COMPUTER INTEGRATED MANUFACTURING TECHNOLOGIES

3RD YEAR SEM-1 BTECH MECHANICAL ENGINEERING (R18A0312)

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COURSE OBJECTIVES

UNIT - 1	**CO1:** Learn about geometry of metal cutting theory, mechanism of chip formation and mechanism of orthogonal cutting and merchants force diagram
UNIT - 2	CO2: Learn about ways to reduce the surface roughness by using different machining process
UNIT - 3	CO3: To write APT and CNC programming concepts
UNIT - 4	CO4: Learn the concepts of DNC Systems and Post Processors
UNIT - 5	CO5: To know about Computer aided process planning and computer aided inspection and Quality control

UNIT 1

METAL CUTTING THEORY

CO1: Learn about geometry of metal cutting theory, mechanism of chip formation and mechanics of orthogonal cutting and merchants force diagram

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UNIT – I (SYLLABUS)

ELEMENTS OF CUTTING PROCESS

- Geometry of Single point tool and angles, chip formation.
- Types of chips, built up edge and its effects.
- Mechanics of orthogonal cutting-cutting forces, cutting speeds, feed, depth of cut, tool life, coolants and Machinability

Lathe Machine

- Principle of working, specification of lathe and types of lathe, operations of lathe and work holding devices.

COURSE OUTLINE-UNIT 1

LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning objectives
1	Metal cutting theory, elements of cutting process, Geometry of single point tool and angles	Cutting in manufacturing of cutting, tool points and angles	• understand the imp of cutting in manufacturing • cutting process
2	Chip formation, types of chips	theory of chip formation in cutting process	• understand types of chips
3	Mechanics of orthogonal cutting, Cutting forces and speeds	orthogonal cutting and speeds	• understand difference between orthogonal & oblique cutting
4	Depth of cut, feed, tool life, coolants and machinability	tool life,coolants	• understand relative movement of tool • imp of cooling in manufacturing
5	Lathe machine-principle of working	Lathe principles	• working of lathe in brief and its principle
6	Types of lathe and its specifications	Types of lathe machines	• understanding types of lathe like speed, centre lathe
7	Operations of lathe, work holding and tool holding devices	operation of lathe machines and tool holding devices	• Understanding basic operations of lathe and various tool holding devices

LECTURE 1

METAL CUTTING THEORY- ELEMENTS OF CUTTING PROCESS

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TOPICS TO BE COVERED

- Metal cutting theory Introduction
- Material removal process
- Metal cutting features
- Elements of cutting process
- Geometry of single point tool and angles
- Single point cutting tool types

LECTURE 1

Metal Cutting Theory

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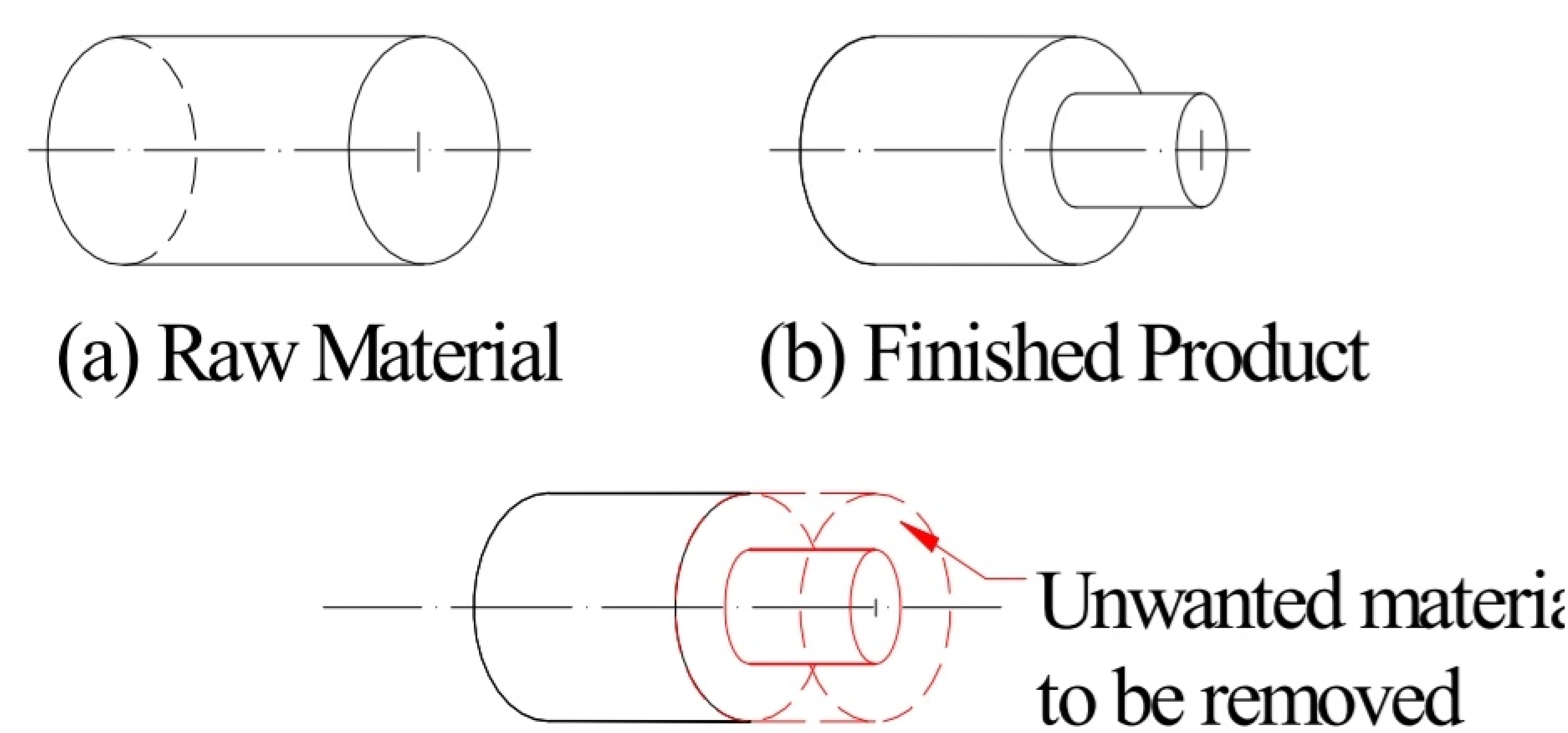
Metal Cutting Theory

- INTRODUCTION- In an industry, metal components are made into different shapes and dimensions by using various metal working processes. Metal working processes are classified into two major groups. They are: Non-cutting shaping or chips less or metal forming process - forging, rolling, pressing, etc. Cutting shaping or metal cutting or chip forming process - turning, drilling, milling, etc

- Machining: Term applied to all material-removal processes. Metal cutting: The process in which a thin layer of excess metal (chip) is removed by a wedge-shaped single-point or multipoint cutting tool with defined geometry from a work piece, through a process of extensive plastic deformation.

