = Voltage

A = Current in Amperes

t = Welding time in minutes

E = Efficiency of the welding machine

= 0.6 for welding transformer

= 0.25 for welding generator

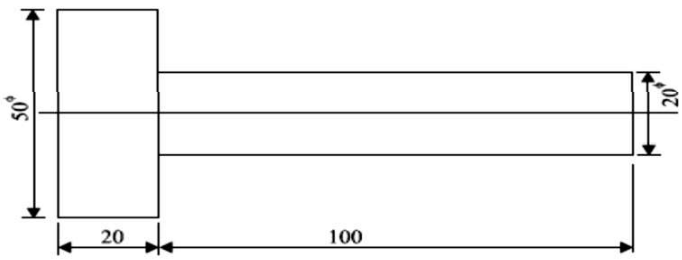
r = Ratio of operating time to connecting time taken by the operator

C = Cost of electricity per kWh *i.e.*, Unit.

Overheads

The overheads include the expenses due to office and supervisory staff, lighting charges of office and plant, inspection, transport, cost of consumables and other charges. The cost of equipment is also apportioned to the individual components in the form of depreciation.

3. **150 components, as shown in Fig. are to be made by upsetting a dia 20 mm bar. Calculate the net weight, gross weight and length of dia 20 mm bar required. The density of material may be taken as 7.86 gms/cc. (10 marks)(AU M/J '16)**



Solution :

$$\text{Net volume of material} = \frac{\pi}{4}\,[(5)^2 \times 2 + (2)^2 \times 10]$$

$$= \frac{\pi}{4}\,(50 + 40) = 70.72 \text{ cm}^3$$

$$\text{Net weight per component} = 70.72 \times 7.86 = 556 \text{ gms}$$

$$\text{Net weight for 150 components} = 556 \times 150 = 83{,}400 \text{ gms}$$

$$= 83.4 \text{ kgs}$$

Losses :

$$\text{Shear loss} = 5 \text{ percent of net weight}$$

$$= \frac{5}{100} \times 556 = 27.8 \text{ gms}$$

$$\text{Scale loss} = 6\% \text{ of net weight}$$

$$= \frac{6}{100} \times 556 = 33.4 \text{ gms}$$

$$\text{Gross weight/component} = 556 + 27.8 + 33.4$$

$$= 617 \text{ gms}$$

$$\text{Gross weight for 150 components} = 617 \times 150 = 92{,}550 \text{ gms}$$

$$= 92.550 \text{ kgs}$$

$$\text{Length of 20 mm f bar required} = \frac{92550}{\frac{\pi}{4}(2)^2 \times 7.86}$$

$$= 3744 \text{ cms} = 37.44 \text{ meters.}$$

4. **Two 1 m long M.S plates of 10 mm thickness are to be welded by a lap joint with a 8 mm electrode. Calculate the cost of welding. Assume the following data.**

(i) **Current used = 30 amperes**
(ii) **Voltage = 300 V**
(iii) **Welding speed = 10 m/hr**
(iv) **Electrode used = 0.1 kg/m of welding**
(v) **Labour charges = Rs. 4.00/hr**
(vi) **Power charges = Rs. 0.2/kWh**
(vii) **Cost of electrode = Rs. 40.00/kg**

(viii) Efficiency of machine = 70% (16 marks) (AU M/J '12)

Solution

(a) Cost of electrode required for 1 m length of welding = 0.1 kg

Cost of electrode as Rs. 40/kg = 40 × 0.1 = Rs. 4.

(b) Labour cost

Time required for welding 1 m length

$$= \frac{1}{10} \text{ hr}$$

Labour charge $= \frac{1}{10} \times 4 = \text{Rs. } 0.4$

(c) Power charges, as power consumed

$$= \frac{V \times I}{\text{Efficiency of the machine}}$$

$$= \frac{300 \times 30}{0.7} = 12.85 \text{ kW}$$

Energy consumed for welding 1 m length

$$= 12.85 \times \frac{1}{10} = 1.285 \text{ kWh}$$

Power charges at Rs. 0.1/kWh $= 1.28 \times 0.4$

$= \text{Rs. } 0.512$

Total welding cost = Cost of electrode + Labour charges + Power charges

$= 4 + 0.4 + 0.512 = \text{Rs. } 4.912.$

5. **Generalize the meaning of Tonghold loss in forging. (6 marks) (AU N/D '16)**

This is the loss of material due to a projection at one end of the forging to be used for holding it with a pair of tongs and turning it round and round to give the required cross section in drop forging. About 1.25 cm and 2.5 cm of the size of the bar is used for tonghold. The tonghold loss is equal to the volume of the protections. For example, the tonghold loss for a bar of 2 cm diameter will be

$$= \frac{\pi}{2}(2)^2 \times \mathbf{1.25}\ cu.cm$$

6. **State and explain various losses which are to be considered in a forging shop. (8 marks) (AU N/D '16) (AU N/D '17)**

Losses in Forging

It is well known that some metal is always lost in the different operations of forging and this lost metal must be added to the net weight before calculating the material cost. The different losses to be considered are:

a) Scale loss
b) Flash loss
c) Tonghold loss
d) Sprue loss
e) Shear loss

(i) Scale loss

This is the material lost because of the surface oxidation in heating and forging the piece. When iron is heated at a high temperature in atmospheric conditions a thin of iron oxide is formed all round the surface of the heated metal which goes as a waste. The iron oxide film is known as scale and it falls from the surface of the metal on being beaten up by the hammer. Scale loss depends upon the surface area, heating time and the type of material. For forgings under 5 kg loss is 7.5 per cent of the net weight, and for forgings from 5 to 12.5 kg and over an addition of 6 per cent and 5 per cent of the net weight is necessary for scale loss.

