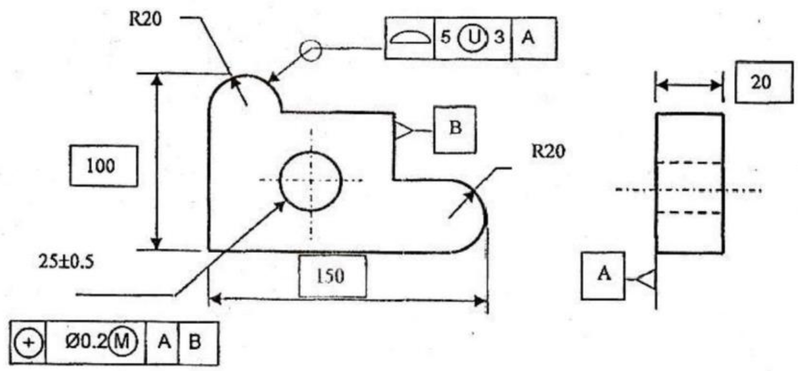
Unit -1 Introduction to Process Planning

Part A

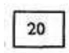
1. What are the details required for process planning? (AU A/M '18)

- 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

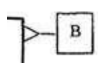
2. Study the drawing shown in fig and interpret any one geometric tolerance symbol (AU A/M '18)



Symbols used for Geometric tolerance



Boxed dimension (theoretically exact)



Datum indication


Circular or cylindrical tolerance

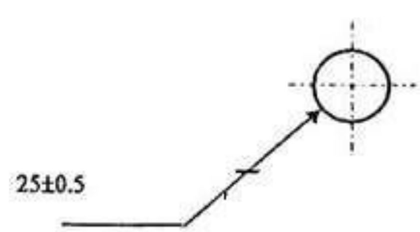

Location (position)

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.

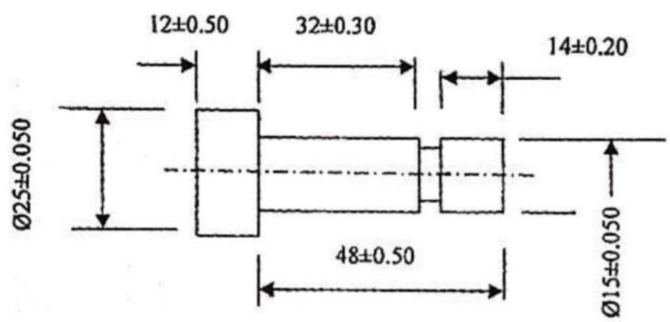
Source code

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.

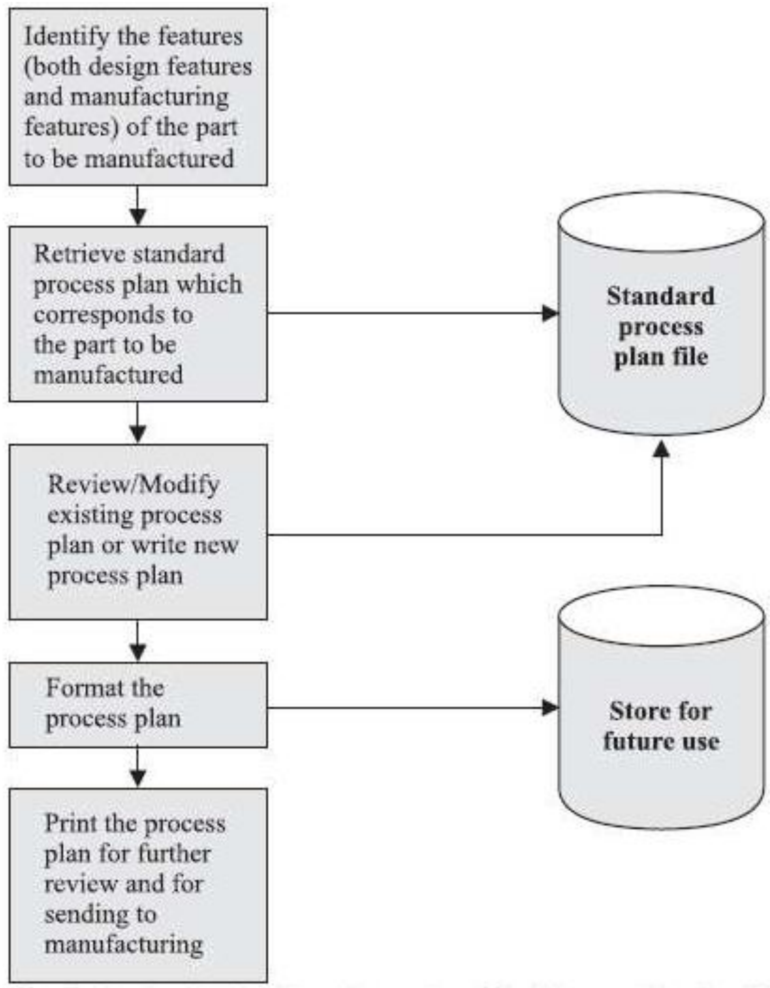
The manual approach to process planning begins when a detailed engineering drawing and data on batch size are issued to a production engineer. This information is used to determine the following:

- 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

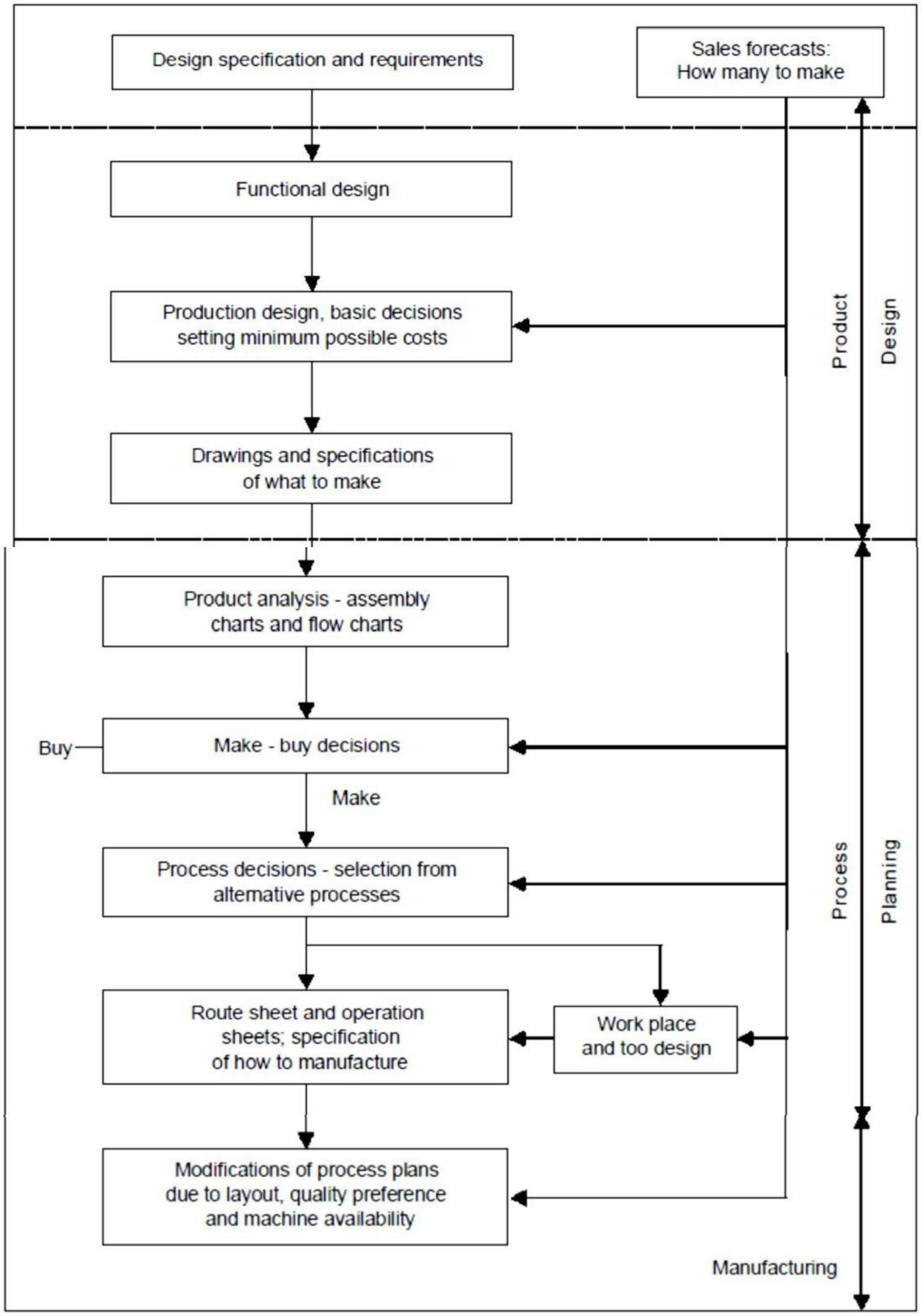
The purpose of process planning is to determine and describe the best process for each job so that,

