ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

1.PROCESS PLANNING:

Process planning is a preparatory step before manufacturing, which determines the sequence of operations or processes needed to produce a part or an assembly. This step is more important in job shops, where one-of-a-kind products are made or the same product is made infrequently.

Planning processes can result in increased output, higher precision, and faster turnaround for vital business tasks. A process is described as a set of steps that result in a specific outcome. It converts input into output.

Process planning is also called manufacturing planning, material processing, process engineering, and machine routing. It is the act of preparing detailed work instructions to produce a part. It is a complete description of specific stages in the production process.

Process planning determines how the product will be produced or service will be provided. Process planning converts design information into the process steps and instructions to powerfully and effectively manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to make simpler and improve process planning and realize more effectual use of manufacturing resources.

It has been documented that process planning is required for new product and services. It is the base for designing factory buildings, facility layout and selecting production equipment. It also affects the job design and quality control.

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

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

The task of process planning consists of determining the manufacturing operations required to transform a part from a rough (raw material) to the finished state specified on the engineering drawing.

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

"Process planning is a detailed specification which lists the operations, tools, and facilities. Process planning is usually accomplished in manufacturing department.

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

According to the American Society of Tool and Manufacturing Engineers. "process planning is the systematic determination of the methods by which a product is to be manufactured, economically and competitively."

It consists of

(î) the selection of manufacturing processes and operations, production equipment, tooling and jigs & fixtures;

(ii) determination of manufacturing parameters; and

(iii) specification of selection criteria for the quality assurance (QA) methods to ensure product quality

Importance of Process Planning

Process planning establishes the link between engineering design and shop floor manufacturing. Since process planning determines how a part / product will be manufactured, it becomes the important determinant of production costs and profitability. Also, production process plans should be based on in-depth knowledge of process and equipment capabilities, tooling availability, material processing characteristics, related costs, and shop practices.

The economic future of the industry demands that process plans that are developed should be feasible, low cost, and consistent with plans for similar parts.

In addition, process planning facilitates the feedback from the shop floor to design engineering regarding the manufacturability of alternative.

Process planning is an intermediate stage between designing the product and manufacturing.

Objective of Process Planning:

The chief of process planning is to augment and modernize the business methods of a company. Process planning is planned to renovate design specification into manufacturing instructions and to make products within the function and quality specification at the least possible costs. This will result in reduced costs, due to fewer staff required to complete the same process, higher competence, by eradicating process steps such as loops and bottlenecks, greater precision, by including checkpoints and success measures to make sure process steps are completed precisely, better understanding by all employees to fulfil their department objectives. Process planning deals with the selection of the processes and the determination of conditions of the processes.

The particular operations and conditions have to be realised in order to change raw material into a specified shape. All the specifications and conditions of operations are included in the process plan. The process plan is a certificate such as engineering drawing. Both the engineering drawing and the process plan present the fundamental document for the manufacturing of products. Process planning influences time to market and productions cost. Consequently, the planning activities have immense importance for competitive advantage.

PRINCIPLES OF PROCESS PLANNING:

General principles for evaluating or enhancing processes are as follows:

1. First define the outputs, and then look toward the inputs needed to achieve those outputs.
2. Describe the goals of the process, and assess them frequently to make sure they are still appropriate. This would include specific measures like quality scores and turnaround times.
3. When mapped, the process should appear as a logical flow, without loops back to earlier steps or departments.
4. Any step executed needs to be included in the documentation. If not, it should be eliminated or documented, depending on whether or not it's necessary to the process.
5. People involved in the process should be consulted, as they often have the most current information.
6. Process planning includes the activities and functions to develop a comprehensive plans and instructions to produce a part. The planning starts with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are routings which specify operations, operation sequences, work centers, standards, tooling and fixtures. This routing becomes a major input to the manufacturing resource planning system to define operations for production activity control purposes and define required resources for capacity requirements planning purposes.

Process plans which characteristically offer more detailed, step-by-step work instructions including dimensions linked to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints.

Process plans results in fabrication and assembly drawings to support manufacture and annual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. But process planning is very lengthy and the results differ based on the person doing the planning.

MAJOR STEPS IN PROCESS PLANNING:

Process planning has numerous steps to complete the project that include the definition, documentation, review and improvement of steps in business processes used in a company.

Definition:

The first step is to describe what the process should accomplish. It includes queries like, what is the output of this process? Who receives the output, and how do they define success?, What are the inputs for the process?, Are there defined success measures in place - such as turnaround time or quality scores? And Are there specific checkpoints in the process that need to be addressed.

Documentation:

During the documentation stage, interviews are conducted with company personnel to determine the steps and actions they take as part of a specific business process. The results of these interviews is written down, generally in the form of a flow chart, with copies of any forms used or attached. These flow charts are given to the involved departments to review, to make sure information has been correctly captured in the chart.

Review:

Next, the flow charts are reviewed for potential problem areas.

Process planning in manufacturing may include the following activities:

1. Selection of raw-stock,
2. Determination of machining methods,
3. Selection of machine tools,
4. Selection of cutting tools,
5. Selection or design of fixtures and jigs,

6. Determination of set-up,
7. Determination of machining sequences,
8. Calculations or determination of cutting conditions,
9. Calculation and planning of tool paths,
10. Processing the process plan

ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

2. METHODS OF PROCESS PLANNING:

The two general methods / approaches to process planning are

1. Manual process Planning and
   (i) Traditional approach
   (ii) Workbench approach
2. Computer Aided Process Planning
   (i) Retrieval CAPP system
   (ii) Generative CAPP system

Manual process Planning

(i) Traditional approach

In traditional process planning systems, the process plan is prepared manually. The task involves examining and interpreting engineering drawing.

Making decisions on machining process selection, equipment selection, operations sequence, and shop practices.

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

The traditional process planning usually involves the following three stages, are;

Stage 1: The process planner interprets the component/product drawing using his own experience and intuition. Taking into account the type of resources available, he decides on how the component / product should be made. He lists the sequence of operations to be carried out in order to manufacture the product.

Stage 2: The process planner refers the manual to decide on tools, feeds, speeds. etc., for each element of each operation, Also the specific operation setup times and operation times for each operation are calculated using the manual.

Stage 3: Finally, the resulting process plan is documented as a routing sheet.

Workbook Approach

- The workbook approach is a modified version of traditional approach of process planning that uses the developed workbook for preparing route sheet.
- In this approach, the workbooks of predetermined sequence of operations for possible elements of operations of components / products arc developed. Once the drawing interpretation is carried out, the suitable predetermined sequence of operations are selected from the developed workbook and the details are documented in the route sheet.

Advantages of Manual Process Planning

The advantages of employing manual process planning are as follows:

(i) Manual process planning is very much suitable for small scale companies with few process plans to generate.

(ii) This method is highly flexible.

(iii) This requires low investment costs.

Disadvantages of Manual Process Planning

The disadvantages of manual process planning include the following:

(i) Manual process planning is a very complex and time consuming job requiring a large amount of data.

(ii) This method requires the skilled process planner.

(iii) More possibilities for human error because this method depends on the planner's skill, judgement and experience.

(iv) It increases paper work.

(v) Inconsistent process plans result in reduced productivity.

(vi) It is not very responsive to changing manufacturing environment, new processes, new tooling, new materials, etc.

