ME8793 PROCESS PLANNING AND COST ESTIMATION

UNIT 1 INTRODUCTION TO PROCESS PLANNING

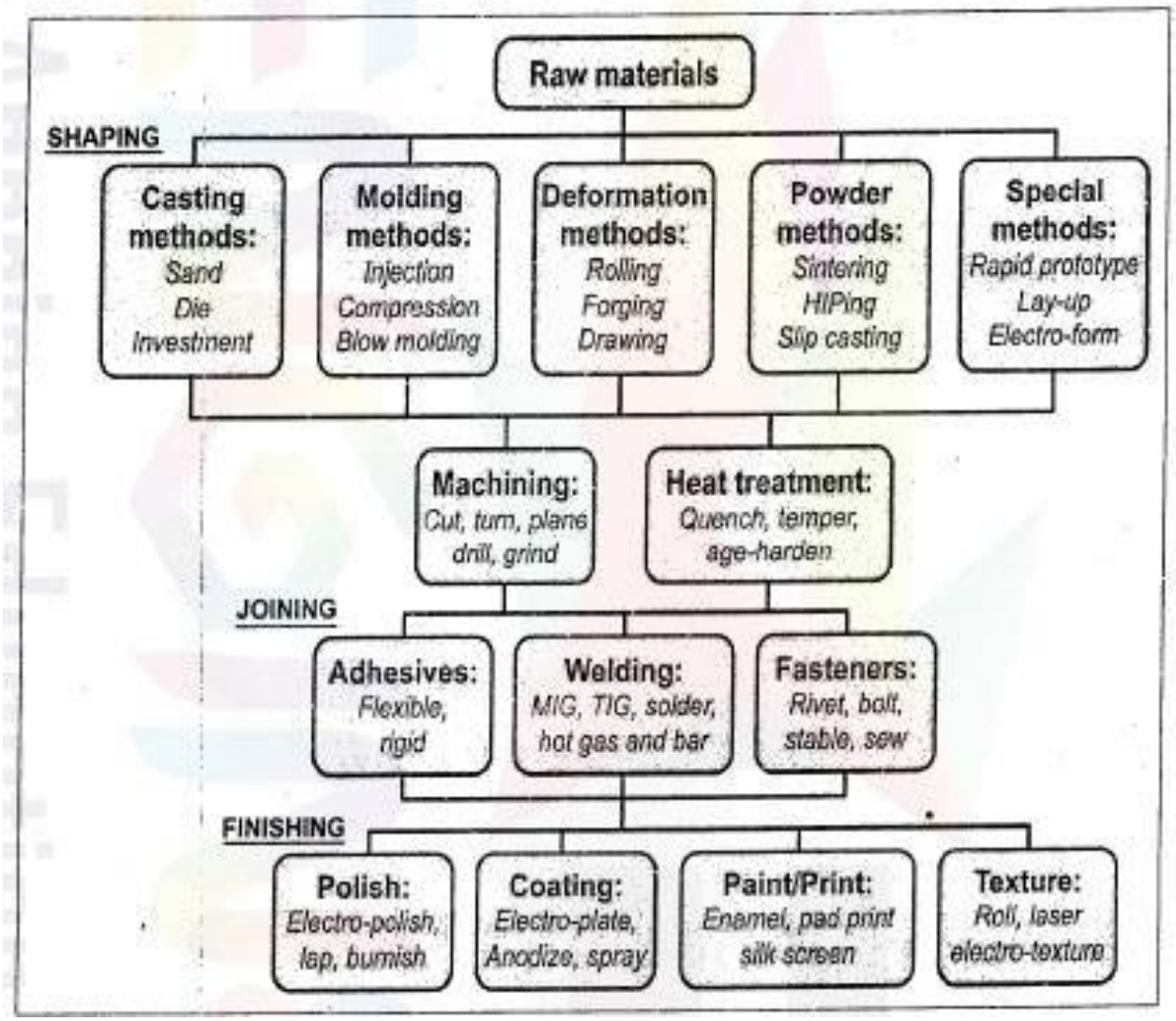
4 STEPS IN PROCESS SELECTION:

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:

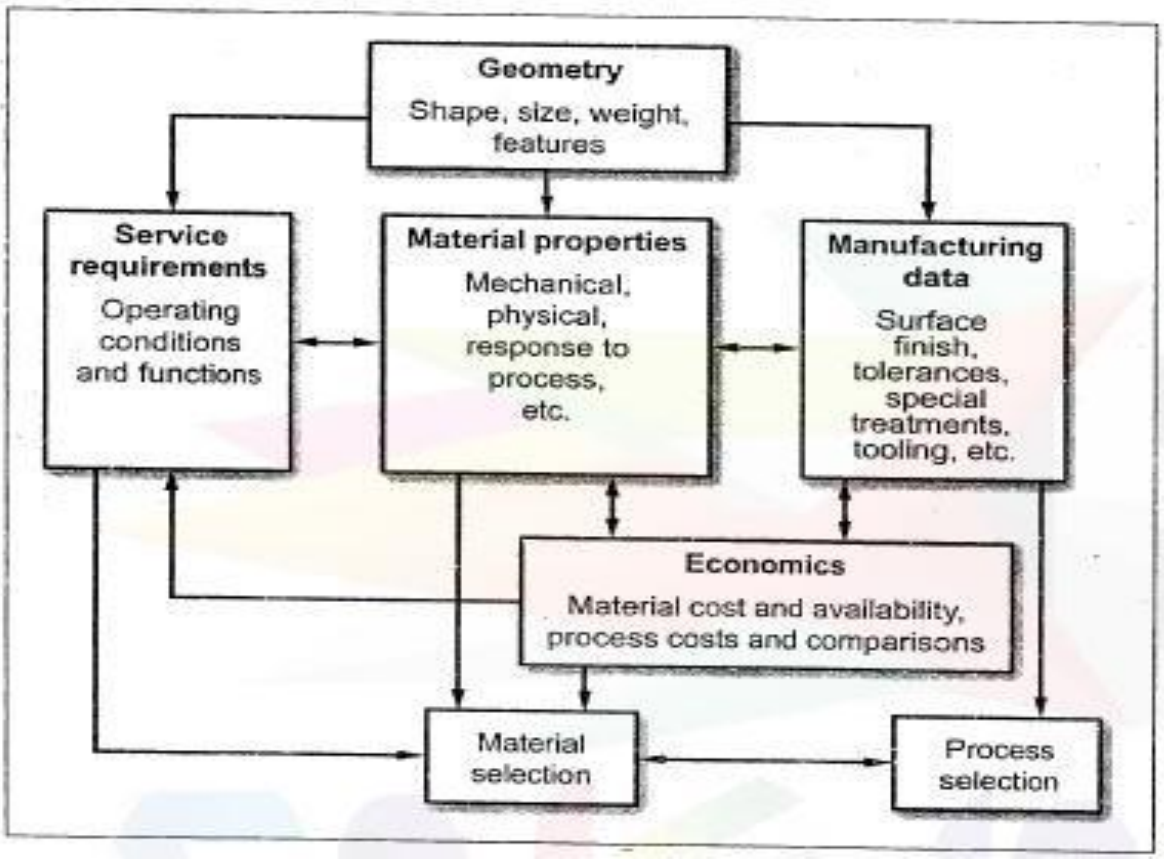
1. Shaping,
2. Joining, and
3. Finishing.

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.

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

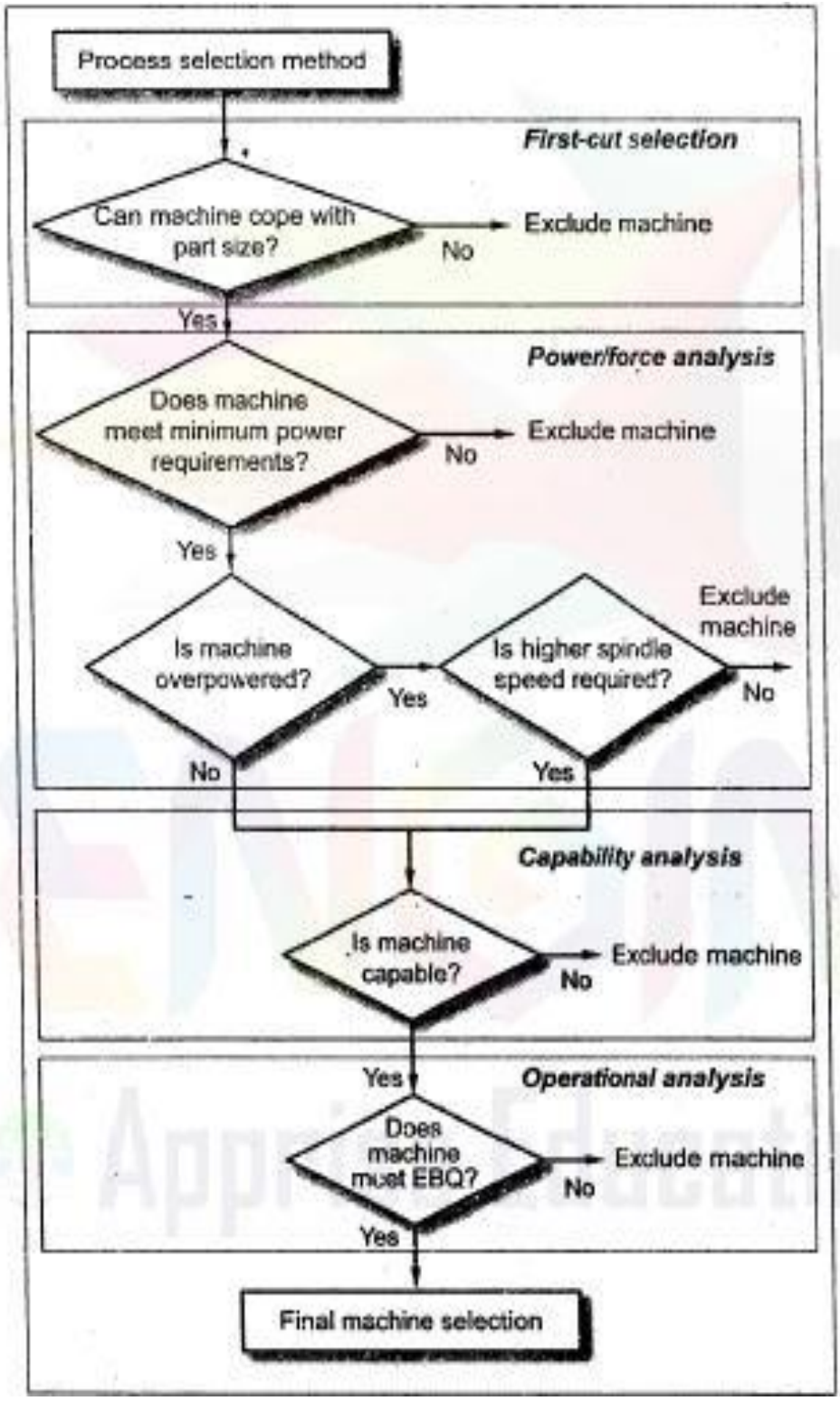
The machine capacity is nothing but the production rate of the machine. The machines under consideration should be capable of achieving specified output per unit lime matching with the master production schedule (MPS) requirements.