Metal Cutting Theory



MATERIAL REMOVAL PROCESSES

- Machining is an essential process of finishing by which work pieces are produced to the desired dimensions and surface finish by gradually removing the excess material from the preformed blank in the form of chips with the help of cutting tool(s) moved past the work surface(s).
- Principle of machining - the fig illustrates A metal rod of irregular shape, size and surface is converted into a finished product of desired dimension and surface finish by machining by proper relative motions of the tool-work pair.

MATERIAL REMOVAL PROCESSES

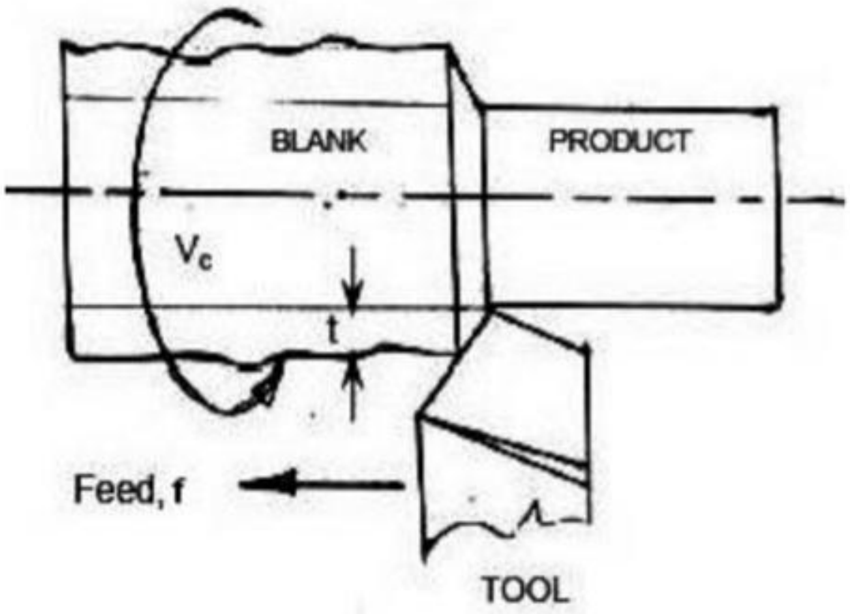


Fig. 1.1 Principle of machining (Turning)

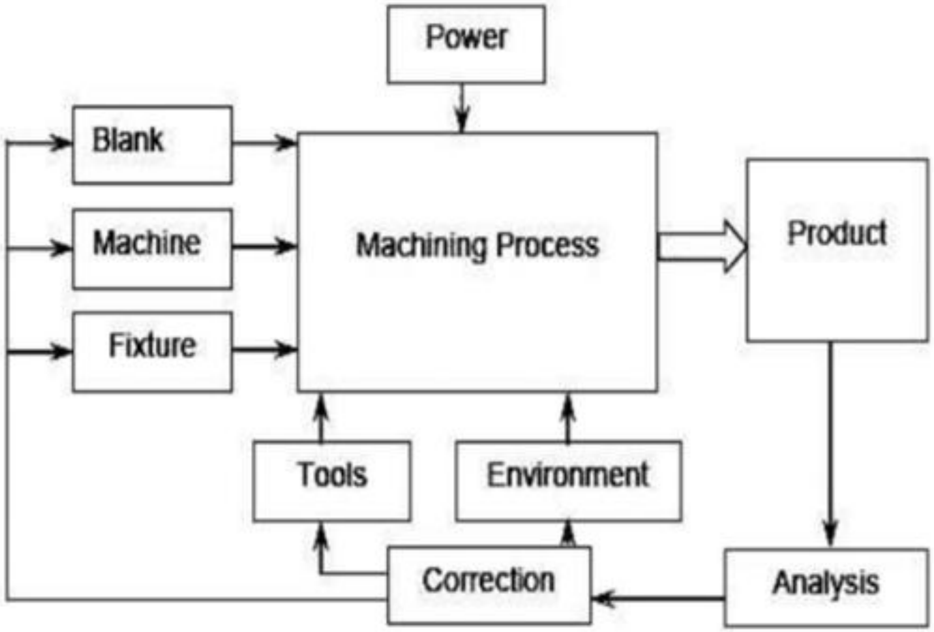


Fig. 1.2 Requirements for machining

Metal Cutting: features

- Closer dimensional accuracy
- Surface texture/finish
- Economical
- Complex shape
- Size
- Material loss (~50%)
- Scarcity of materials
- Special equipment
- Skilled operators
- Time required
- All materials cannot be machined

Essentials of Metal Cutting Operation

- Machine Tool
- Cutting Tool
- Method
- Operator

ELEMENTS OF CUTTING PROCESS

Principle Elements of Metal Machining:

1: Cutting Speed:

The cutting speed can be defined as the relative surface speed between the tool and the job. It is a relative term since either the tool or the job or both may be moving during cutting. It is expressed in m/min.

2: Feed:

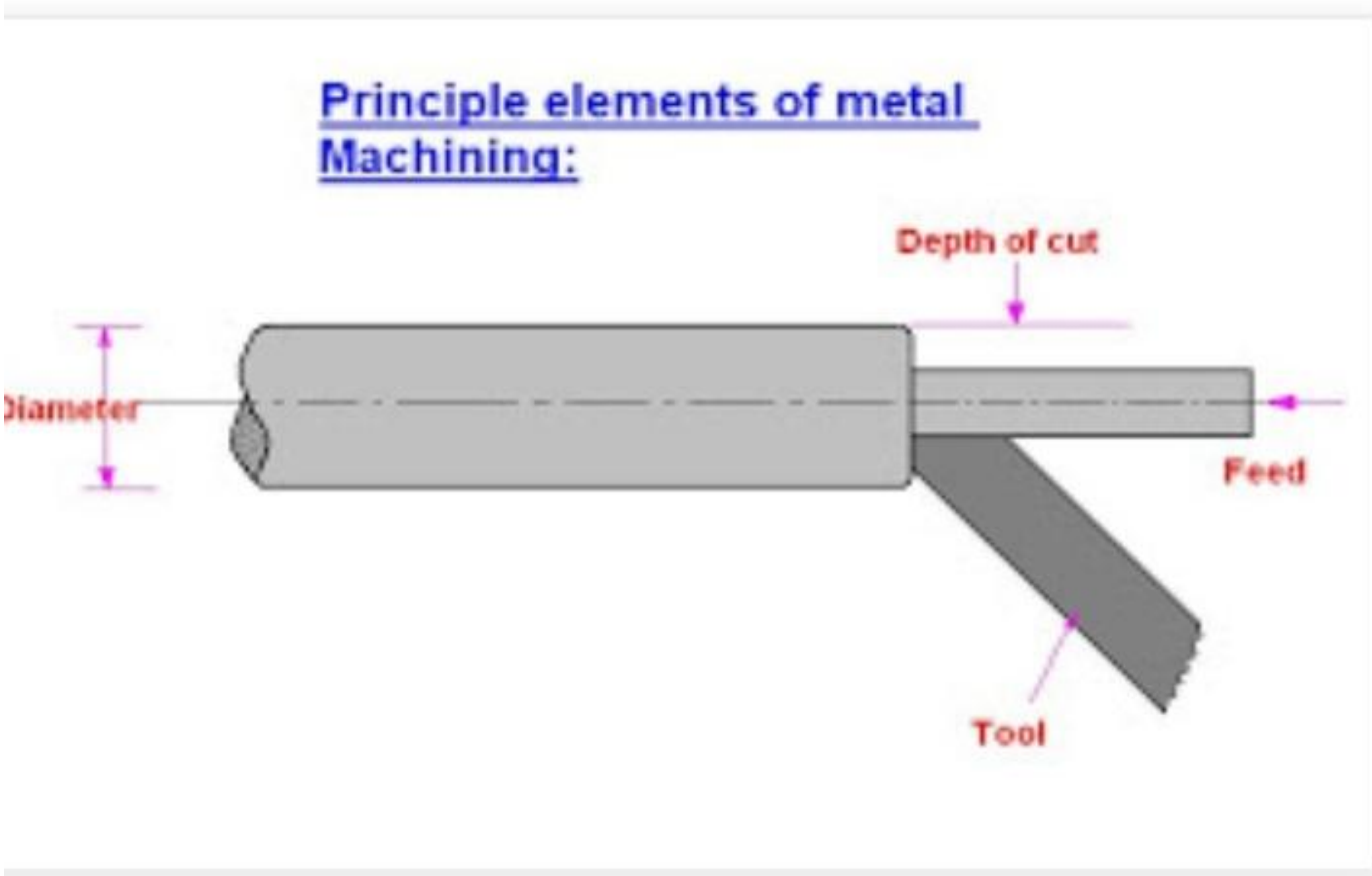
It may be defined as the relatively small the cutting tool relative to the work piece in a direction which is usually perpendicular to the cutting speed direction. It is expressed in mm/rev or mm/stroke.

It is more complex element as compare to the cutting speed. It is expressed differently for various operations.

3:Depth of cut:

The depth of cut is the thickness of the layer of the metal remove in one cut or pass measured in a direction perpendicular to the machine surface. The depth of cut is always perpendicular to the direction feed motion.

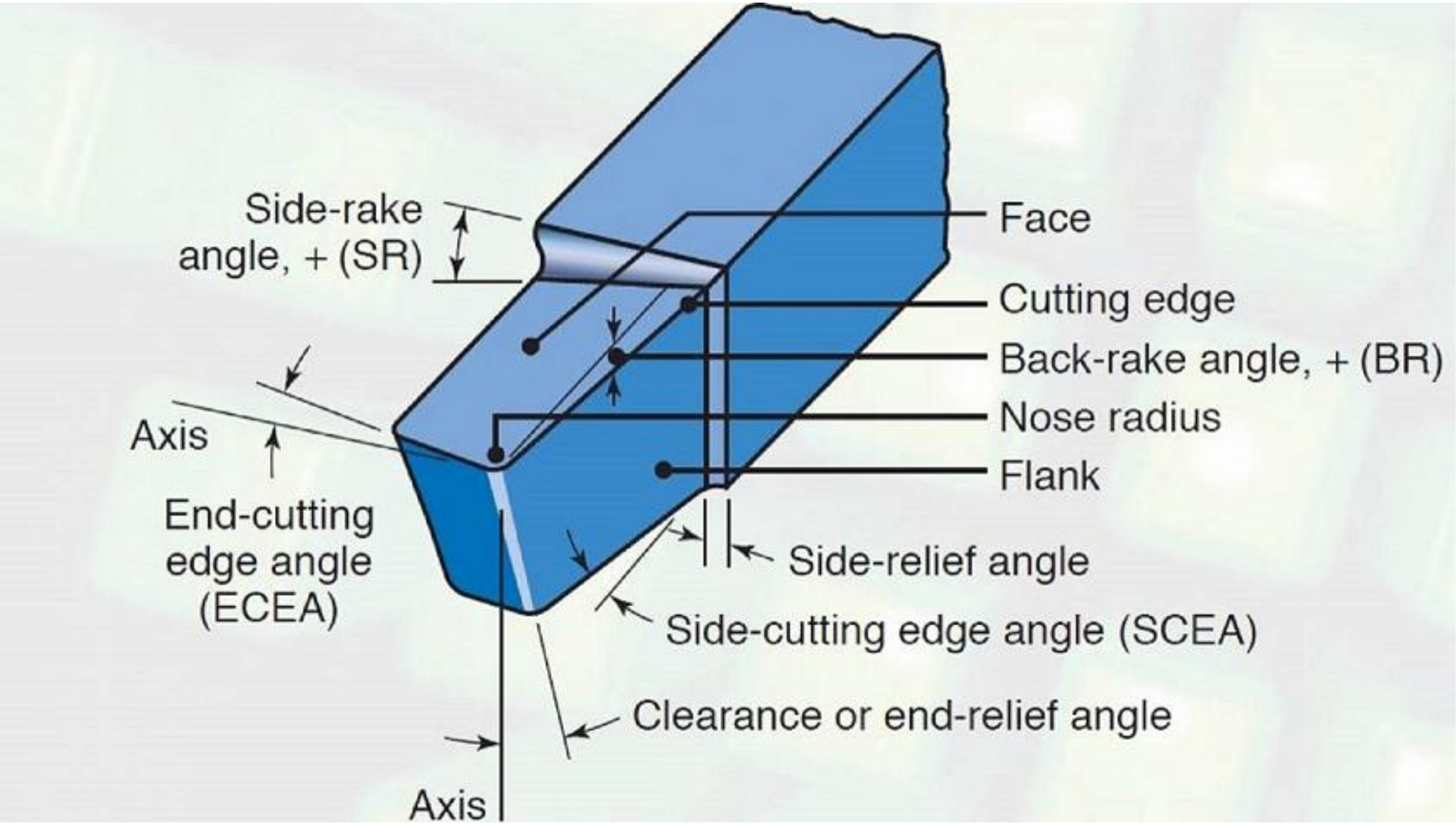
ELEMENTS OF CUTTING PROCESS



Single-point cutting tool

- Single Point Cutting Tool is a tool that helps to perform several operations (like Turning, Facing, Producing Flat surface) on Lathe, Shaper, Planer Machine.
- This tool consists of a sharpened cutting part called its point and the shank.
- The point of the tool is bounded by the face (along which the chips slides as they are cut by the tool), the side flank or major flank the end flank or minor flank and the base.
- As we know we perform several operations on the lathe (like turning, facing) from the single-point cutting tool.
- Design and fabrication are very easy for this tool.This tool can be made at a very cheaper rate as compared to others