COMPUTER AIDED PROCESS PLANNNG (CAPP)

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

- With the use of computers in the process planning, one can reduce the routine clerical work of manufacturing engineers.
- Also, it provides the opportunity to generate rational, consistent and optimal plans.
- In addition, CAPPprovides the interface between CAD and CAM.

Benefits of CAPP

The benefits of implementing CAPP include the following

- Process rationalization and standardization: CAPP leads to more logical and consistent process plans than manual process planning.
- Productivity improvement: As a result of standard process plan, the productivity is improved (due to more efficient utilization of resources such as machines, tooling, stock material and labour).
- Product cost reduction: Standard plans tend to result in lower manufacturingcosts and higher product quality.
- Elimination of human error

- Reduction in time: As a result of computerizing the work, a job that used to lake several days, is now done in a few minutes.
- Reduced clerical effort and paper work
- Improved legibility: Computer-prepared route sheets are neater and easier to read than manually prepared route sheets.
- Faster response to engineering changes: Since the logic is stored in the memory of the computer.
- Incorporation of other application programs: The CAPP program can be

interfaced with other application programs, such as cost estimating and work standards.

Approaches of CAPP

The two basic approaches or types of CAPP system are

1. Retrieval CAPP system
2. Generative CAPP system

1. Retrieval CAPP system

- A retrieval CAPP system, also called a variant CAPP system, has been widely used in machining applications.
- The basic idea behind the retrieval CAPP is that similar parts will have similar process plans.
- In this system, a process plan flit a new part is created by recalling, Identifying aid retrieving an existing plan for a similar part and making the necessary modifications for the new part.

Procedure for Using Retrieval CAPP System

A retrieval CAPP system is based on the principles of group technology (GT) and past classification and coding. In this system, for each part family a standard process plan (i.e., route sheet) is prepared and stored in computer files. Through classification and coding, a code number is generated. These codes are often used to identify the part (amity and the associated standard plan. The standard plan is retrieved edited for the new part.

Advantages of Retrieval CAPP system

- Once a standard plan has been written, a variety of parts can be planned.
- Comparatively simple programming and installation (compared with generative CAPP systems) is required to implement a planning System.
- The system is understandable, and the planner has control of the final plan.
- It is easy to learn and easy to use.

Drawbacks of Retrieval CAPP System

- The components to be planned are limited to similar components previously planned.
- Experienced process planners are still required to modify the standard plan for the specific component.

GENERATIVE CAPP SYSTEMS

- In the generative approach, the computer Is used to synthesize or generate each individual process plan automatically and without reference to any prior plan.
- A generative CAPP system generates the process plan based on decision logics and pre -coded algorithms, The computer stores the rules of manufacturing and the equipment capabilities (not any group of process plans).
- When using a system, a specific process plan for a specific part can be generated without army involvement of a process planner.
- The human role in running the system includes: (i) inputting the GT code of the given part design, and (ii) monitoring the function.

Components of a Generative CAPP System

The various components of a generative system are:

a. A part description, which identifies a series of component characteristics, including geometric features, dimensions, tolerances and surface condition.

b. A subsystem to define the machining parameters, for example using look-up tables and analytical results for parameters.

c. A subsystem to select and sequence Individual operations. Decision logic is used to associate appropriate operations with features of a component, and heuristics and algorithms are used to calculate operation steps, times and sequences.

d. A database of available machines and tooling.

e. A report generator which prepares the process pIan report

Advantages of Generative CAPP

The generative CAPP has the following advantages:

i. It can generate consistent process plans rapidly.

ii. New components can be planned as easily as existing components.

iii. It has potential for integrating with an automated manufacturing facility to provide detailed control information.

Drawbacks of Generative CAPP System:

The generative approach is complex and very difficult to develop.

ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

3.DRAWING INTERPRETATION AND MATERIAL EVALUATION

3.1 DRAWING INTERPRETAT1ON

Introduction

The first step in preparing the process plan for any component / project is the drawing interpretation.

The technical drawing is usually prepared by the design department, The drawing expresses certain functional requirements of the components / product under consideration.

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

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

A typical technical drawing containing a various information that are required for developing a process plan.

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

- Material of the component, its designation, its coding Number of parts to be produced
- Weight of the component
- Dimensions of the parts
- Dimensional and geometric tolerances of the different features of the part
- Size and accuracy of the parts. etc.

A Brief on Engineering Drawing

As we all know, the engineering drawing is known as universal language of engineers as the drawing is used as the most common form of communication among the engineers

For the purpose of process planning, the orthographic projection drawings are commonly employed in engineering drawings. The orthographic projection is the method of detailing a 3D object on a 2D plane using a number of different views viz., front, top, right hand and left hand side views.

The orthographic projection is used as an unambiguous and accurate way of providing information, primarily for manufacturing and detail design. However, this form of representation can make ii difficult to visualize objects. Pictorial views (such as perspective. isometric and oblique pictorial projections) can be created to give a more three dimensional impression of the object.

Types of Drawing

The three types of drawings used in the industry are:

1. Detail drawings,
   - (i) Single-part drawings, and
   - (ii) Collective drawings.
2. Assembly drawings, and
   - (i) Single-part assembly drawings, and
   - (ii) Collective assembly drawings.
3. Combined drawings.

1. Detail Drawings

- The detail drawings provide all the information required for manufacture of the required component / product
- This information include all dimensions, tolerances, surface finish specifications and material specifications.

Two types of detail drawings are:

(i) Single-part drawings, and

(ii) Collective singe-part drawings.

(i) Single-part Drawings

- A single-part drawings contain the complete detailed information to enable a single component to be manufactured without reference to other sources.
- Such single-part drawings define shape or form and size, and provide the required specifications.
- The drawings are fully dimensioned, including tolerances where necessary, to show all sizes and locations of the various features.
- The specification of the part includes information relating to the material used, the heat-treatment required and surface finish details.

(ii) Collective Single - Part Drawings

- The collective single-part drawings are used where one or two dimensions of a component are variable, all others being standard.
- Collective Single-Part drawing of a rivet
- The drawing covers 20 rivets similar in every respect except length.
- This type of drawings are generally used for basically similar pails where one or more dimensions differ from the rest.

2. Assembly Drawings

- Machines and mechanisms consist of numerous parts and a drawing which shows the complete product with all its components in their correct physical relationship Le known as an assembly drawing.
- A drawing which gives a small part of the whole assembly is known at sub-assembly drawing.

Two types of assembly drawings a,

(i) Single-part assembly drawing, and

(ii) Collective assembly drawing.

(i) Single-part assembly drawing

The single-part assembly drawing contains the information to build a single sub-assembly or assembly.

The assembly drawings provide the following information;

- Part list
- Quantity required of each component
- Overall dimensions
- Weight
- Material specifications
- Data regarding the design characteristics
- Operating details and instructions

(ii) Collective Assembly Drawings

The collective assembly drawing is used where a range of products which are similar in appearance but differing in size is manufactured and assembled. Typical collective assembly drawing of a nut with bolts of various lengths

It shows a typical collective assembly drawing of a nut with bolts of various lengths. A nut and bolt fastening is used to secure plates of different combined thickness; the nut is standard, but the bolts are of different lengths as shown.

3. Combined Detail and Assembly Drawings

A combined detail and assembly drawing show an assembly with part list and the derails of these parts on one drawing.