(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;

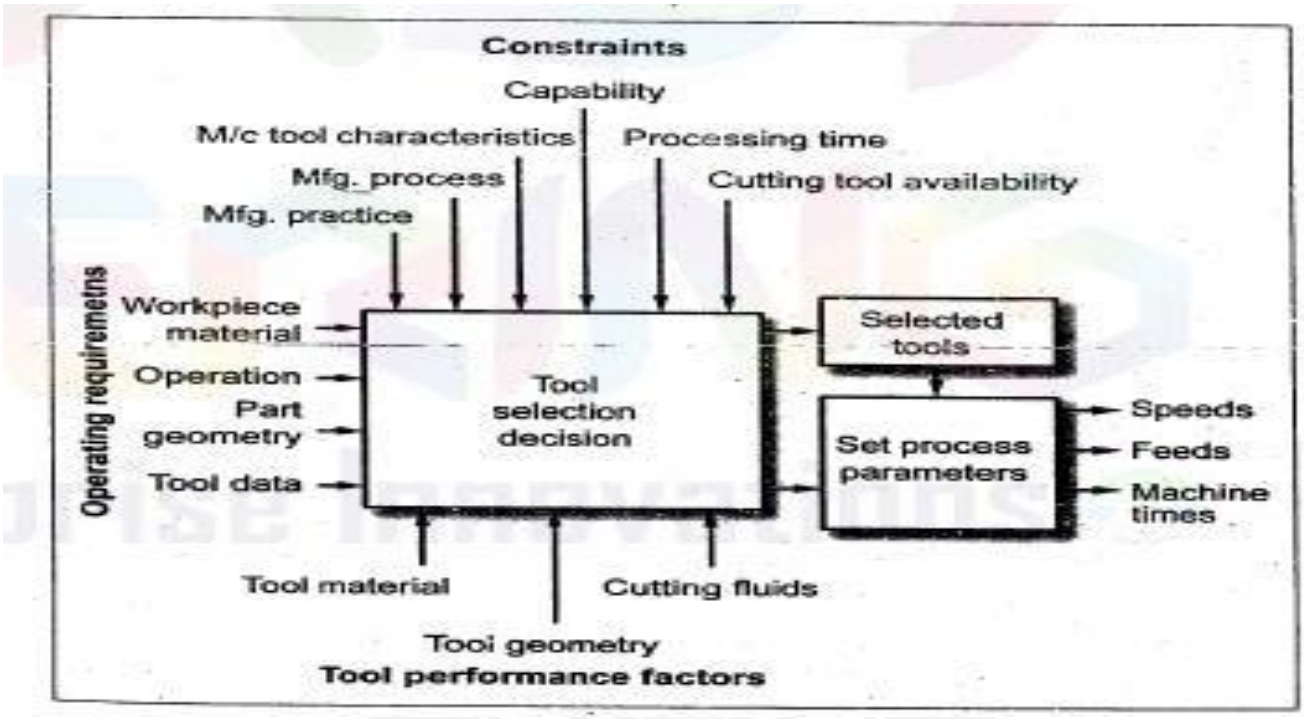
1. Constraints on tool selection
    - (a) Manufacturing practice
    - (b) Manufacturing process
    - (c) Machine tool characteristics
    - (d) Capability
    - (e) Processing time
    - (f) Cutting tool availability
2. Operating requirements for tool selection
    - (a) Workpiece material
    - (b)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