Single-point cutting tool



Single Point Cutting Tool Types

There are only two types of tool:

1. Single and
2. Multi-Point cutting tool.

1. Single Point cutting tool:

- One cutting point or tip is available
- Example: Lathe Machine, Planning Machine tool

2. Multi-Point cutting tool:

- More than One cutting point or tip is available
- Example: Milling cutter, Grinding wheel, drill tool, extra.

Single point cutting tool angle

Angle:

1. *Side Cutting edge angle*
2. *End cutting edge angle*
3. *Side relief angle*
4. *End relief angle*
5. *Back Rack angle*
6. *Side rack angle*

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LECTURE 2

TOPICS TO BE COVERED

- Chip formation
- Mechanism of chip formation in machining ductile materials
- Mechanism of chip formation in machining brittle materials
- types of chips formation

LECTURE 2

Chip formation

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CHIP FORMATION

Mechanism of chip formation

- **Machining is a semi-finishing or finishing process essentially done to impart required or stipulated dimensional and form accuracy and surface finish to enable the product to:**

1. **Fulfill its basic functional requirements.**
2. **Provide better or improved performance.**
3. **Render long service life**

Machining is a process of gradual removal of excess material from the preformed blanks in the form of

chips

CHIP FORMATION

The form of the chips is an important index of machining because it directly or indirectly indicates:

- ❖ Nature and behavior of the work material under machining condition.
- ❖ Specific energy requirement (amount of energy required to remove unit volume of work material) in machining work.
- ❖ Nature and degree of interaction at the chip-tool interfaces

CHIP FORMATION

- The form of machined chips depends mainly upon:

1. Work material.
2. Material and geometry of the cutting tool.
3. Levels of cutting velocity and feed and also to some extent on depth of cut.
4. Machining environment or cutting fluid that affects temperature and friction at the chip-tool and work-tool interfaces.

- Knowledge of basic mechanism(s) of chip formation helps to understand the characteristics of chips and to attain favorable chip forms.

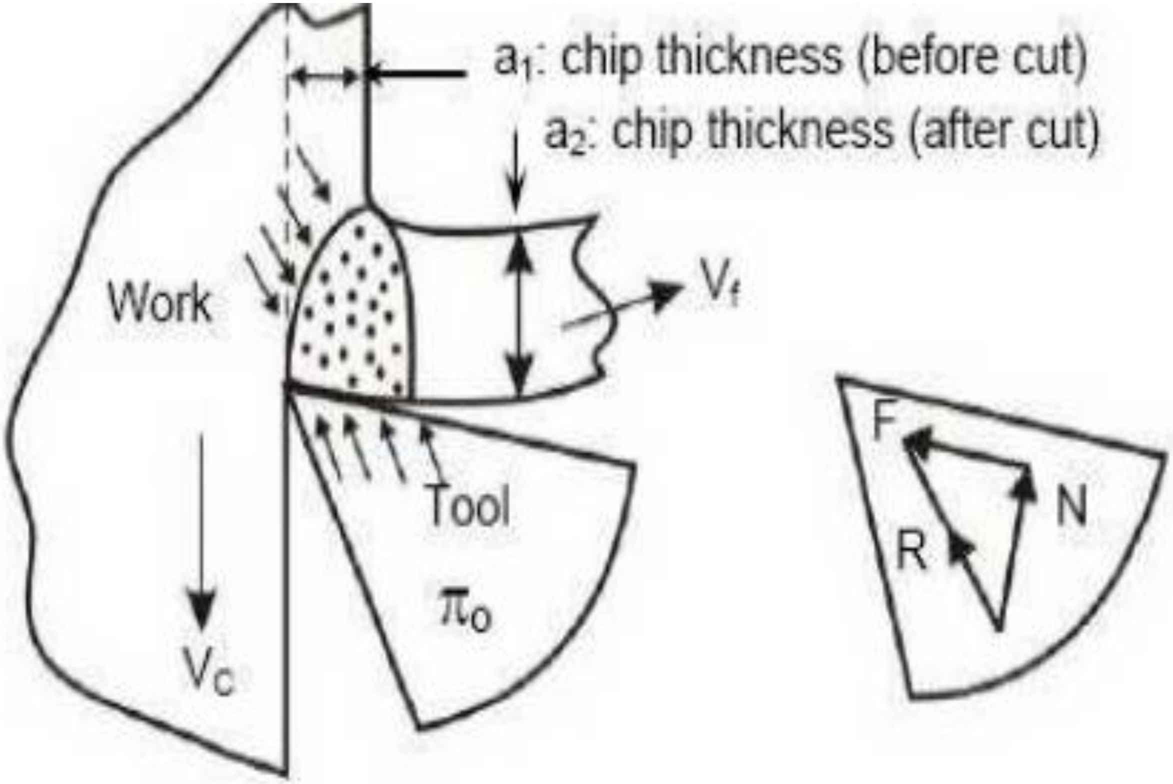
Mechanism of chip formation in machining ductile materials

- During continuous machining the uncut layer of the work material just ahead of the cutting tool (edge) is subjected to almost all sided compression Compression of work material (layer) ahead of the tool tip.
- The force exerted by the tool on the chip arises out of the normal force, N and frictional force, F as indicated in Fig. 1.10. Due to such compression, shear stress develops, within that compressed region,in different magnitude, in different directions and rapidly increases in magnitude.
- Whenever and wherever the value of the shear stress reaches or exceeds the shear strength of that work material in the deformation region, yielding or slip takes place resulting shear deformation in that region and the plane of maximum shear stress.