Such drawings arc more suited to small "one-off" or limited production-run assemblies. lt not only reduces the actual number of drawings, but also the drawing office time spent in scheduling and printing

INFORMATION ON THE DRAWING SHEET REQUIRED FOR PROCES PLANNING (CRITICAL PROCESSIÑG FACTORS)

The important Information derived from the drawings that are required for process planning include:

- Geometric and dimensions
- Material specifications
- Notes on special material treatments
- Dimensional tolerances specifications
- Geometrical tolerances specifications
- Surface finish specifications
- Tool references
- Gauge references
- Quantity to be produced
- Part lists
- Notes on equivalent parts
- Notes on screw thread forms

The process planners should have the clear knowledge on the above parameters and some of them are briefed below.

Dimensions

A drawing should provide complete dimensions of the component to ensure that the design intent can be mat of all stages of manufacture.

For our purpose of process planning. all dimensions can be classified into any one of the following three types.

1. Functional dimensions: These dimensions influence/affect the way in which part operates.

2. Non-Functional dimensions: These dimensions do not influence/affect the way

in which the part operates, but they can influence the efficiency of the part,

3. Auxiliary dimensions: Though these dimensions not related to the way the part operates, but they are required in order to manufacture the part.

Material Specifications

- The materials of the parts are to be stated as a specification in the drawing.
- The material evaluation and the most commonly used materials for manufacture are presented.

Special Material Treatments

In order to achieve the desired material] properties of the parts, the parts are treated. Those details should be mentioned as a note in the part drawings.

Tolerances, Limits and Fits

- To ensure that an assembly will function correctly, its component must fit together in a predictable manner.
- In practice, no component can be manufactured to an exact size, so the designer has to decide on appropriate upper and lower limits for each dimension.
- Accurately tolerance dimensioned features usually take much time to manufacture correctly and therefore can increase production cost significantly. Good engineering practice finds the optimum balance between required accuracy for the function of the component and minimum cost of manufacture.

Dimension Tolerances

If a dimension is specified, in millimeters, as 10±0.02, the part will be acceptable if the dimension is manufactured to an actual size between 9,98 and 10,02 mm.

General Tolerancing

General tolerance notes apply tolerances to all unspecified dimensions on a drawing. They can save time and help to make a drawing less clustered.

Example: Tolerance except where otherwise stated ±0.5.

LIMITS AND FITS FOR SHAFTS AND HOLES

Basic size and shaft / hole Tolerancing systems

The basic size or nominal size is the size of shaft or hole that the design specifies before applying the limits to it.

There are two systems used for specifying shaft/hole tolerances:

- Basic hole system: Starts with the basic hole size and adjusts shaft size to fit.
- Basic shaft system: Starts with the basic shaft size and adjusts hole Size to fit.

Because holes are usually made with standard tools such as drills and reamers, etc. the basic hole system tends to be preferred and therefore they are commonly used.

Fit

The fit represents the tightness or looseness resulting from the application of tolerances to mating parts, i.e. Shafts and holes.

Fits are generally classified as one of the following:

1. Clearance fit: Assemble/ dissemble by hand

Creates running and sliding assemblies. ranging from loose low cost to free-running high temperature change applications and accurate minimal play locations

2. Transition fit: Assembly usually requires press tooling or mechanical assistance of some kind.

Creates close accuracy with little or no interference.

3. Interference fit : Parts need to be forced or shrunk fitted together.

Creates permanent assemblies, that retain and locate themselves.

Geometrical Tolerancing

A geometrical tolerance limits the permissible variation of form, attitude or location of a feature of the component.

The various types of Geometrical Tolerancing are:

- Straightness tolerances
- Flatness tolerances
- Roundness tolerances
- Cylindricity tolerances
- Parallelism tolerances
- Squareness tolerances
- Angularity tolerances
- Concentricity tolerances
- Symmetry tolerances
- Position tolerances

Surface Finish

Surface finish is the depth of irregularities of a surface resulting from the manufacturing process used to produce it.

Three basic types of surface irregularities that can occur are:

Form error: The form error is for longer wavelength deviations of a surface from the corresponding nominal surface. Form errors result from large scale problems in the manufacturing process such as errors in a machine tool ways, guides or spindles, inaccurate alignment of workpiece.

Roughness: Roughness includes the finest (shortest wavelength) irregularities of a surface. Roughness generally results from a particular production process or material condition.

Waviness: Waviness includes the more widely spaced (longer wavelength) deviations of a surface from it nominal shape. Waviness is generally caused by machine vibration or heat. The surface texture is the combination of roughness and waviness.

Surface texture = Roughness + Waviness

Surface roughness symbols and surface texture symbols are used for indicating surface roughness and surface texture on components respectively.

3.2 MATERIAL SELECTION AND EVALUATION

INTRODUCTION

The second step in the process planning n material evaluation and process selection.

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

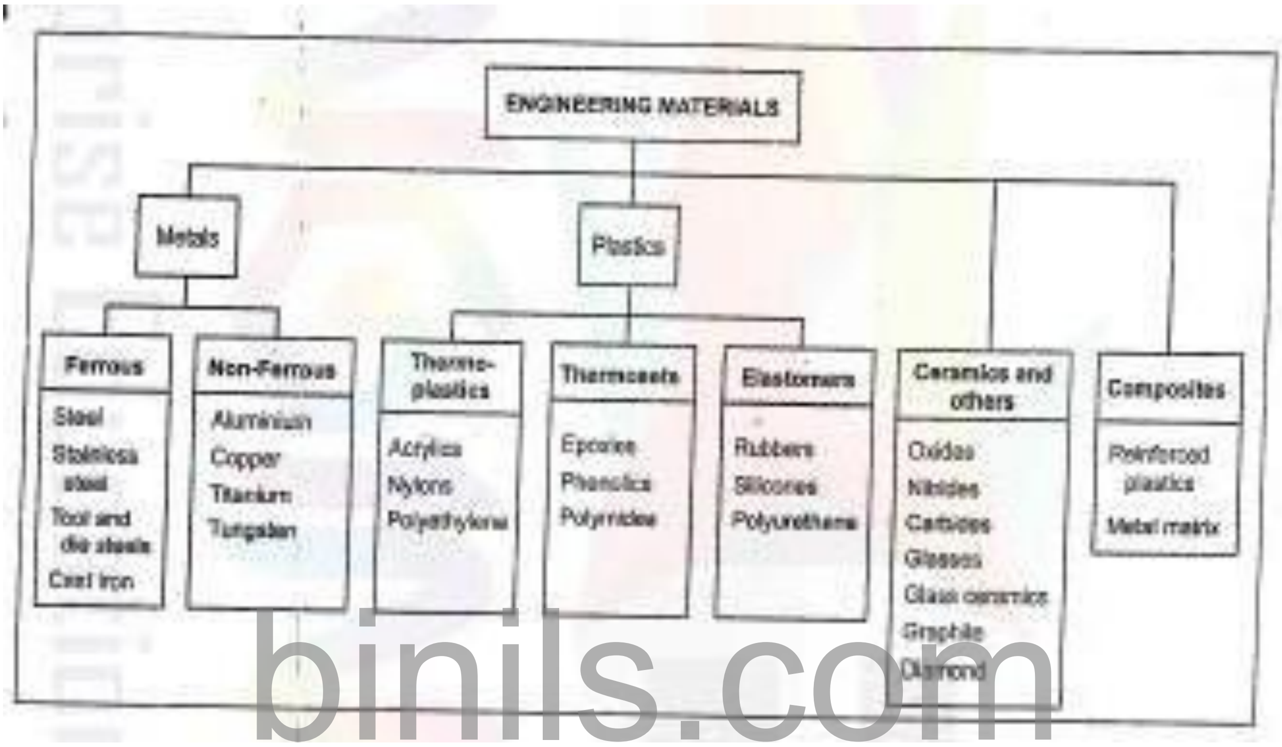
It should be noted that the material and process selections should be made taking into consideration the products to be manufactured, and the materials and processes available within the organization.

