# ME8793 PROCESS PLANNING AND COST ESTIMATION

## UNIT 2 PROCESS PLANNING ACTIVITIES

## PROCESS PARARMETERS CALCULATION FOR VARIOUS PRODUCTION PROCESSES:

## INTRODUCTION

The process planning involves the various activities such as drawing interpretation, material evaluation and process selection, selection of machines and tooling, setting process parameters, selection of work holding devices, selection of quality assurance and inspection methods, cost estimating and then documenting the details using route sheets.

- The process planning activities—drawing interpretation, material evaluation and process selection and selection of machines and tooling were discussed in detail.
- In this unit, the remaining process planning activities—setting process parameters, selection of worholding devices (Le.. jigs and fixtures), selection of inspection/quality assurance methods and economics of process planning will be described in detail, one by one.

## PROCESS PARAMETERS CALCULATION:

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

1. Cutting speed,
2. Feed rate, and
3. Depth of cut

## CUTTING SPEED

The cutting speed also known as surface cutting speed or surface speed, can be defined as the relative speed between the tool and the workpiece.

It is a relative term, since either the tool or the workpiece or both may be moving during cutting. Unit: It is expressed in meters per minute (mpm).

**Factors Affecting the Selection of Cutting Speed**

The major factors considered for selecting cutting speed are as follows.

1. Nature of the. Cut

- ❖ Continuous cut like turning, boring, drilling, etc., are done at higher cutting speed. Shock initiated cuts in shaping machine, planning machine, slotting machine, etc. are done at lower cutting speed.
- ❖ Intermittent cuts, as in milling, hobbing. etc., are done at quite lower speed for dynamic loading.

2. Work Material (type, strength, heat resistance, toughness, chemical reactivity, etc.)

- ❖ For example, harder, stronger, heat resistant and work harden able materials are machined at lower cutting speed.
- ❖ Soft, non-sticky and thermally conductive materials can be machined at relatively higher cutting speed.

3. Cutting Tool Material (type, strength, hardness, heat and wear resistance, toughness, chemical stability, thermal conductivity, etc)

- ❖ For example, HSS tools are used at within 40 m/mm only in turning mild steel whereas for the same work cemented carbide tools can be used at the cuffing speed of 80 to 300 m/min.

4. Cutting Fluid Application

- ❖ Proper selection and application of cutting fluid may increase in cutting speed by 20 to 50%

5. Purpose of Machining

- ❖ Rough machining with large material removal rate (MRR) is usually done at relatively low or moderate cutting speed.
- ❖ Finish machining with small feed and depth of cut is usually done at high cutting speed.

6. Kind of Machining Operation

- ❖ Unlike turning, boring. etc., the operations like the threading, reaming, knurling. etc., are carried out at much lower cutting speed.

7. Capacity of the Machine Tool

- ❖ Powerful, strong, rigid and stable machine tools allow much higher cutting speed, if required and permissible.

8. Condition of the Machine Tool

Cutting Speeds (metre/minute) for different combinations of operation and material

| Material | Operation | | | | | |
|---|---|---|---|---|---|---|
| | Turning and boring | Drilling | Reaming | Shaping, slotting and planing | Milling | Grinding |
| Aluminium | 300 | 120 | 120 | 25 | 200–300 | 20 |
| Brass | 45–75 | 50 | 25 | 12–15 | 40 | 22 |
| Cast iron | 20 | 15 | 10 | 10 | 50 | 12 |
| Copper | 30 | 50 | 15 | 10 | 40 | 22 |
| Mild steel | 30 | 25 | 12 | 20 | 20 | 15 |

Cutting Speed ranges for different combinations workpiece and tool material

| S.No. | Workpiece Material | Cutting Speed (m/min) | |
|---|---|---|---|
| | | HSS | Carbides |
| 1. | Low-carbon steels | 20 – 110 | 60 – 230 |
| 2. | Medium-carbon steels | 20 – 80 | 45 – 210 |
| 3. | Steel alloys (Ni-based) | 20 – 80 | 60 – 170 |
| 4. | Grey cast iron | 20 – 50 | 60 – 210 |
| 5. | Stainless steels | 20 – 50 | 55 – 200 |
| 6. | Chromium nickel | 15 – 60 | 60 – 140 |
| 7. | Aluminium | 30 – 110 | 60 – 210 |
| 8. | Aluminium alloys | 60 – 370 | 60 – 910 |
| 9. | Brass | 50 – 110 | 90 – 305 |
| 10. | Plastics | 30 – 150 | 50 – 230 |

## FEED AND FEED RATE

Feed is the distance through which the tool advances into the workpiece during one revolution of the workpiece or the cutter. Feed rate is the speed a: which the cutting tool penetrates the workpiece. Unit: Feed rate is usually expressed in millimeters per spindle revolution (mm/rev) or millimetres per minute (mm/mm).