(ii) Flash loss

There is a certain quantity of metal which comes between the flat surfaces of the two dies after the die cavity has been filled in. This material equal to the area of the flat surface is a wastage. For finding the flash loss, the circumference is determined which multiplied by cross-sectional area of flash will give the volume of the flash. The volume multiplied by material density gives the flash loss. Generally, it is taken as 3 mm thick and 2 mm wide all round the circumference.

(iii) Tonghold loss

This is the loss of material due to a projection at one end of the forging to be used for holding it with a pair of tongs and turning it round and round to give the required cross section in drop forging. About 1.25 cm and 2.5 cm of the size of the bar is used for tonghold. The tonghold loss is equal to the volume of the protections. For example, the tonghold loss for a bar of 2 cm diameter will be

$$= \frac{\pi}{2}(2)^2 \times 1.25 \text{ cu.cm}$$

(iv) Sprue loss

The connection between the forging and tonghold is called the sprue or runner. The material loss due to this portion of the metal used as a contact is called sprue loss. The sprue must be heavy enough to permit lifting the workpiece out of the impression die without bending. The sprue loss is generally 7.5 per cent of the net weight.

(v) Shear loss

In forging, the long bars or billets are cut into required length by means of a sawing machine. The material consumed in the form of saw-dust or pieces of smaller dimensions left as defective pieces is called shear loss. This is usually taken as 5% of the net weight. From above we see that nearly 15 to 20% of the net weight of metal is lost during forging. And as already said these losses must be added to the net weight to get the gross weight of the material.

7. A factory produces 100 bolts and nuts per hour on a machine. Material cost is Rs. 375, labour Rs. 245 and direct expense is Rs. 80. The factory on cost is 150% and office on cost is 30%. If sales price is Rs. 11.30 find whether company incurs profit or loss. (10 marks) (AU N/D '15)

Solution

Material cost	= 375.00
Labour	= 245.00
Direct expenses	= 80.00
Factory expenses	= 150% of labour cost

	= 245 × 1.5 = Rs. 367.50
Factory cost	= 375 + 245 + 80 + 367.5
	= Rs. 1067.50
Office on cost	= 30% of factory cost
	= 1067.50 X 0.3
	= Rs. 320.25
Total cost	= 1067.50 + 320.25
	= 1387/-
Cost per nut	= 1387/100
	= 13.87/-
Sales price	= 11.30

Hence, company incurs a loss of Rs. 2.57/-.

8. Estimate the selling price per piece of a casting component from the following data :

Net weight of cast component	= 5.117 kg
Density of material	= 7.2 gms/cc
Cost of molten metal at cupola spout	= Rs. 20 per kg
Process scrap	= 20 percent of net weight
Scrap return value	= Rs. 6 per kg
Administrative overheads	= Rs. 30 per hour
Sales overheads	= 20 percent of factory cost
Profit	= 20 percent of factory cost

Other expenditures are:

Operation	*Time (min)*	*Labour cost/hr (Rs.)*	*Shop overheads/hr (Rs.)*
Moulding and pouring	15	20	60
Shot blasting	5	10	40
Fettling	6	10	40

(16 marks) (AU N/D '13)

(i) *Material cost :*

Net weight of cast component	= 5.117 kg
Process scrap	= 20 percent of 5.117 kg
	= 0.2 × 5.117 = 1.02 kg
Total metal required per component	= 5.12 + 1.02 = 6.14 kg
Cost of metal poured	= 6.14 × 20 = Rs. 122.8
Process return value	= 1.02 × 6 = Rs. 6.12
Material cost per component	= 122.8 – 6.1 = Rs. 116.7

(ii) *Labour cost and factory overheads :*

Labour cost	= Rs. 6.83
Shop overheads	= Rs. 22.33

Process	Time per piece (Minutes)	Labour cost per piece (Rs.)	Shop overheads per piece (Rs.)
Melting and pouring	15	5.00	15.00
Shot blast	5	0.83	3.33
Fettling	6	1.00	4.00
Total	**26 min**	**6.83**	**22.33**

(iii) Factory cost per component = 116.70 + 6.83 + 22.33 = Rs. 145.86

(iv) Administrative overheads = (30 × 26) /60 = Rs. 13

(v) Sales overheads = 0.2 × 145.86 = Rs. 29.17

(*vi*) Profit = 0.2 × 145.86 = Rs. 29.17

Selling price per component = Factory cost + Administrative overheads+ Sales overheads + profit