Also the selection of materials influences the selection of appropriate manufacturing processes. In the following sections, the common materials and manufacturing processes used in manufacture and the methods for their selection see presented.

OVERVIEW OF ENGINEERING MATERIALS FOR MANUFACTURE

Classification of Materials for Manufacture

A taxonomic classification scheme of engineering materials used in manufacturing is presented.



Properties of Engineering Materials

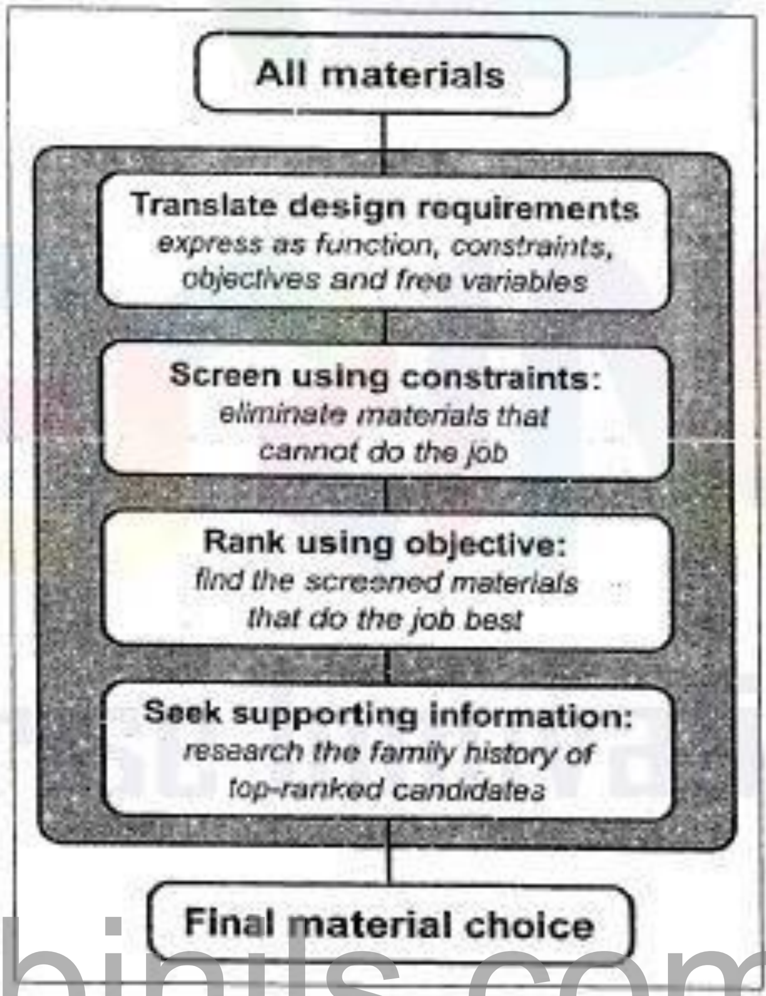
All materials exhibit many different properties and qualities. The properties of material provide a basis for predicting its behavior under various conditions.

Both design engineer and process planner should have wide knowledge of materials and their properties so that they can select a suitable material for the product.

MATERIAL SELECTION PROCESS AND METHODS

Material Selection Process

The selection of approximate materials for the product under consideration is a complex task.



The four-steps involved in the material selection process are:

Translation: Interpreting the design requirements in terms of function, constraints, objectives, and free variables.

Screening: Deriving attribute limits from the constraints and applying these to isolate a subset of viable materials.

Ranking: Ordering the viable candidates by the value of a material index, the criterion of excellence that maximizes or minimizes some measures of performance.

Seeking supporting information for the top-ranked candidates, exploring aspects of their past history, their established uses, their behavior in relevant environments. their availability and more until a sufficiently detailed picture is built up that a final choice can be made.

Material Selection Methods

The commonly used methods for material selection are:

- Selection with computer-aided databases
- Performance indices
- Decision matrices
- Selection with expert systems
- Value analysis
- Failure analysis
- Cost-benefit analysis

MATERIAL EVALUATION METHOD

The materials considered for selection are to be evaluated based on the following three considerations:

1. Shape or geometry considerations,
2. Material property requirements, and
3. Manufacturing considerations.

Shape or Geometry Considerations

- The shape or geometry considerations of a component/product influences die manufacturing processes to be employed to manufacture the component/product.
- Some of the important shape or geometry considerations are:
- Relative size of the component
- Complexity of the shape (symmetrical or uniform)
- Dimensional tolerance requirements
- Surface finish requirements
- Allowances to be made for wear during service
- Design for assembly
- Design for manufacturability

The influence of shape/geometry of raw materials on the selection of manufacturing processes to be employed.

Material Property Requirements

The material property requirements can be obtained under the following three categories.

(i) Mechanical properties.

(ii) Physical properties, and

(iii) Service environment.

Some of the mechanical property requirements include:

- Loading type involved
- Loading magnitude involved
- Chance of impact and cyclic loading
- Need for wear resistance
- Permissible temperature range
- Material deformation requirement

Some of the physical property requirements include:

- Effect of processing in electrical property requirements
- Effect of processing in magnetic property requirements
- Effect of processing in thermal property requirements
- Significant of weight
- Significance of aesthetic requirements Some of the service requirements include:
- Range of operating temperatures and rate of temperature change
- Expected life span of the product
- Most extreme working environment anticipated
- Anticipated maintenance of the product
- Reliability of the product
- Serviceability of the product

- Recyclability of the product

Manufacturing Considerations

The various considerations that influence the selection of manufacturing processes include

- Use of standard components/pans to take the advantage of interchangeability
- Consideration of ease of manufacture of the design
- Quantity and rate of components to be made
- Minimum and maximum section thickness
- Desired level of quality
- Anticipated QA and inspection requirements
- Consideration of ease of assembly of the design

ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

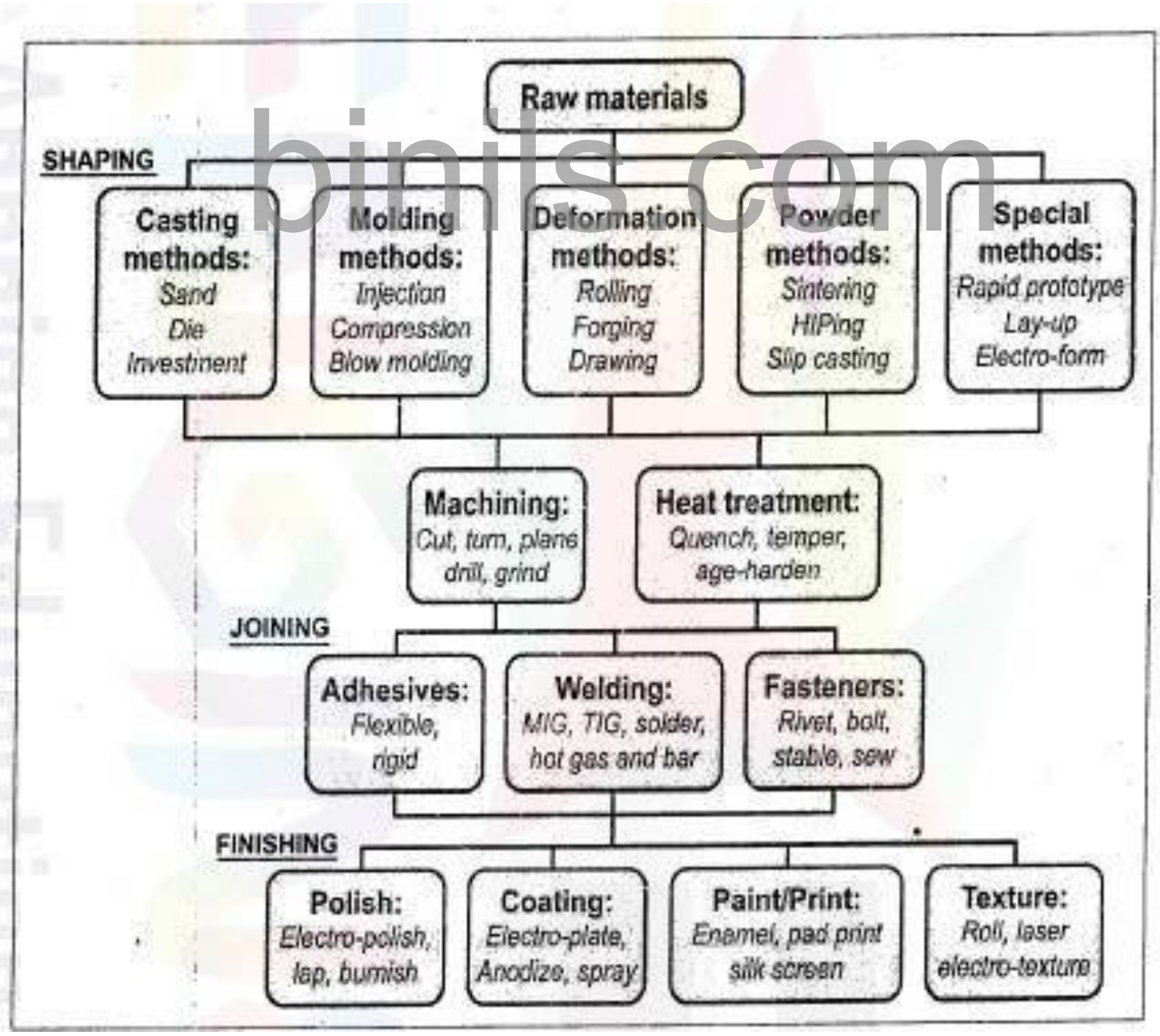
4 STEPS IN PROCESS SELECTION:

PROCESS SELECTION INTRODUCTION PROCESS SELECTION:

A process is a method of shaping, joining, or finishing a material. It is important to choose the right manufacturing process at the design stage itself. The selection of right manufacturing process depends on the materials to be used, on its size, shape and precision and number of parts to be made.

Classification of Manufacturing Processes

The broad classification of manufacturing processes is illustrated



Primary Processes Vs Secondary Processes

Primary processes create shapes. The seven primary processes are casting, moulding, deformation, powder methods, methods of forming composites, special methods and rapid prototyping.

Secondary processes modify shapes and properties. They are: (i) machining, which adds features to an already shaped body, and (ii) heat treatment, which enhances surface or build properties.

The three broad manufacturing process families are:

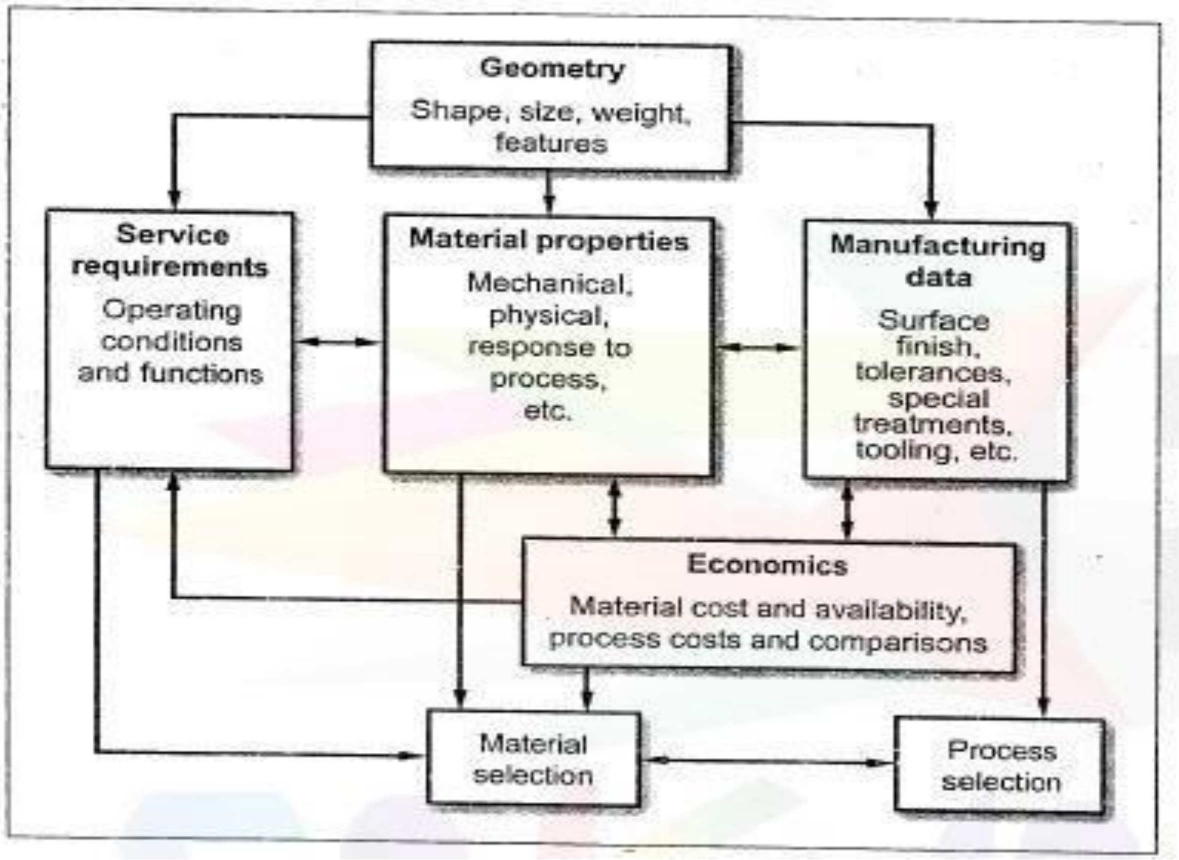
1. Shaping,
2. Joining, and
3. Finishing.

FACTORS IN PROCESS SELECTION

The materials selected in the previous stage will influence the selection of the manufacturing processes to be employed. Some of the factors to be considered in the selection of Manufacturing processes include:

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

Many factors are common to both material and process selection decisions.



Material and Process selection factors

General Guidelines for Process Selection

The following general guidelines can be considered while selecting the manufacturing processes

(i) Identify a manufacturing process which can provide the required dimensional/ geometric accuracy and surface finish.