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.

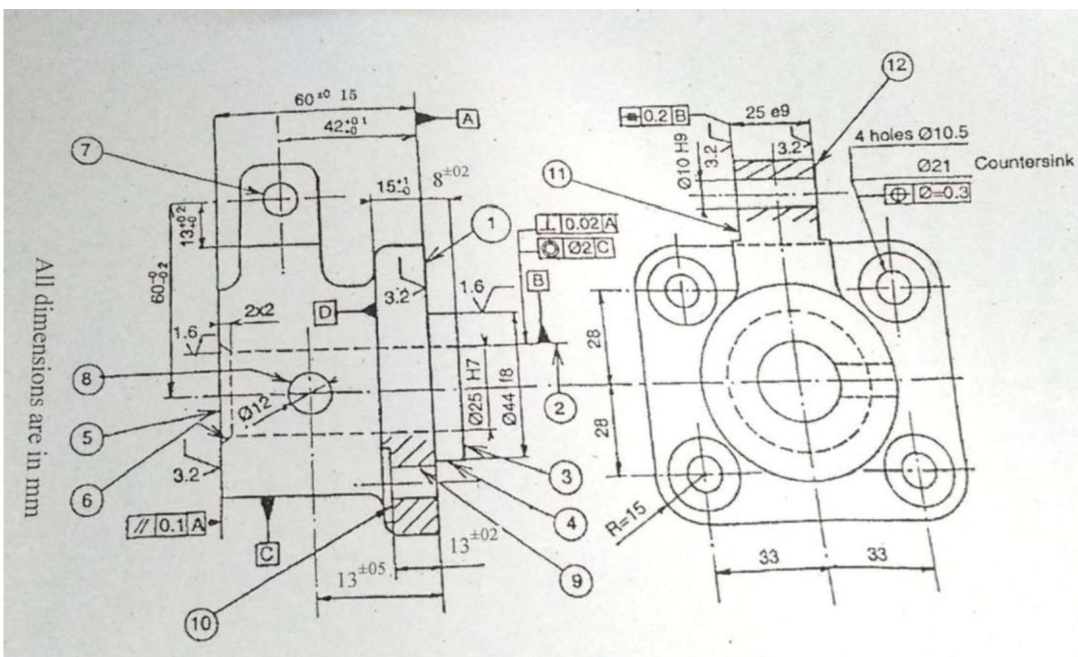
The route sheet is a listing of the sequence of operations which must be performed on the component. It is called a route sheet because it also lists the machines through which the part must be routed in order to accomplish the sequence of operations.