= 145.86 + 13 + 29.17 + 29.17

= Rs. 217.2

9. Calculate the net weight and gross weight for the component shown in Fig. Density of material used is 7.86 gm/cc. (6 marks)

Also calculate :

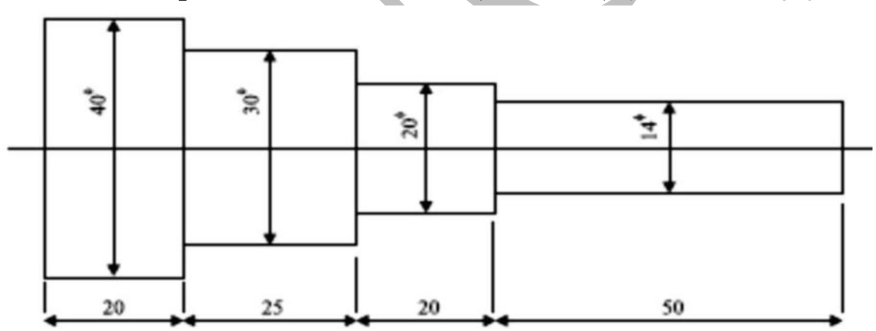
(i) Length of 14 mm dia bar required to forge one component. (4 marks)

(ii) Cost of forging/piece if: (6 marks)

Material cost = Rs. 80 per kg

Labour cost = Rs. 5 per piece

Overheads = 150 percent of labour cost. (16 marks) (AU N/D '13) (AU A/M '17)



$$\text{Net volume of forged component} = \frac{\pi}{4}\left[(4)^2 \times 2 + (3)^2 \times 2.5 + (2)^2 \times 2 + (1.4)^2 \times 5\right]$$

$$= \frac{\pi}{4}(72.3) = 56.76 \text{ cc}$$

$$\text{Net weight} = 56.76 \times 7.86 = 446 \text{ gms}$$

Losses :

Shear loss = 5 percent of net weight

$$= \frac{5}{100} \times 446 = 22.30 \text{ gms}$$

$$\text{Direct material cost} = \frac{696}{1{,}000} \times 8$$

$$= \text{Rs. } 5.57$$

$$\text{Direct labour cost} = \text{Rs. } 5 \text{ per piece}$$

$$\text{Overheads} = 150 \text{ percent f labour cost}$$

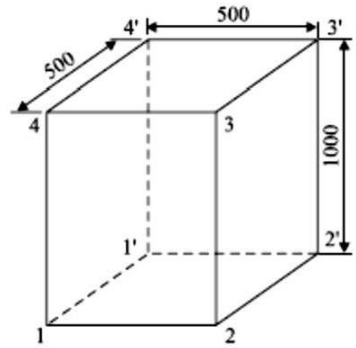
$$= 1.5 \times 5 = \text{Rs. } 7.5$$

$$\text{Cost per piece} = 5.57 + 5 + 7.5$$

$$= \text{Rs. } 18$$

10. A container open on one side of size 0.5 m × 0.5 m × 1 m is to be fabricated from 6 mm thick plates Fig. The plate metal weighs 8 gms/cc. If the joints are to be welded, make calculations for the cost of container. The relevant data is :

Cost of plate = Rs. 10 per kg
Sheet metal scarp (wastage) = 5 percent of material
Cost of labour = 10 percent of sheet metal cost
Cost of welding material = Rs. 20 per meter of weld. (16 marks) (AU A/M



Solution :

(i) To calculate material cost :

Net volume of material used = (4 × 50 × 100 × 0.6) + (50 × 50 × 0.6) = 13,500 cc

Net weight of container = Volume × density of material

= 13,500 × 8 = 1,08,000 gm = 108 kgs

Sheet metal scrap = 5 percent of net weight

$$= \frac{108 \times 5}{100} = 5.40 \text{ kgs}$$

Total weight of sheet metal required for fabrication of one container

= 108 + 5.4 = 113.4 kgs

Cost of sheet metal per container = 113.4 × 10 = Rs. 1134

(ii) To calculate labour charges :

Cost of labour = 10 percent of sheet metal cost

$$= \frac{1134 \times 10}{100} = \text{Rs. } 113$$

(iii) To calculate cost of welding material :

Length to be welded = (4 × 50) + (4 × 100) = 600 cm = 6 meters

Cost of welding material = 6 × 20 = Rs. 120

(iv) Cost of container = Cost of sheet metal material + Cost of labour + Cost of welding material

= 1134 + 113 + 120 = Rs. 1367

11. Work out the welding cost for a cylindrical boiler drum 2 ½ × 1 m diameter which is to be made from 15 mm thick m.s plates. Both the ends are closed by arc welding of circular plates to the drum. Cylindrical portion is welded along the longitudinal seam and welding is done both in inner and outer sides. Assume the following data:

(i) Rate of welding = 2 meters per hour on inner side and 2.5 meters per hour on outer side

(ii) Length of electrodes required = 1.5 m/ meter of weld length

(iii) Cost of electrode = Rs. 0.60 per meter

(iv) Power consumption = 4 kWh/meter of weld

(v) Power charges = Rs. 3/kWh

(vi) Labour charges = Rs. 40/hour

(vii) Other overheads = 200 percent of prime cost

(viii) Discarded electrodes = 5 percent

(ix) Fatigue and setting up time = 6 percent of welding time. (16 marks) (AU N/D '17) (AU A/M '18)

Diameter of drum = 1 meter

Length of drum = 2.5 meter

As the cylindrical portion is welded on both sides and both the ends are closed by welding circular plates, the welding on circular plates being on one side only.