(ii) To allow more choice of manufacturing processes, specify the maximum possible tolerances and surface finish variation for products

(iii) Employ prototypes to verify and validate the potential manufacturing under consideration.

(iv) Perform a comparison analysis of the potential manufacturing processes under consideration, taking into account the variation in assembly costs for different processes.

PROCESS SELECTION METHOD

The selection of the manufacturing process is a difficult and complex task and hence a process selection method is required to systematically approach the task.

Assumptions Made: The following two assumptions are made in the process selection method shown

1. The materials are alerted already and we specified as the design stage

2. Comprehensive information are provided in the design documents (i.e. drawings, parts lists, etc.) and all the required information for manufacturing can be derived from drawing interpretation.

STAGES OF PROCESS SELECTION:

The process selection involves the following four stages:

Stage 1: Drawing Interpretation

Stage 2: Identification of critical processing factors

Stage 3: Comparison potential manufacturing processes

Stage 4: Identification of suitable processes

These stages are presented, one by one, in the following sections.

Stage 1: Drawing Interpretation

- The drawing interpretation is the starting point for the process selection.
- From drawing interpretation, the design requirements are expressed as constraints on material, shape, size, tolerance, roughness and other process related parameters.
- The drawing interpretation can be presented under three different analysis and outputs

1. Geometry analysis

2. Manufacturing information

3. Material evaluation and output from drawing interpretation

The Process Shape Matrix

- The first analysis geometry analysis. The selection of manufacturing processes depends on the geometry and shape of the component/ product. The process-shape matrix showing the links between component geometry and different manufacturing processes.
- The second analysis and output from drawing interpretation is the manufacturing information. The manufacturing information derived from drawing interpretation include:
    - Dimensional and geometric tolerances
    - Limits and fits
    - Surface finish requirements
    - Tolerances specifications
    - Tool references
    - Gauge references
    - Special material treatment

The third and final analysis and output from drawing interpretation is the material evaluation.

Stage. 2: Identification of Critical Processing Factors

- The identification of critical processing factors is the second stage of process selection.
- The combined output from the first stage of drawing interpretation should be analyzed and correlated to identity the critical processing factors.
- The correlation of the potential manufacturing processes front the geometry analysis and the material evaluation wilt provide the opportunity to reduce the number of potential manufacturing processes under consideration.

Stage 3: Comparison of Potential Manufacturing Processes

The third stage of process selection is the comparison of identified potential manufacturing processes. In this stage, the identified potential manufacturing processes are compared using the correlated data from the second stage.

For the comparison purpose, the available appropriate process selection table can be used. The process selection tables will help the decision-making of selection of appropriate manufacturing processes using all the information gathered in previous stages.

When more titan one process satisfy all the requirements, then economic data (such as labor, equipment and tooling costs, batch size and production rate) can be used for decision making. If required, a detailed cost comparison can be carried out between manufacturing processes to help the decision making.

Also, the use of costing methods should be employed in the design and manufacture process.

Stage 4: Identification of Suitable Processes.

The fourth and final stage of process selection is the identification of a suitable manufacturing process. In this stage, using the data from the second slap and a detailed economic analysis, most appropriate manufacturing proven should be selected.

If the manufacture of part involves only one process, then the process selection is complete. Usually the component/part requires many processes. In such cases, the critical processing factor should be reconsidered and stage 3 should be repeated until all the required processes are selected.

ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

5. PRODUCTION EQUIPMENT AND TOOLING SELECTION

Introduction to production equipment and tooling selection:

The third step in the process planning is the selection of production equipment and tooling. Once the process planner baa selected the manufacturing processes to be employed, then the specific production equipment required for carry out the selected processes should be selected.

Some of the important factors to be considered during the selection of production equipment include;

- Component size
- Component weight
- Physical size of the machine
- Construction of die machine
- Power and torque of the machine
- Number of tools available for the machine
- Types of took available for the machine

Once the equipment selection has been over, then the specific tooling for each operation should be identified. While selecting the appropriate tooling for each operation, the various factors should be considered. Some of the important factors to be considered during the selection of appropriate tooling include:

- Availability of tooling
- Workpiece material
- Type of cut
- Part geometry/size
- Tool material

- Machining data
- Machine tool characteristics
- Cutting tool materials
- Tool holding requirements
- Quality requirements
- Capability requirements

The term “tooling” in, manufacturing generally refers to cutting tools, work holding devices and Jigs and fixtures. The cutting tools are also known as consumable tooling. In this section, the focus is on the selection of cutting tools for the manufacturing processes selected. The selection of work holding devices, jigs and fixtures are presented separately. In the following sections, factors In equipment selection, machine selection method, factors in tooling selection and tooling selection method are presented, one by one.

FACTORS IN EQUIPMENT SELECTION

The manufacturing processes selected In the previous stage will influence the selection of suitable machines so be employed.

In fact, the previous stage of selection of processes will make the decision making lark of equipment selection easier. Because once the processes see selected. then the range of machines capable of performing those processes can be short listed, Like in process selection there are various factors are to be considered in the selection of machines. The various factors, considered for machine selection are:

1. Technical factors

(a) Physical size of the workpiece

(b) Machine accuracy

(c) Surface finish

(d) Cutting forces

(e) Power of the machine

2. Operational factors

(a) Batch size

(b) Capacity

(c) Availability

3. Technical Factors

The technical factors ensure that the selected machine tool capable of manufacturing the component / product to the required specification. Some of the important technical factors to be considered include:

(a) Physical size

(b) Machine accuracy

(c) Surface finish

(d) Cutting forces

(e) Machine power

(a) Physical Size

The machine tool to the selected should be of sufficient size so as to carry out the required processing and also to cope with the dimensions of the component/product. Also, the machine tool to be selected should be robust enough to cope with the weight of the component.

(b) Machine Accuracy

The term machine accuracy refers to the capability of the machines under consideration to be able to manufacture parts within the required dimensional and geometric tolerance specification.

Thus the machine accuracy capability of the machine tool should be considered for its selection to ensure the achievement of specified dimensional end geometric tolerance specifications of the component in the design stage.

(c) Surface Finish

The term surface finish refers to the capability of the machines under consideration to be able to manufacture parts to the required surface specification. Thus, the surface finish capability or the machine tool should be considered for its selection to ensure the achievement specified surface finish requirements oldie component in the design stage.

(d) Cutting Forces

It may be noted the machining parameters such as feed, speed and dept of cut influence the magnitude of various cutting forces for the operations identified in a machine tool. Thus, the machine tools under consideration should be capable of providing the calculated cutting forces for the operations identified.

The calculation of machining parameters such as depth of cut, cutting speed, and machining time for various operations are presented.

(e) Machine Power

The power, also known as power rating, of the machine, under consideration should be sufficient enough w provide the power required for all operations identified. The machine power required for each operation can be calculated a below.

Power required for each operation = Cutting force x Cutting speed

2. Operational Factors

The operational factors focus on availability of machine tools under consideration and how they can be used cost-effectively to fulfill the master production schedule (MPS).

- Some of the important operational factors to be considered include:

(a) Batch size

(b) Capacity

(c) Availability

(a) Batch size

The economic batch quantity (EBQ) calculated for each process has to be taken into consideration for machine tools selection. The break-even analysis can be med for comparing potential machine tools under consideration for the calculated batch size and the most economical machine tool will be short listed.