Mechanism of chip formation in machining ductile materials

- But the forces causing the shear stresses in the region of the chip quickly diminishes and finally disappears while that region moves along the tool rake surface towards and then goes beyond the point of chip-tool engagement.
- As a result the slip or shear stops propagating long before total separation takes place. In the meantime the succeeding portion of the chip starts undergoing compression followed by yielding and shear.
- This phenomenon repeats rapidly resulting in formation and removal of chips in thin layer by layer. This phenomenon has been explained in a simple way by Piispannen*1 using a card analogy

Mechanism of chip formation in machining ductile materials



Mechanism of chip formation in machining brittle materials

- The basic two mechanisms involved in chip formation are:
  - ➢ Yielding - generally for ductile materials.
  - ➢ Brittle fracture - generally for brittle materials.
- During machining, first a small crack develops at the tooltip as shown in Fig due to wedging action of the cutting edge. At the sharp crack-tip stress concentration takes place.
- In case of ductile materials immediately yielding takes place at the crack-tip and reduces the effect of stress concentration and prevents its propagation as crack.
- But in case of brittle materials the initiated crack quickly propagates, under stressing action, and total separation takes place from the parent workpiece through the minimum resistance path as indicated in Fig.

Mechanism of chip formation in machining brittle materials

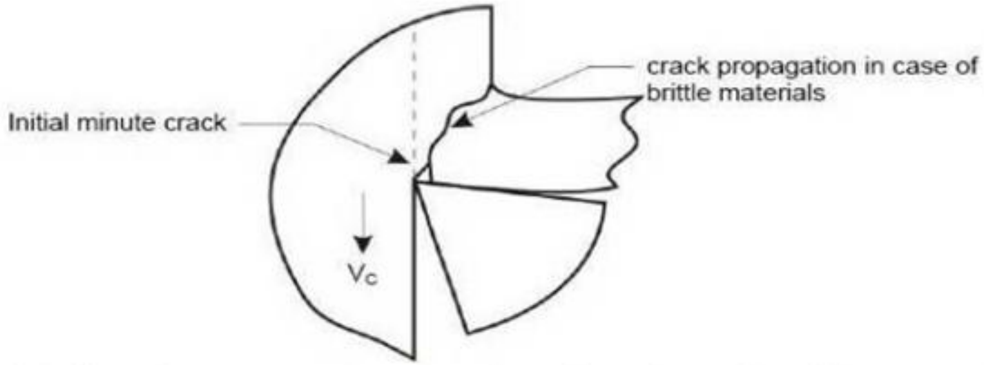
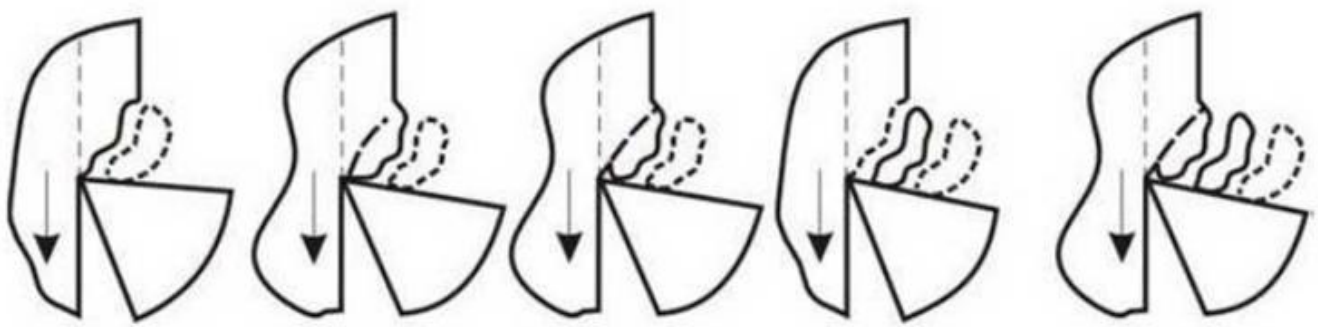


Fig. 1.14 Development and propagation of crack causing chip separation.

Machining of brittle material produces discontinuous chips and mostly of irregular size and shape. The process of forming such chips *is schematically shown in Fig. 1.15 (a, b, c, d and e).*



(a) Separation (b) Swelling (c) Further swelling (d) Separation (e) Swelling again

Fig. 1.15 Schematic view of chip formation in machining brittle materials

TYPES OF CHIPS

- Different types of chips of various shape, size, colour etc. are produced by machining depending upon:
- Type of cut, i.e., continuous (turning, boring etc.) or intermittent cut (milling).
- Work material (brittle or ductile etc.).
- Cutting tool geometry (rake, cutting angles etc.).
- Levels of the cutting velocity and feed (low, medium or high).
- Cutting fluid (type of fluid and method of application).

TYPES OF CHIPS

Discontinuous chips

- This is also called as segmental chips. This mostly occurs while cutting brittle material such as cast iron or low ductile materials.
- Instead of shearing the metal as it happens in the previous process, the metal is being fractured like segments of fragments and they pass over the tool faces.
- Tool life can also be more in this process.
- Power consumption as in the previous case is also low.

TYPES OF CHIPS

Continuous chips without BUE

- When the cutting tool moves towards the work piece, there occurs a plastic deformation of the work piece and the metal is separated without any discontinuity and it moves like a ribbon.
- The chip moves along the face of the tool. This mostly occurs while cutting a ductile material.
- It is desirable to have smaller chip thickness and higher cutting speed in order to get continuous chips.
- Lesser power is consumed while continuous chips are produced.
- Total life is also mortised in this process.

ASSIGNMENT QUESTIONS

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LECTURE-3

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TOPICS TO BE COVERED

- Mechanics of orthogonal cutting
- Orthogonal and oblique cutting
- pure orthogonal cutting
- cutting force components and its significance
- Development of equations for estimation of cutting forces
- Cutting speeds

LECTURE 3

Cutting forces and speeds

Orthogonal Cutting

- It is appears from the diagram shown in Fig (a and b) that while turning ductile material by a sharp tool
- The continuous chip would flow over the tool’s rake surface and in the direction apparently perpendicular to the principal cutting edge, i.e., along orthogonal plane which is normal to the cutting plane containing the principal cutting edge.
- But practically, the chip may not flow along the orthogonal plane for several factors like presence of inclination angle, λ, etc.

ORTHOGONAL CUTTING

π_o) angle.