Length of weld = 2 × p × dia of drum + (2 × length of drum)

= 2 × p × 1 + (2 × 2.5)

= 11.28 meters ≈ 11.3 meters.

(i) To calculate direct material cost: In this example the cost of electrodes is the direct materiel cost.

Length of electrode required = 1.5 m/m of weld

Net electrode length required for 11.3 meters weld length = 1.5 × 11.3 = 16.95 meters

Discarded electrode = 5 percent

Total length of electrodes required = 16.95 + [(5 × 16.95)/100] = 17.8 meters

Cost of electrodes = 0.6 × 17.8 = Rs. 10.68.

(ii) To calculate direct labour cost: To calculate the labour charges, first we have to calculate the time required for making the weld (assuming that side plates have single side welding and longitudinal seam is welded on both sides).

Length of weld on inside of drum = 2.5 meter

Length of weld on outside of drum = 2 × p × 1 + (2.5) = 8.8 meters

Time taken for inside weld = (2.5 × 1)/2 = 1.25 hrs

Time taken for outside weld = (8.8 × 1)/2.5 = 3.5 hrs

Net time required for welding = 1.25 + 3.5 = 4.75 hrs

Fatigue and setting up allowances = 4.75 × 0.06 = 0.28 hrs

Total time required = 4.75 + 0.28 = 5 hrs

Direct labour cost = 40 × 5 = Rs. 200

(iii) To calculate cost of power consumed

Power consumption = 4 × 11.3 = 45.2 kWh

Cost of power consumed = 45.2 × 3 = Rs. 135.6

(iv) To calculate the overhead charges:

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

Prime cost = 10.68 + 200 + 135.60 = Rs. 346

Overheads = (200 x 346)/100 = Rs. 692

(v) Total cost of making boiler drum = 10.68 + 200 + 135.6 + 692 = Rs. 1038

12. List the various sections that will be normally found in a foundry shop. (4 marks) (AU N/D '17)

Generally a foundry shop has the following sections :

1. Pattern Making Section

In this section the patterns for making the moulds are manufactured. The machines involved in making the patterns are very costly and small foundries may not be able to afford these machines. In such cases the pattern are got made for outside parties who are specialists in pattern making. Patterns are made either from wood or from a metal.

2. Sand-mixing Section

In this section raw sand is washed to remove clay etc., and various ingredients are added in the sand for making the cores and moulds.

3. Core-making Section

Cores are made in this section and used in moulds to provide holes or cavities in the castings.

4. Mould Making Section

This is the section where moulds are made with the help of patterns. The moulds may be made manually or with moulding machines.

5. Melting Section

Metal is melted in the furnace and desired composition of metal is attained by adding various constituents. Metal may be melted in a cupola or in an induction or in an arc furnace. In some cases pit furnace is also used for melting the metals.

6. Fettling Section

The molten metal after pouring in the moulds is allowed to cool and the casting is then taken out of mould. The casting is then cleaned to remove sand and extra material and is shot blasted in fettling section. In fettling operation risers, runners and gates are cut off and removed.

7. Inspection Section

The castings are inspected in the inspection section before being sent out of the factory.

Unit– 5 Machining Time Calculation

Part – A

1. Write steps involved in cutting time calculation (AU A/M ’18)

Step 1: Calculation of length of cut (L)

Step 2: Calculation of feed (f) and depth of cut

Step 3: Calculation of speed (S); [rpm (N) = 1000 S/ πD]

Step 3: Calculation of machining time by using the formula ($\frac{L}{f \times N}$)

2. What are the typical data required for cutting time calculation in shaping (AU A/M 75

Shaping time T_m = [{L x B x (1+ k)} / (1000 v f)] x number of cuts

B = width of the work

N = Number of stroke/min

f = Feed/stroke in mm

V = Cutting speed m/min

K = Return time/Cutting time

3. Write short notes on tear down time (AU N/D ’17)

It is the time taken to remove the tools, jigs and fixtures from the machine and to clean the machine and tools after the operation has been done on the last component of batch. The tear down time is usually small. The tear down time occurs only once for a complete lot or batch taken for machining. Standard data are available for tear down time for various machines.