(b) Capacity

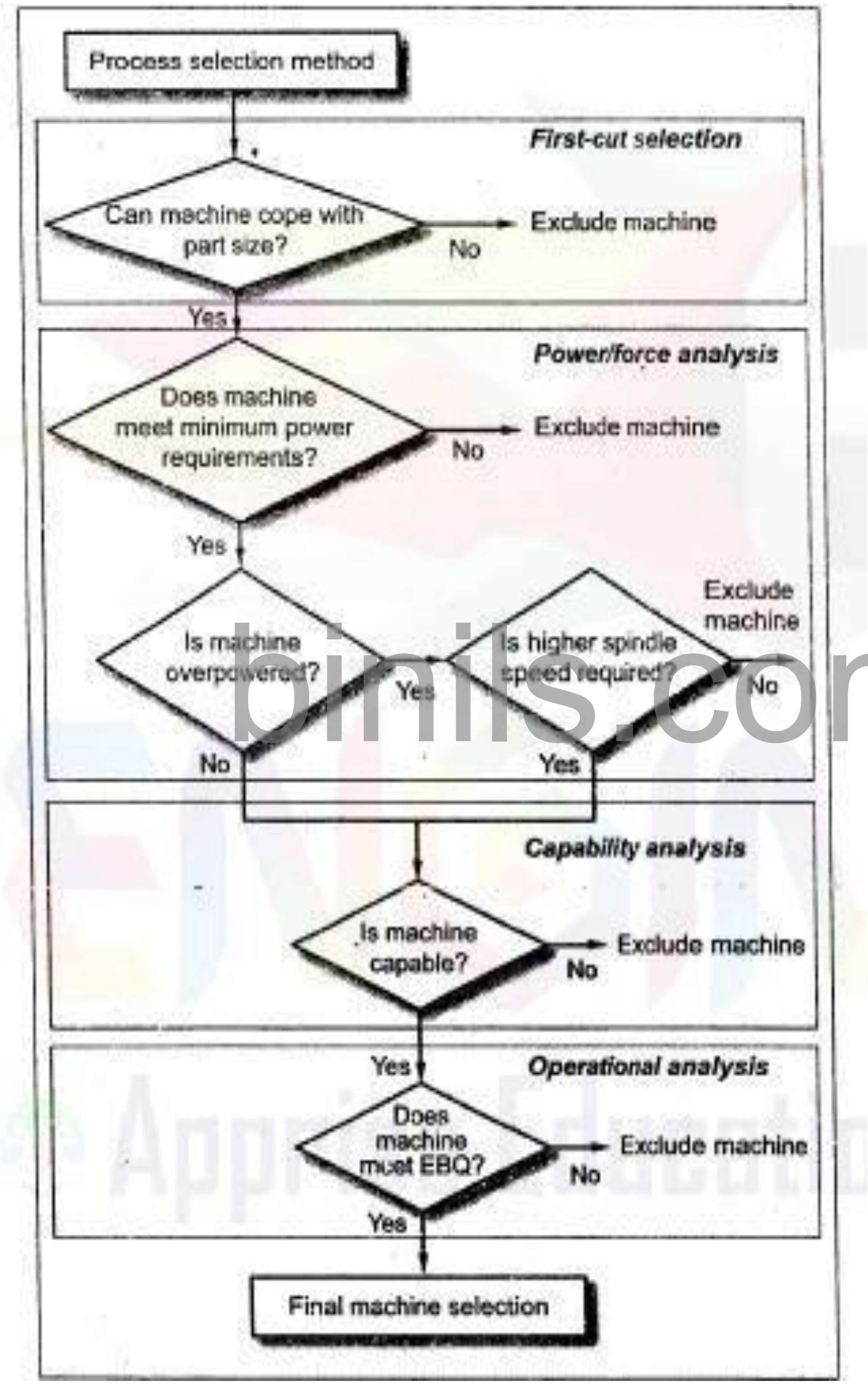
The machine capacity is nothing but the production rate of the machine. The machines under consideration should be capable of achieving specified output per unit lime matching with the master production schedule (MPS) requirements.

(c) Availability

The term availability refers to the proportion of time a machine is actually available to perform work out of the time it should be available. Since the availability la related to the overall efficiency and reliability, availability of the machine under consideration should be analyzed.

MACHINE SELECTION METHODS (STEPS IN MACHINE SELECTION)

Like the process selection method, a machine selection method ¡s required to systematically approach the machine selection task.



Stages of Machine Selection

The machine selection involves the following four stages:

Stage 1: First-cut selection

Stage 2: Power/force analysis

Stage 3: Capability analysis

Stage 4: Operational analysis

These stages are presented, one by one, in the following sections.

Stage 1: First Cut Selection

In this stage, based on the preselected manufacturing processes already, the machine types are identified and specified. For example, if turning operation is preselected already, then the type of machine to be selected is lathe. At this stage, only one factor i.e., physical size of the machine in relation to the component is considered for selection.

Stage 2: Power / Force Analysis

The selected machines in the stage I should be verified with the specified power/force requirements. The selected machines should be sufficient enough to meet the power requirements for all operations. Those machines that cannot meet the power requirements should be excluded for further consideration.

Also those machines with a far greater power output than the required can also be excluded, wider they offer any significant advantages.

Stage 3: Capability Analysis

In this capability analysis stage, the factors such as dimensions and geometric accuracy and (he surface finish requirement are considered for further short-listing the machines selected in stage 2.

Those machines that are capable of meeting the Specified dimensional and geometric accuracy, and surface finish requirements alone will be selected and considered for the final Stage.

Stage 4: Final Selection

At the end of third stage, if there are more than one machine are available for selection, then the machine with the lowest machining time for most operations will be selected. During this final selection stage, (he following selection method is used:

(i) The machine limitations (physical size, power and force) arc considered first, and then the machine capabilities (machine accuracy and surface finish).

(ii) The economies of machines are calculated and compared to finalize the single machine selection.

FACTORS IN TOOLING SELECTION

Like in machine selection, there are various factors that influence the tool selection decisions. The various factors considered for tooling selection are grouped under three head as given below;

1. Constraints on tool selection
   - (a) Manufacturing practice
   - (b) Manufacturing process
   - (c) Machine tool characteristics
   - (d) Capability
   - (e) Processing time
   - (f) Cutting tool availability
2. Operating requirements for tool selection
   - (a) Workpiece material
   - (b) Operation