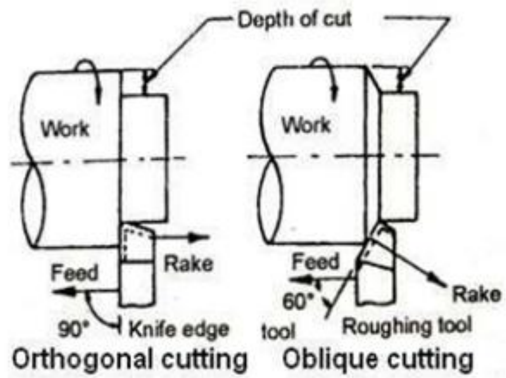


Fig. 1.7 (a) Setup of orthogonal and oblique cutting

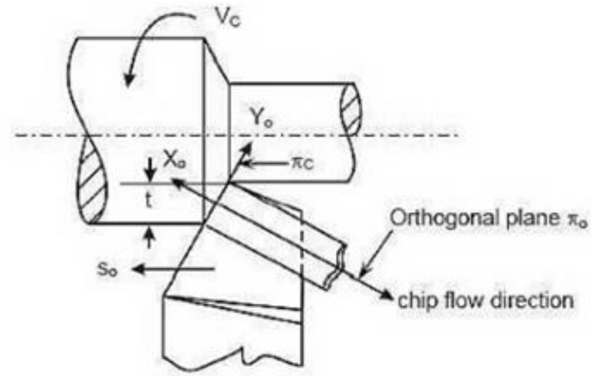
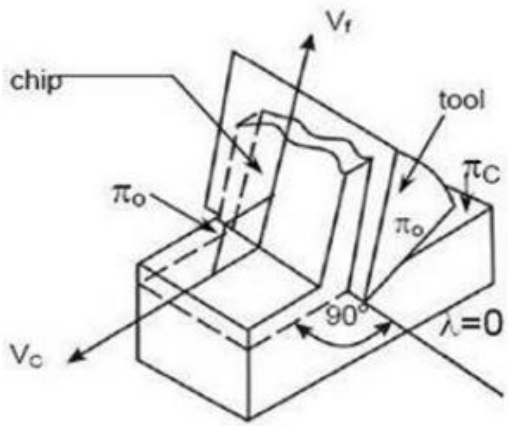
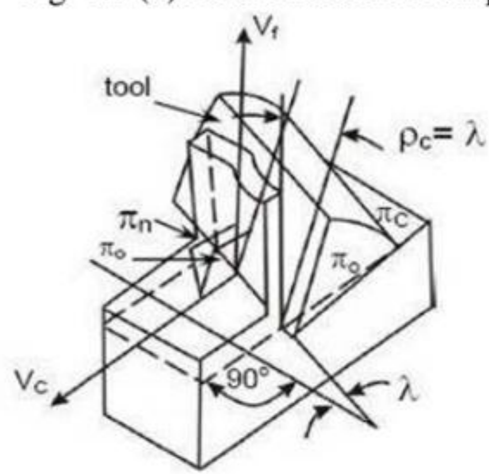


Fig. 1.7 (b) Ideal direction of chip flow in turning





ORTHOGONAL CUTTING AND OBLIQUE CUTTING

- The role of inclination angle, λ on the direction of chip flow is schematically shown in Fig which visualizes that:

When λ = 00, the chip flows along orthogonal plane, i.e, ρc = 00.

When λ ≠ 00, the chip flow is deviated from πo and ρc = λ where ρc is chip flow deviation (from πo) angle.

ORTHOGONAL AND OBLIQUE CUTTING

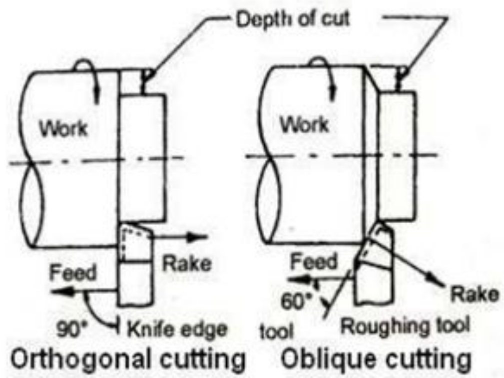


Fig. 1.7 (a) Setup of orthogonal and oblique cutting

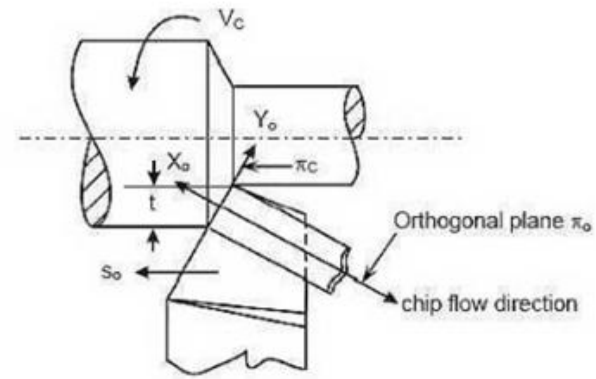


Fig. 1.7 (b) Ideal direction of chip flow in turning

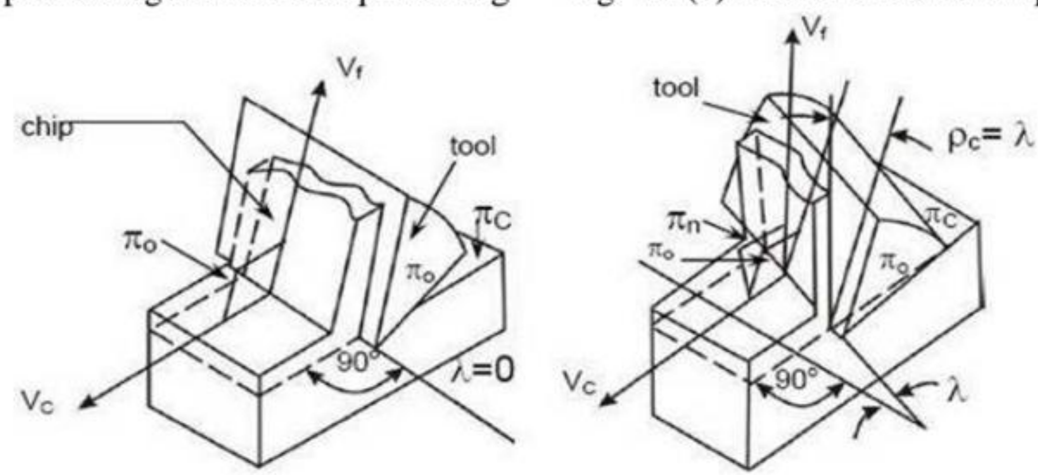


Fig. 1.8 Role of inclination angle, λ on chip flow direction

ORTHOGONAL AND OBLIQUE CUTTING

- **Orthogonal cutting**: When chip flows along orthogonal plane, πo, i.e., ρc = 00.
- **Oblique cutting:** When chip flow deviates from orthogonal plane, i.e. ρc ≠ 00.
- But practically ρc may be zero even if λ = 00 and ρc may not be exactly equal to λ even if λ ≠ 00.
- Because there is some other (than λ) factors also may cause chip flow deviation

Pure orthogonal cutting

- This refers to chip flow along πo and φ = 900 as typically shown in Fig. 1.9. Where a pipe like job of uniform thickness is turned (reduced in length) in a center lathe by a turning tool of geometry; λ = 00 and φ = 900 resulting chip flow along πo which is also πx in this case.