4. Give the formula for estimation of machining time for drilling (AU N/D ’17)

Time for drilling = $\frac{\text{Depth of hole to be produced}}{\left(\frac{\text{feed}}{\text{rev}}\right) \times (\text{rpm})} = \frac{L}{f \times N}$

5. Define cutting speed. List various factors affecting cutting speed. (AU N/D ’16) (AU A/M ’17)

Cutting speed is the speed at which the cutting edge of tool passes over the job and it is usually expressed in meters per minute. The cutting speed depends on the cutting tool material, the work piece material and the operation. Once the cutting speed has been selected, the revolutions per minute of job/machine are calculated as follows:

$$S = \pi DN/1000 \text{ or } N = 1000\ S/\ \pi D$$

Where S = Surface cutting speed in meters per minute

D = Diameter of the job in mm

N = r.p.m. of machine/job.

6. What is machining time? (AU N/D ’16)

It is the time for which the machine works on the component, i.e. from the time when the tool touches the work piece 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.

7. Derive an expression for machining time in planning machine. (AU N/D ’11)

Planing time Tm = [(L + 250) (B + 50) (1+ k)] / (1000 v f)

B = width of the work

N = Number of stroke/min

f = Feed/stroke in mm

V = Cutting speed m/min

K = Return time/Cutting time

8. Derive an expression for machining time for plain turning in lathe. (AU N/D '10)

Turning, on a lathe, is the removal of excess material form the workpiece by means of a pointed tool, to produce a cylindrical or cone shaped surface. From cutting speed, r.p.m. of job are calculated by using the formula.

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

where N = r.p.m. of job

S = Surface cutting speed in meters/minute

D = Diameter of the stock to be turned (in mm)

if f = Feed per revolution (in mm)

L = Length of stock to be turned (in mm)

T = Time required for turning (in minutes)

$$\text{Then } T = \frac{L}{f\ X\ N}$$

9. What are the different types of milling operations? (AU M/J '07)

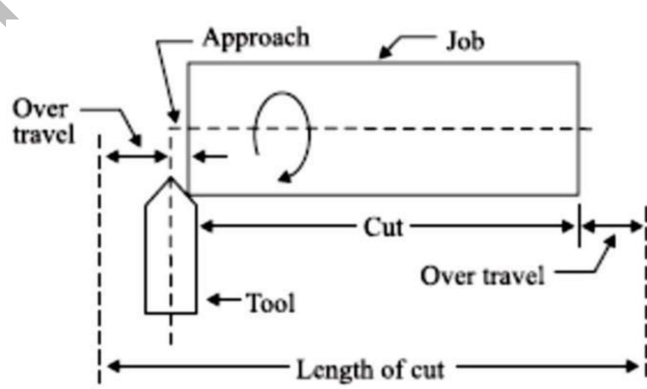
- Face milling
- Slab milling
- Profile milling
- Keyway cutting
- Slotting

10. Define tool approach and tool travel (AU A/M '17)

Length of cut : It is the distance travelled by the tool to machine the work piece and is calculated as follows :

Length of cut (L) = Approach length + Length of work piece to be machined + Over travel

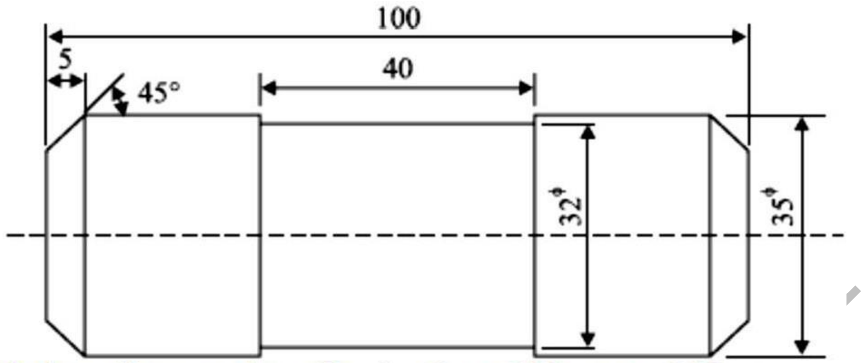
Approach is the distance a tool travels, from the time it touches the work piece until it is cutting to full depth. Over travel is the distance the tool is fed while it is not cutting. It is the distance over which the tool idles before it enters and after it leaves the cut. These terms are explained in the Fig. for a cutting operation on lathe.



Total tool travel = length of job + approach + over travel

Part – B

1. **A mild steel bar 100 mm long and 38 mm in diameter is turned to 35 mm dia. And was again turned to a diameter of 32 mm over a length of 40 mm as shown in the Fig. 5.23. The bar was machined at both the ends to give a chamfer of 45° × 5 mm after facing. Calculate the machining time. Assume cutting speed of 60 m/min and feed 0.4 mm/rev. The depth of cut is not to exceed 3 mm in any operation. (16 marks)(AU N/D'16) (AU N/D'17)**