### Factors Affecting Feed Rate

The factors that are considered during selection of feed value are:

I. Work material (type, strength, hardness, etc.)

II. Capacity of the machine tool (power, rigidity, etc.)

III. Cutting tool (material, geometry and configuration)

IV. Cutting fluid application

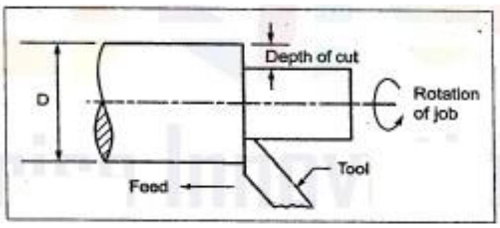
V. Surface finish desired

VI. Type of operation

VII. Nature of cut

## DEPTH OF CUT

Depth of cut is the thickness of the layer of metal removed in one cut or pass, measured in a direction perpendicular to the machined surface. The depth of cut is always perpendicular to the direction of feed motion. Unit: It is generally measured in mm.




Illustrates the terms feed and depth of cut.

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

Selection of Depth of Cut

1. Depth of cut for Turning and Boring

The general guidelines for turning and boring recommend a depth of cut of 6mm for roughing and 0.4mm for finishing

2. Depth of cut for Milling

The maximum depth of cut for milling is generally considered to be half the cutter diameter

3. Depth of cut for Drilling

The maximum depth of cut for drilling is generally considered to be half the feed rate of the tool and minimum considered to be 0.3mm

4. Depth of cut for Shaping and Planning

In general, the recommended depth of cut for shaping and planning are in the range of 1-4mm

5. Depth of cut for Grinding

The general recommendations for depth of cut for surface and cylindrical grinding are equal to the values for feeds selected in mm/pass.

**Machining Time Calculations**

The important reasons for selecting / calculating the process parameters – cutting speed, feed rate and depth of cut are to determine the machining times. Because the data for cutting speed, feed rate and depth of cut for the processes will be used to calculate the machining times.

**SELECTION OF JIGS AND FIXTURES:**

**INTRODUCTION**

From the drawing interpretation, the process planner has to identify the need for a work holding device or a jig or a fixture for the selected operation. The process planner will communicate the identified requirements of the work holding device to a specialist tool engineer for the detailed design and drawings that are needed for manufacturing it.

In the following sections. the overview of the function, types, principles and selection a jigs and fixtures are presented.

## WORKHOLDING DEVICE

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

Types of workholdlng devices: The work holding devices can be broadly classified into two:

1. General workholdîng devices
    - Vices
    - Clamps and abutments_
    - Chucks
    - Collet
    - Centres
    - Mandrels
    - Face plates
2. Specialist workholding devices
    - Jigs
    - Fixtures

### Jigs

A jig may be defined as a work holding device which locales and holds the workpiece for a specific operation. It ¡s also provided with tool guiding elements.

Jigs are usually lighter in construction and direct the tool to the correct position on the workpiece. Jigs are rarely clamped on the machine table because it is necessary to move on the table to align the bushes in the jig with the machine spindle. Jigs are used on drilling, reaming, tapping and counterboring operations.

Functions of jigs are:

1. To locate and position the workpiece relative to the cutting tool.
2. To clamp the workpiece during drilling, reaming or tapping.
3. To guide the tool (drill, reamer or tap) into the proper position on the workpiece.

**Fixtures**

A fixture may be defined as a work holding device which only holds and positions the workpiece. ¡t does not guide the cutting tool. Sometimes, there is a provision in the fixture for setting the tool with respect to the workpiece.

- ❖ Fixtures are often clamped to the machine table.
- ❖ Fixtures are used in turning, milling, grinding, shaping, planning and boring operations.

Functions of fixtures are:

1. To locate and position the workpiece relative to the cutting tool.
2. To clamp the workpiece during machining, welding, inspection or assembly.

**Jigs Vs. Fixtures**

| S.No | Characteristics | Jig | Fixtures |
|---|---|---|---|
| 1. | Definition | Locates and hold the work and guides the cutting tool in true position of the work | Only holds and positions the work, but doesn't guide the work |
| 2. | Elements | Work locating elements, | Work locating elements, tool |

| | | | |
|---|---|---|---|
| | | tool guiding elements and work clamping elements | setting elements and work clamping elements |
| 3. | Construction | Light | Heavy |
| 4. | Applications | Drilling, reaming, tapping, counter boring, countersinking | Milling, turning, grinding, broaching etc |
| 5. | Special Features | Drill bushes used for tool guiding | Feeler gauges, setting blocks to adjust position of tool in relation to work |

## Reasons for Using Jigs and Fixtures

The purpose arid advantages of jigs and fixtures are as follows:

1. It reduce/ eliminates the efforts of marking, measuring and setting of work piece on a machine.

2. The workpiece and tool are relatively located at their exact positions before the operation automatically within negligible time. So it reduces product cycle time,

3. It reduces the production cycle Lime and hence increases production capacity.

4. Interchangeability of manufacture is achieved by enabling the production of identical parts.

5. The operating conditions like speed, feed rate and depth of cut can be set to higher values due to rigidity of clamping of workpiece by jigs and fixtures.