PURE ORTHOGONAL CUTTING

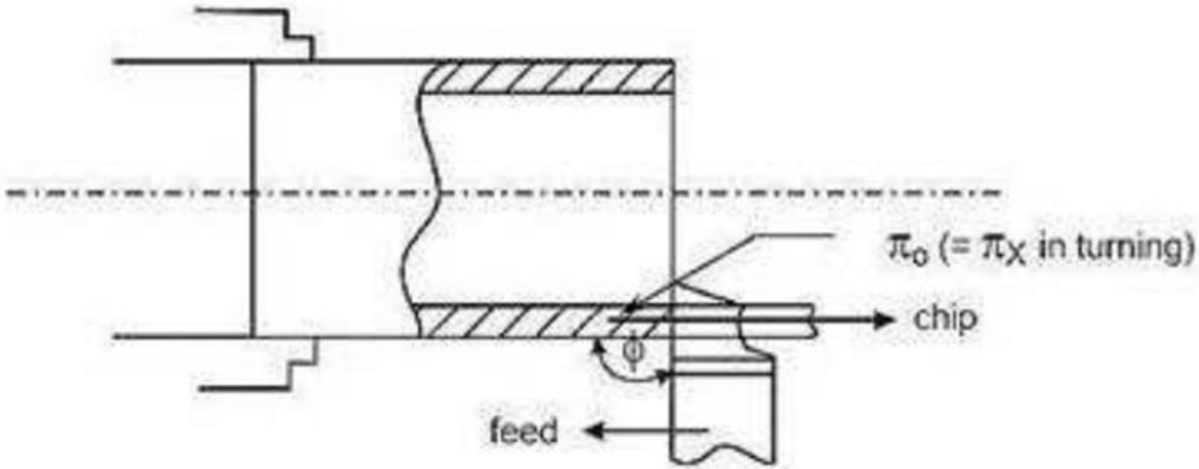


Fig. 1.9 Pure orthogonal cutting (pipe turning)

ORTHOGONAL METAL CUTTING

- Benefit of knowing and purpose of determining cutting forces

The aspects of the cutting forces concerned:

- ❖ Magnitude of the cutting forces and their components.
- ❖ Directions and locations of action of those forces.
- ❖ Pattern of the forces: static and / or dynamic.
- ❖ Knowing or determination of the cutting forces facilitate or are required for:
- ❖ Estimation of cutting power consumption, which also enables selection of the power source(s) during design of the machine tools.
- ❖ Structural design of the machine - fixture - tool system.

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ORTHOGONAL METAL CUTTING

- ❖ Evaluation of role of the various machining parameters (process - VC, fo, t, tool - material and geometry, environment - cutting fluid) on cutting forces.
- ❖ Study of behaviour and machinability characterization of the work materials.
- ❖ Condition monitoring of the cutting tools and machine tools

Cutting force components and their significances

- The single point cutting tools being used for turning, shaping, planing, slotting, boring etc. are characterized by having only one cutting force during machining.
- But that force is resolved into two or three components for ease of analysis and exploitation. Fig visualizes how the single cutting force in turning is resolved into three components along the three orthogonal directions; X, Y and Z.
- The resolution of the force components in turning can be more conveniently understood from their display in 2-D as shown in Fig.

Cutting force components and their significances

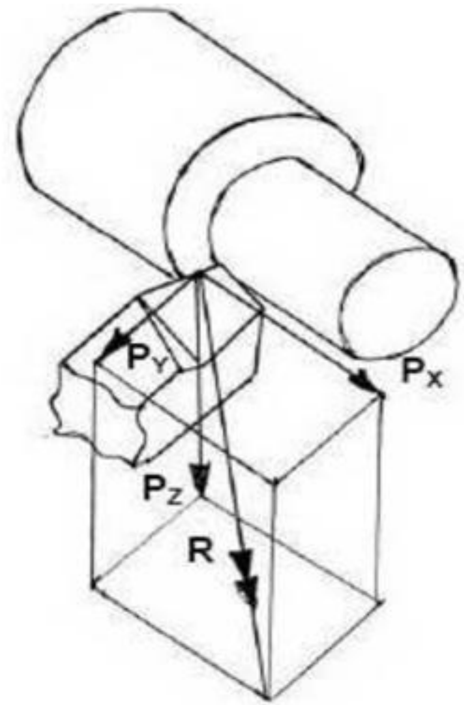

Fig. 1.37 Cutting force R resolved into P_X, P_Y and P_Z

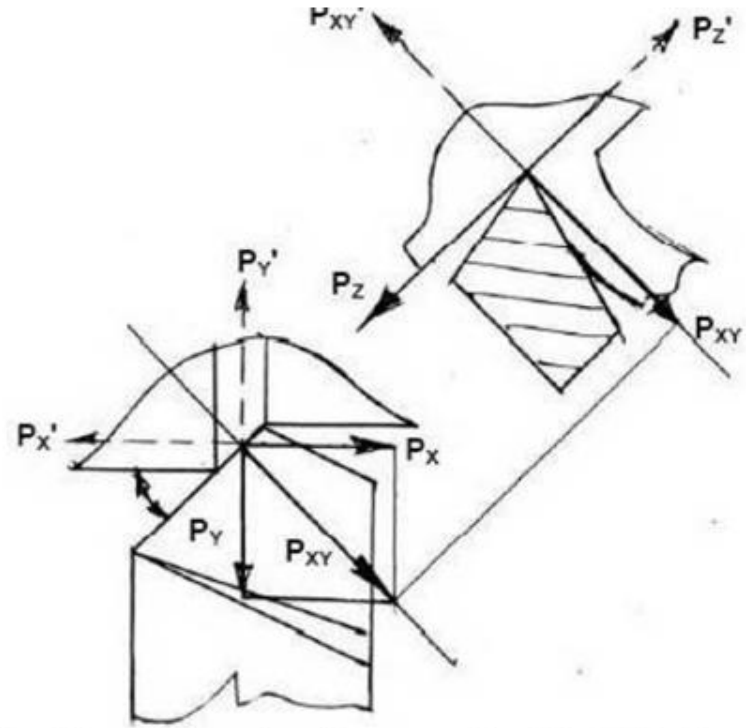

Fig. 1.38 turning force resolved into P_Z, P_X and P_Y

Cutting force components and their significances

The resultant cutting force, R is resolved as, R = PZ + PXY

and PXY = PX + PY

where, PX = PXY sinφ

and PY = PXY cosφ

PZ - Tangential component taken in the direction of Zm axis.