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. Dimensional tolerance symbols

Parallelism

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

Position

⌖	Ó = 0.3

Perpendicularity

⊥	0.02	A

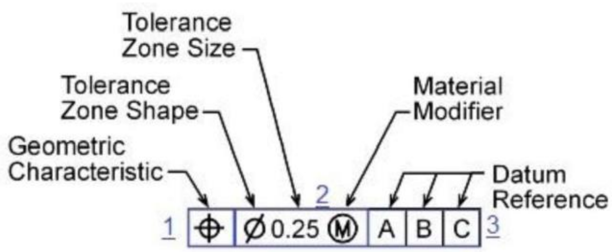
Symmetry

≡	0.2	B

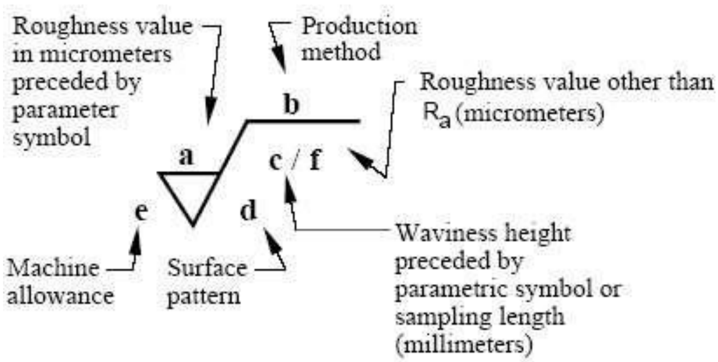
Concentricity

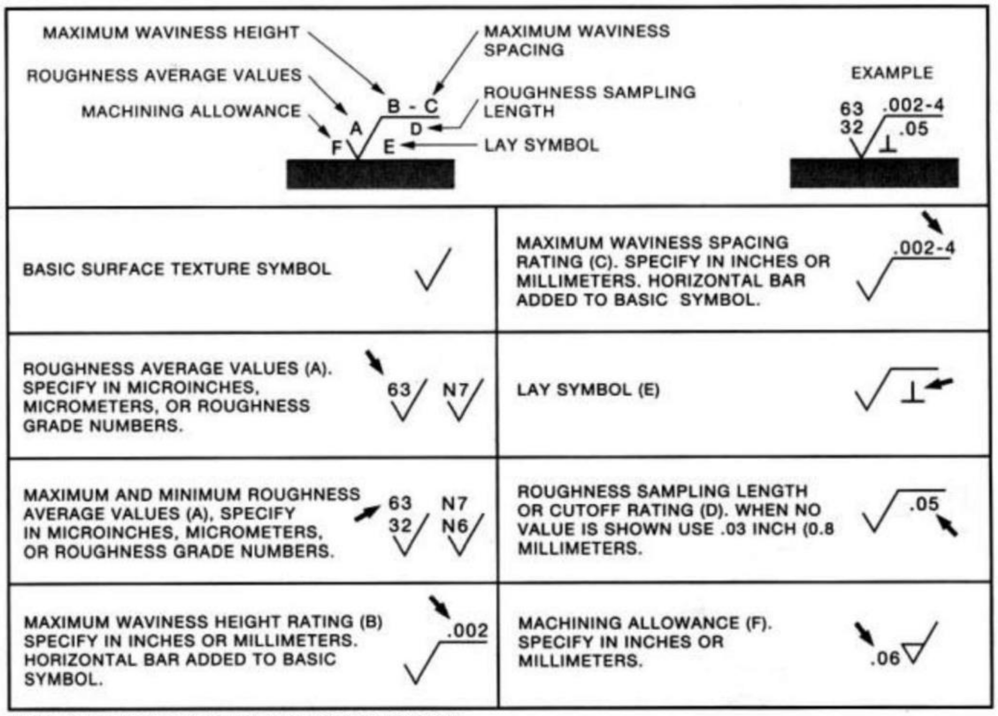
◎	Ó 2	C

b. Form tolerance feature control frame



b. Surface finish symbols





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