6. Operators working become comfortable as his efforts in setting the workpiece can be eliminated.

7. Semi-skilled operators can be assigned the work so it also saves the cost of manpower.

8. It reduces the cost of inspection as the products are produced with less defects.

## Elements of Jigs and Fixtures

The three basic elements of jigs and fixtures are given below.

1. Clamping elements

Clamping elements are used to exert a force to press the workpiece against locating surfaces and they bold the action of cutting forces.

2. Locating elements

Locating elements are used to position the workpiece accurately with respect to the tool guiding or setting elements in the fixture.

3. Tool guiding and setting elements

Tool guiding elements are used in jigs where a hardened bushing is fastened to sides of the jig to guide the tool to its proper position in the work.

Tool setting elements are used in fixtures where a target or set block is used to set the location of the tool with respect to the workpiece within the fixture.

**PRINCIPLES OF JIGS AND FIXTURES DESIGN**

The main consideration of jigs and fixture design are summarized below;

1. Location

- ❖ Locating surfaces should be as smaIl as possible and the location must be done from the machined surface.
- ❖ Sharp corners in the locating surfaces must be avoided.
- ❖ Locating pins should be easily accessible and visible to the operator.
- ❖ Adjustable locators should be provided for rough surface,

2. Clamping

- ❖ Clamping should always be arranged directly above the points supporting the work.
- ❖ Quick acting clamps should be used wherever possible.
- ❖ Clamps should not cause deformation of the workpiece.

- Position of clamps should provide best resistance to the cutting tool.
- Cutting forces of the tool should act against the solid part of the jig and not against the clamps.
- All the clamps and adjustments should be on the sides.
- Clamps should allow rapid loading and unloading of the components.

3. Loading

- The loading and unloading process of the workpiece should be as easy as possible.
- Loading and supporting surface usually made of hardened material and also it should be renewable wherever possible.
- Enough space should be Left for hand movements between the walls of a jig and workpiece.

4. Stability and Rigidity

- Jigs and fixtures should possess a high rigidity to withstand the cutting forces. At least four legs should be provided on the jigs for stability.
- The fixtures are rigidly fixed on the machine table. Make the equipment as rigid as necessary for the operation.

5. Clearance for chips

Adequate space in the form of channel ways should be provided to enable the metal chips to be blown to clear easily.

6. Fool Proof Design

- Jigs aid fixtures should be fool proof besides being safe to use.
- The design of Jigs and fixture such that it is Impossible to use the workpiece and tool in any position other than the correct one.

- ❖ Locating plan a. provided for this purpose.

7. Provisions for Tool Guides

Provisions for tool guides in Jig bushing and cutter setting devices in fixture should be made.

8. Provisions for Indexing

Provisions for indexing the workpiece should be made wherever it is necessary. It enables the workpiece to divide into any number of equi-spaced faces.

9. Weight

- ❖ Jigs aid fixtures should be lighter in weight
- ❖ Jig weight should be kept below 15 kg since they are to be handled often.

10. Safety

- ❖ Jigs aid fixtures are designed for safety
- ❖ Handles and Levers should be large enough. All sharp edges should be removed or avoided.

11. Coolant Supply

Adequate arrangements must be made for the supply of coolant to the cutting edges for reducing the friction.

12. Economy

Jigs and fixture should reduce machining aid production costs by providing ease of manufacturing.

**SET OF DOCUMENTS FOR PROCESS PLANNING:**

(Information Required for Process Planning)

In order to prepare a process plan, the following documents information are required.

1. Assembly and components drawings of the product and bill of materials:

The details include:

- ❖ Components drawings
- ❖ Assembly drawings
- ❖ Raw material specification
- ❖ Dimensional and geometric specifications
- ❖ Surface finish specifications
- ❖ Number of pans required
- ❖ Bill of materials

2. Specification of various machine tools available in the catalogues of machine tools:

- ❖ The various possible operations that can be performed.
- ❖ The maximum and minimum dimensions that can be machined on the machines.
- ❖ The accuracy of the dimensions that can be obtained.
- ❖ Available feeds and speeds on the machine
- ❖ Capacity/power ratings of motors.
- ❖ Spindle size, table size, etc.

3. Machining/Machinability data handbook

- ❖ Tables of cutting speeds, depth of cut, feeds for different processes and for different work materials

4. Catalogues of various cutting tools and tool inserts.

5. Sizes of standard materials commercially available in the market.

6. Charts of limits, fits and tolerances.

7. Tables of tolerances and surface finish obtainable for various machining processes.

8. Tables of standard time for each operation.

9. Tables of machine hour cost of all machine tools available.

10. Tables of standard cost.

11. Table of allowances.

12. Process plans of certain standard components such as shafts, bushings, flanges, etc.

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