Solution : *Ist operation* : Turning from f 38 mm to f 35 mm

$$S = 60 \text{ meters/min.}$$

$$D = 38 \text{ mm}$$

$$N = \frac{1{,}000\ S}{\pi D} = \frac{1{,}000 \times 60}{\pi \times 38}$$

$$= 503 \text{ r.p.m.}$$

$$\text{Time taken} = \frac{\text{Length of cut}}{\text{r.p.m.} \times \text{Feed/rev.}}$$

$$= \frac{100}{503 \times 0.4} = 0.5 \text{ min.}$$

2nd operation : External relief

$$L = 40 \text{ mm.}$$

$$D = 35 \text{ mm.}$$

$$S = 60 \text{ m/min.}$$

$$N = \frac{60 \times 1{,}000}{\pi \times 35} = 545 \text{ r.p.m.}$$

$$\text{Time taken for second operation} = \frac{\text{Length}}{\text{r.p.m.} \times \text{Feed/rev.}}$$

$$= \frac{40}{545 \times 0.4} = 0.18 \text{ min.}$$

3rd operation : Facing of both ends

$$L = \text{Length of cut}$$

$$= \frac{35}{2} = 17.5 \text{ mm}$$

$$D = 35 \text{ mm}$$

$$S = 60 \text{ m/min}$$

$$N = \frac{60 \times 1{,}000}{\pi \times 35} = 545 \text{ r.p.m.}$$

$$\text{Time for facing one end} = \frac{17.5}{0.4 \times 545} = 0.08 \text{ min}$$

$$\text{Time for facing both ends} = 2 \times 0.08 = 0.16 \text{ min}$$

4th operation : Chamfering 45° × 5 mm

$$\text{Length of cut} = 5 \text{ mm}$$

$$N = 545 \text{ r.p.m.}$$

$$\text{Time taken for chamfering on one side} = \frac{5}{545 \times 0.4} = 0.02 \text{ min}$$

$$\text{Time taken for chamfering on both sides} = 0.02 \times 2 = 0.04 \text{ min}$$

$$\text{Total machining time} = 0.50 + 0.18 + 0.16 + 0.04$$

$$= 0.88 \text{ min}$$

2. **Find the time required to drill 4 holes in a cast iron flange each of 2 cm depth, if the hole diameter is 2 cm. Assume cutting speed as 21.9 m/min. and feed as 0.02 cm/rev. (8 marks) (AU N/D '16)**

Solution

Depth of hole = 2 cm = 20 mm

Diameter of hole = 2 cm = 20 mm

Cutting speed = 21.9 m/min

Feed = 0.02 cm/rev,

Depth hole = *l* + 0.3 d

= 2 + 0.3 (2) = 2.6

Number of holes = 4

(i) N = (1000 V) / π D

= (1000 x 21.9) / 3.14 x 20

= 350 rpm

(ii) T_m = Depth of hole / (Feed x rpm)

= 2.6 / (0.02 x 350)

= 0.3714 min

(ii) Time for drilling four holes = 0.3714 × 4 = 1.486 min.

3. **A keyway has to be cut in spindle whose dimensions are 40 cm long 4 cm diameter with a 1 cm width. The cutter diameter is 10 cm. If the cutter is revolving at 120 rpm, what time will be required to cut one cm deep keyway at a feed of 0.05 cm/rev of cutter? (8 marks)(AU N/D '16)**

$$\text{Table travel} = \sqrt{d(D-d)} + 0.5 = \sqrt{1(10-1)} + 0.5 = 3.5 \text{ cm}$$

$$\text{Total table movement} = 40 + 35 = 43.5 \text{ cm}$$

$$\text{Time required} = \frac{\text{Total table travel}}{N \times \text{Feed}}$$

$$= \frac{43.5}{120 \times .05} = 7.25 \text{ min.}$$

4. **A 20 × 5 cm CI surface is to be faced on a milling m/c with a cutter having a diameter of 10 cm and having 16 tooth for the cutting speed and feed are 50 m/min and 5 cm/min respectively, determine the milling time, rpm, and feed/tooth. (8 marks) (AU N/D '15)**

$$N = \frac{1000 \times V}{\pi \times D} = \frac{1000 \times 50}{\pi \times 100} = 160 \text{ rpm}$$

$$\text{Feed/min} = f_t = n \times N = f_t \times 16 \times 160$$

$$\text{Feed/tooth } f_t = \frac{50}{16 \times 160} = 0.0196 \text{ mm}$$

$$\text{Milling time T} = \frac{L + \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right] + 7}{(f_t \times n) \times N}$$

$$= \frac{200 + \frac{1}{2}\left[100 - \sqrt{100^2 - 50^2}\right] + 7}{0.0196 \times 16 \times 160}$$

$$\boxed{T = 4.27 \text{ min}}$$

5. **A T-slot is to be cut in a C.I. slab as shown in Fig. Estimate the machining time. Take cutting speed 25 m/min, feed is 0.25 mm/rev. Dia of cutter for channel milling is 80 mm. (16 marks) (AU N/D '14) (AU N/D '17)**

Solution:

The T-slot will be cut in two steps :