(c) Part geometry

(d) Tooling data

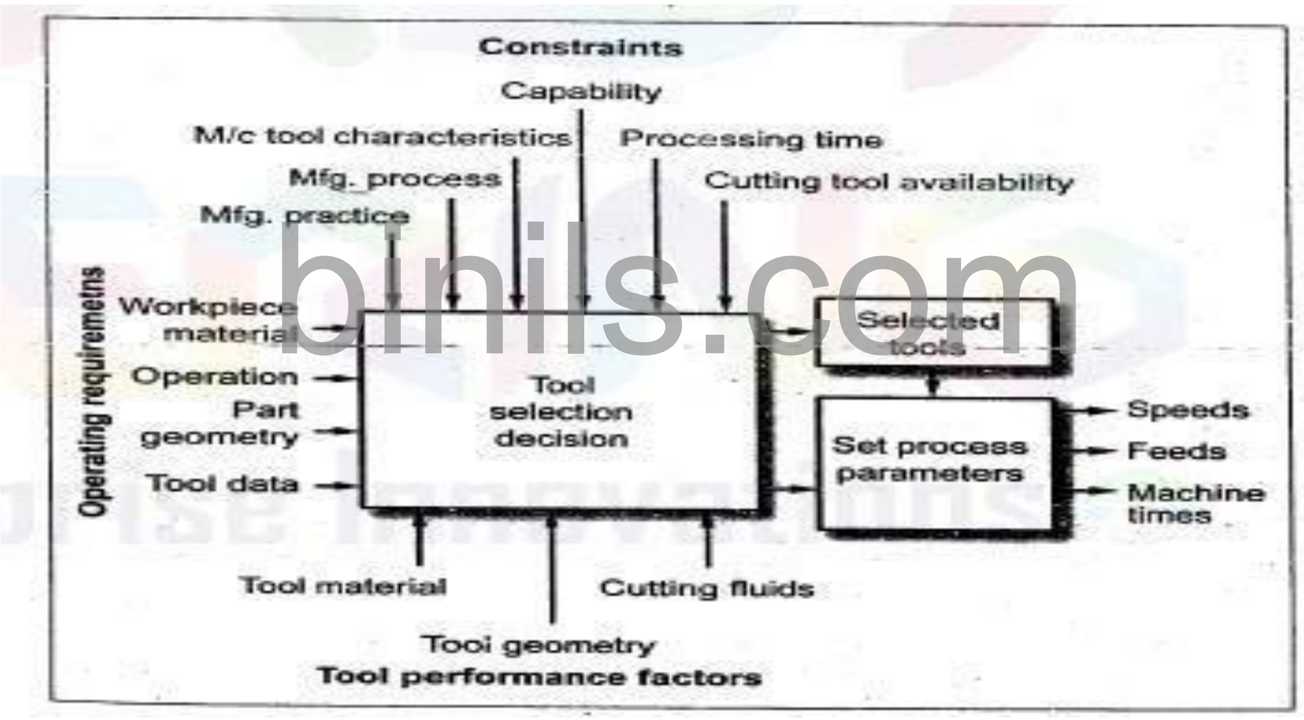
3. Factors affecting tooling performance

(a) Culling tool materials

(b) Culling tool geometry

(c) Cutting fluids

Factors in tooling selection



Constraints on Tool Selection

There are six constraints that are to be considered in tool selection. The six constraints influencing tool selection decision arc:

(a) Manufacturing practice

(b) Manufacturing process

(c) Machine tool characteristics

(d) Capability

(e) Processing lime

(t) Cutting tool availability

1. Manufacturing practice

The manufacturing practice, with respect to how the toot is actually fed into the workpiece, can be categorized into two:

(i) Continuous cutting, and

(ii) Intermittent cutting.

In continuous cutting, the cutting tool is continuously fed into the workpiece. Example: Turning, milling and drilling.

In intermittent cutting, the cutting tool is not continuously fed into the workpiece. Example: Shaping and planning. Thus, the type of manufacturing practice will Limit the selection of tooling.

2. Manufacturing Process

Since the selection of manufacturing processes and the machine tools are completed and are known at this stage, these will limit the selection of tooling to be employed. For example, if the process selected is turning, then the tool selection is limited to single point cutting tool suitable for turning.

3. Machine Tool Characteristics

The various machine tool characteristics that should be considered for tool selection include:

- Availability of suitable work holding devices
- Machine tool structure (i.e. rigidity)
- Power output
- Range of speeds available
- Range of feeds available
- Availability of machines

4. Capability

The two important capability factors to be considered for tool selection are:

- Dimensional and geometric accuracy required
- Surface finish specifications

5. Machining Time

Since the machining time influences the power, feed and Speed requirements for both machine and tooling, this factor should be considered for tool selection. The calculation of machining time of various operations is presented.

6. Cutting Tool Availability

While selecting the cutting tool, the available cutting tools should be given first priority.

Operating Requirements for Tool Selection

The term operating requirements here refers to the conditions under which the cutting takes place.

There are four operating requirements that affect the tool selection. They are:

(a) Workpiece materials

(b) Operation

(c) Part geometry

(d) Tooling data

1. Workplace Material

The selection of cutting tool highly depends on the workpiece material to be used. This is because different workpiece materials during cutting result in different chip formation and heat generation, ibis in turn will determine the cutting tool geometry and the cutting tool material.

2. Operation

Since specific operation requires specific cutting tool, the select operation itself generally determine the suitable tool to be employed.

3. Part Geometry

The processing of specific part geometry requires the cutting tool with specific geometric feature. Hence the part geometry factor should be considered during tool selection.

4. Tooling Data

The manufacture tooling data book or catalogue can be used to select tools suitable tools for the specified operations.

Factors affecting Tooling Performance

There are three factors that affect the tooling performance include:

- Cutting tool materials
- Cutting tool geometry
- Use of cutting fluids

1. Cutting Tool Materials

Since there are variety of materials are used for making cutting tools, the choice of- cutting tool material for the required operation has influence in the tool performance.

The commonly used cutting tool materials are high-speed steels (HSS), carbides, cast non-ferrous, ceramics, etc.

2. Cutting Tool Geometry

The cutting tool geometry such as tool angles, rake angles, cutting edge angles, tool nose radius, etc., affect the tool performance.

The workpiece material and tool material influence the cutting tool geometry

3. Use of Cutting Fluids

The cutting fluids during cutting serve the following two primary functions:

(a) Cooling purpose: It cools both the workpiece and the tool, by which the temperature is reduced, which in turn will maintain the hardness and prevent any workpiece distortion.

(b) Lubricating purpose: It reduces friction between the tool and the workpiece and also helps maintain the wear resistance of the tool. Thus the use of cutting fluids enhances the performance of cutting tools employed.

TOOLING SELECTION METHOD

Like the machine selection method, tool selection process is required to systematically approach the tool selection task. The five stages of the tool selection process are:

Stage 1: Evaluation of process and machine selections

Stage 2: Analysis of machining operations

Stage 3: Analysis of workpiece characteristics

Stage 4: Tooling analysis

Stage 5: Selection of tooling

The five stages of the tool selection process are

Stage 1: Evaluation of Process and Machine Selections

In this stage, based on the preselected manufacturing processes and machine tools already, the range of tools that can be employed re limited.

Stage 2: Analysis of Machining Operations

From the short-listed tools in stage I, the specific tool types to carry out certain operation in each selected machines are to be analyzed. This analysis helps to identify die specific tool types for specific operations.

Stage 3: Analysis of Workpiece Characteristics

The workpiece characteristics that ate to be analyzed for tool selection include workpiece material, workpiece geometry, the requirements of dimensional and geometric accuracy, and surface finish. This analysis or workpiece characteristics will help to further refine the tool type and geometry to suit the operations.

Stage 4: Tooling Analysis

From the general tooling specifications generated at stage 3, a tooling list can be prepared using the tooling data available. This tooling list provides the list of tools available for the operations required.

Stage 5: Selection of Tooling

During the final selection stage, the following selection process is used:

(i) If single-piece tooling le to be used, then a suitable tool holder should be selected. Then the tool geometry and tool material can be defined.

(ii) If insert type tooling is to be used, then the following steps to be adapted

a) Select clamping system

b) Select tool holder type and size

c) Select insert shapes and size

d) Determine tool edge radius

e) Select insert type

f) Select tool material