Step I : Cut a 20 mm wide and 35 mm deep channel along the length

Dia of cutter = 80 mm

Cutting speed = 25 m/min

Length of job = 260 mm

$$\text{r.p.m. of cutter} = \frac{25 \times 1000}{\pi \times 80} = 100$$

$$\text{Over travel} = \sqrt{Dd - d^2}$$

$$= \sqrt{80 \times 35 - 35^2} = 40 \text{ mm}$$

$$\text{Total tool travel} = 260 + 40 = 300 \text{ mm}$$

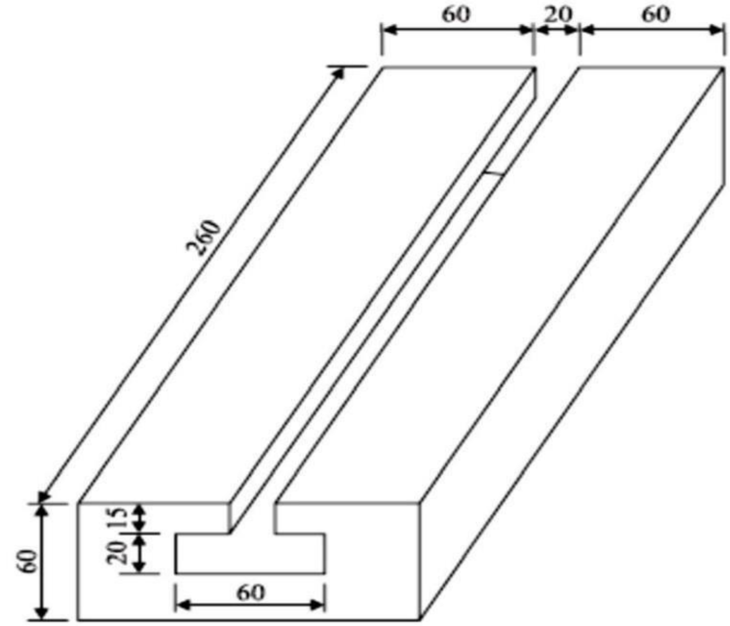
$$\text{Time for cutting slot} = \frac{\text{Length of cut}}{\text{Feed/min.}}$$

$$= \frac{300}{0.25 \times 100} = 12 \text{ min.}$$

$$\text{r.p.m. of cutter} = \frac{25 \times 1{,}000}{\pi \times 60} = 133$$

In this case

since



***Step II* :** Cut T-slot of dimensions 60 × 20 with a T-slot cutter
Here dia of cutter = 60 mm

80

Total time to cut T-slot = 12 + 8.7
= 20.7 minutes

6. Calculate the machining time required to produce one piece of the component shown in Fig. given below starting from f 25 mm bar. The following data is available. (16 marks) (AU N/D '14) (AU N/D '13)

For turning:

Cutting speed = 40 m/min.

Feed = 0.4 mm/rev.

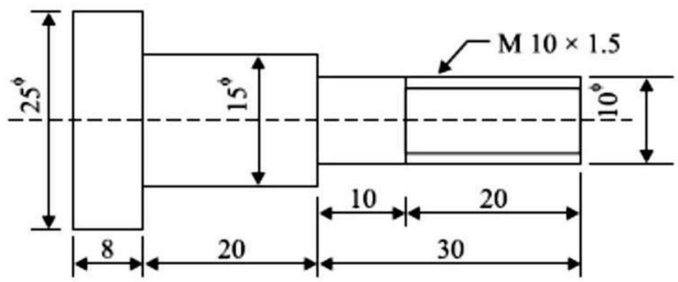
Depth of cut = 2.5 mm/per pass

For thread cutting:

Cutting speed = 8 m/min.

As depth of material to be removed is

(25 – 15)



it will be accomplished i

Average Dia = D_{av}

Spindle r.p.m. = $\frac{40}{2}$

Time taken = $\frac{50}{637 \times 0.4}$ = 0.2 min.

Solution:

Step 1 **:** Time for turning to 15 mm dia from 25 mm dia.

For 2 cuts time taken = 0.4 min.

Step 2 **:** Turning from 15 mm to 10 mm dia over a length of 30 mm in one pass

$$N = \frac{40 \times 1{,}000}{\pi \times 15} = 850 \text{ rev/min.}$$

$$\text{Time taken} = \frac{30}{0.4 \times 850} = 0.09 \text{ min.}$$

Step 3 **:** Threading

$$N = \frac{8 \times 1{,}000}{\pi \times 10} = 255 \text{ r.p.m.}$$

$$\text{Feed} = \text{pitch} = 1.5 \text{ mm}$$

$$\text{Threads per cm} = \frac{10}{1.5} = \frac{100}{15}$$

$$\text{No. of cuts} = \frac{25}{\text{Threads per cm}}$$

$$= \frac{25 \times 15}{100} = 3.75 = 4 \text{ cuts}$$

$$\text{Time for one cut} = \frac{\text{Length of cut}}{\text{Feed/rev.} \times \text{r.p.m.}}$$

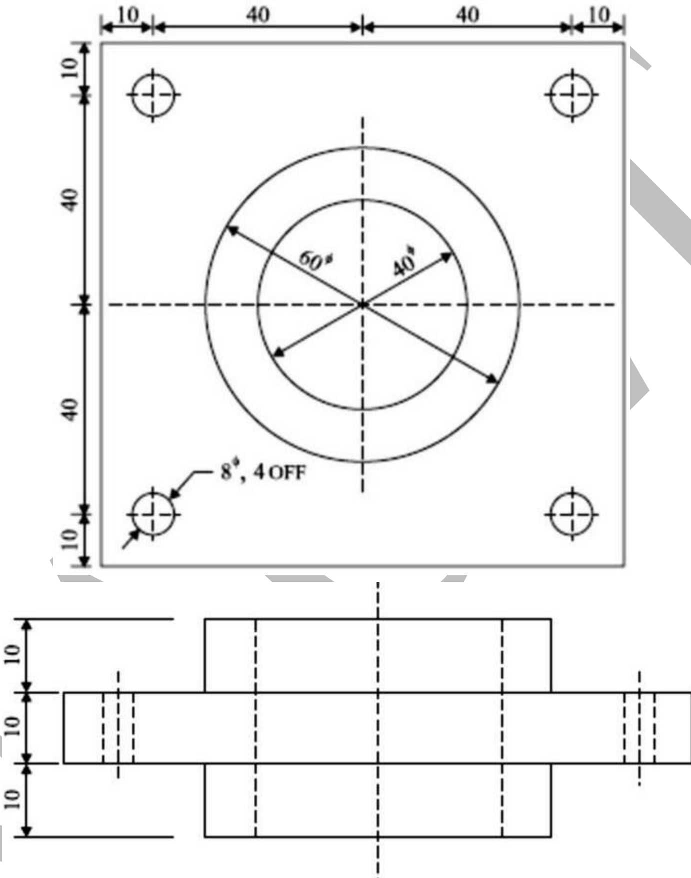
$$= \frac{20}{1.5 \times 255} = 0.05 \text{ min.}$$

Time for 4 cuts = 0.05 × 4 = 0.2 min.

Total time for producing one component = 0.4 + 0.09 + 0.2

= 0.69 min.

7. **Calculate the machining time to drill four 8 mm dia holes and one 40 mm dia central hole in the flange shown in Fig. 20 mm dia hole is drilled first and then enlarged to 40 mm f hole. Take cutting speed 10 m/min, feed for 8 mm drill 0.1 mm/rev, for 20 mm drill feed is 0.2 mm/rev. and for 40 mm f drill feed is 0.4 mm/rev. (16 marks) (AU A/M '17) (AU A/M '18)**



Solution :

(*i*) Time to drill four 8 mm dia holes

S = 10 m/min.

Dia of drill D = 8 mm.

L = 10 mm

f = 0.1 mm/rev.

$$N = \frac{S \times 1{,}000}{\pi D} = \frac{10 \times 1{,}000}{\pi 8}$$

$$= 398 \text{ r.p.m.}$$

$$\text{Time taken to drill one hole} = \frac{L}{f \times N} = \frac{10}{0.1 \times 398}$$

$$= 0.25 \text{ min.}$$

$$\text{Time to drill 4 holes} = 0.25 \times 4 = 1 \text{ minute.}$$

(ii) Time to drill one hole of 40 mm diameter :

This hole is made in two steps :

(a) Drill 20 mm £ hole — 30 mm long

$$N = \frac{10 \times 1,000}{\pi \times 20} = 159 \text{ r.p.m.}$$

$$\text{Time taken} = \frac{30}{0.2 \times 159} = 0.95 \text{ min.}$$

(ii) Enlarge 20 mm £ hole with 40 mm £ drill

Here $$N = \frac{10 \times 1,000}{\pi \times 40} = 80 \text{ r.p.m.}$$

$$f = 0.4 \text{ mm/rev.}$$

$$\text{Time taken} = \frac{30}{0.4 \times 80} = 0.94 \text{ min.}$$

Total time taken to drill all the holes = 1.0 + 0.95 + 0.94
= 2.9 min.

11. Find the time required on a shaper to machine a plate 600 mm × 1,200 mm, if the cutting speed is 15 meters/min. The ratio of return stroke time to cutting time is 2 : 3. The clearance at each end is 25 mm along the length and 15 mm on width. Two cuts are required, one roughing cut with cross feed of 2 mm per stroke and one finishing cut with feed of 1 mm per stroke. **(8 marks) (AU N/D '17)**

Solution :

S = 15 m/minute

Length of stroke = L = Length of plate + clearance on both sides
= 1200 + 2 × 25 = 1,250 mm.

Cross travel of table = W = Width of job + clearance
= 600 + 2 × 15 = 630 mm.

K =2/3 = 0.67

Cross feed for rough cut = 2 mm/stroke

Cross feed for finish cut = 1 mm/stroke

$$\text{Time for one complete stroke} = \frac{L(1+K)}{1000 \times S}$$

$$= \frac{1,250(1+0.67)}{1,000 \times 15}$$

$$= 0.14 \text{ min}$$

$$\text{No. of strokes for roughing cut} = \frac{\text{Cross travel of table}}{\text{Feed/stroke (Roughing)}}$$

$$= \frac{630}{2} = 315$$

$$\text{No. of strokes for finishing cut} = \frac{\text{Cutting travel of table}}{\text{Feed/stroke (Finishing)}}$$

$$= \frac{630}{1} = 630$$

Total no. complete strokes required = 630 + 315 = 945

Total machining time = 945 × 0.14 = 132 min.