PX - Axial component taken in the direction of longitudinal feed or Xm axis.

PY - Radial or transverse component taken along Ym axis.

Significance of PZ, PX and PY

PZ: Called the main or major component as it is the largest in magnitude. It is also called power component as it being acting along and being multiplied by VC decides cutting power (PZ.VC)

consumption.

PY: May not be that large in magnitude but is responsible for causing dimensional inaccuracy and

vibration.

PX: It, even if larger than PY, is least harmful and hence least significant.

Development of equations for estimation of cutting forces

The two basic methods of determination of cutting forces and their characteristics are:

(a) Analytical method: Enables estimation of cutting forces.

Characteristics:

- Easy, quick and inexpensive.
- Very approximate and average.
- Effect of several factors like cutting velocity, cutting fluid action etc. are not revealed.
- Unable to depict the dynamic characteristics of the forces

Development of equations for estimation of cutting forces

(b) Experimental methods: Direct measurement.

Characteristics:

- Quite accurate and provides true picture.
- Can reveal effect of variation of any parameter on the forces.
- Depicts both static and dynamic parts of the forces.
- Needs measuring facilities, expertise and hence expensive.

Cutting Speeds for Turning and Threading with HSS Tool Bits

MATERIAL	STRAIGHT TURNING SPEED		THREADING SPEED	
	Feet Per	Meters Per	Feet Per	Meters Per
Low-Carbon Steel	80-100	24.4-30.5	35-40	10.7-12.2
Medium-Carbon Steel	60-80	18.3-24 4	25-30	7.6-9.1
High-Carbon Steel	35-40	10.7-12.2	15-20	4.6-6.1
Stainless Steel	40-50	12.2-15.2	15-20	4.6-6.1
Aluminum and its Alloys	200-300	61.0-91.4	50-60	15.2-18.3
Ordinary Brass and Bronze	100-200	30.5-61.0	40-50	12.2-15.2
High Tensile Bronze<	40-60	12.2-18.3	20-25	6.1-7.6
Cast Iron	50-80	15.2-24 4	20-25	6.1-7.6
Copper	60-80	18.3-24.4	20-25	6.1-7.6

ASSIGNMENT QUESTIONS

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LECTURE-4

TOPICS TO BE COVERED

- Depth of cut
- feed rate
- tool life
- coolants
- machinability

LECTURE-4

Tool life and coolants

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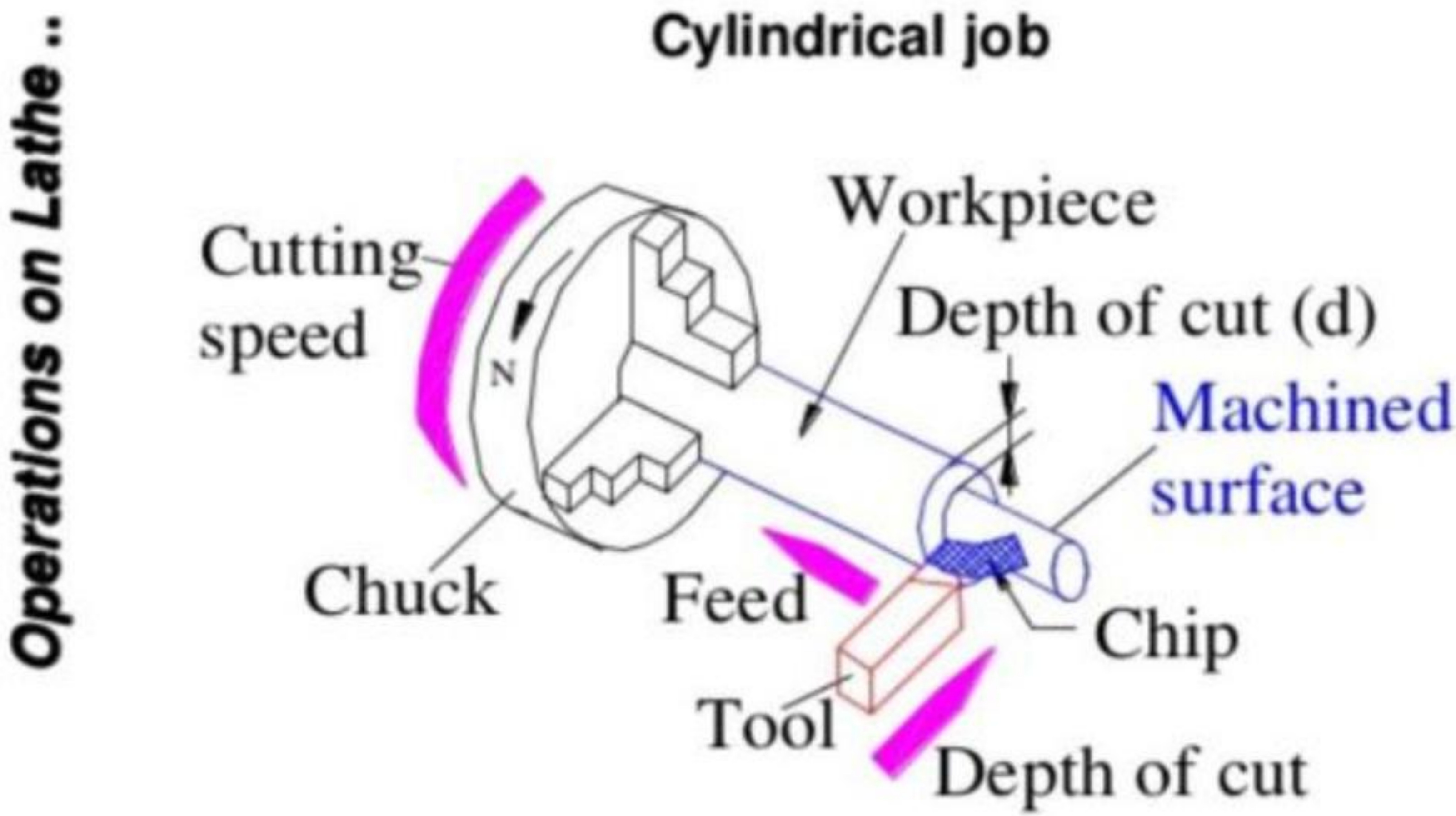
DEPTH OF CUT

- Cutting speed is defined as the speed at which the work moves concerning the tool (usually measured in feet per minute).
- The cutting speed, expressed in FPM, must not be confused with the spindle speed of the lathe which is expressed in RPM.
- To obtain uniform cutting speed, the lathe spindle must be revolved faster for workplaces of small diameter and slower for workplaces of large diameter.

DEPTH OF CUT

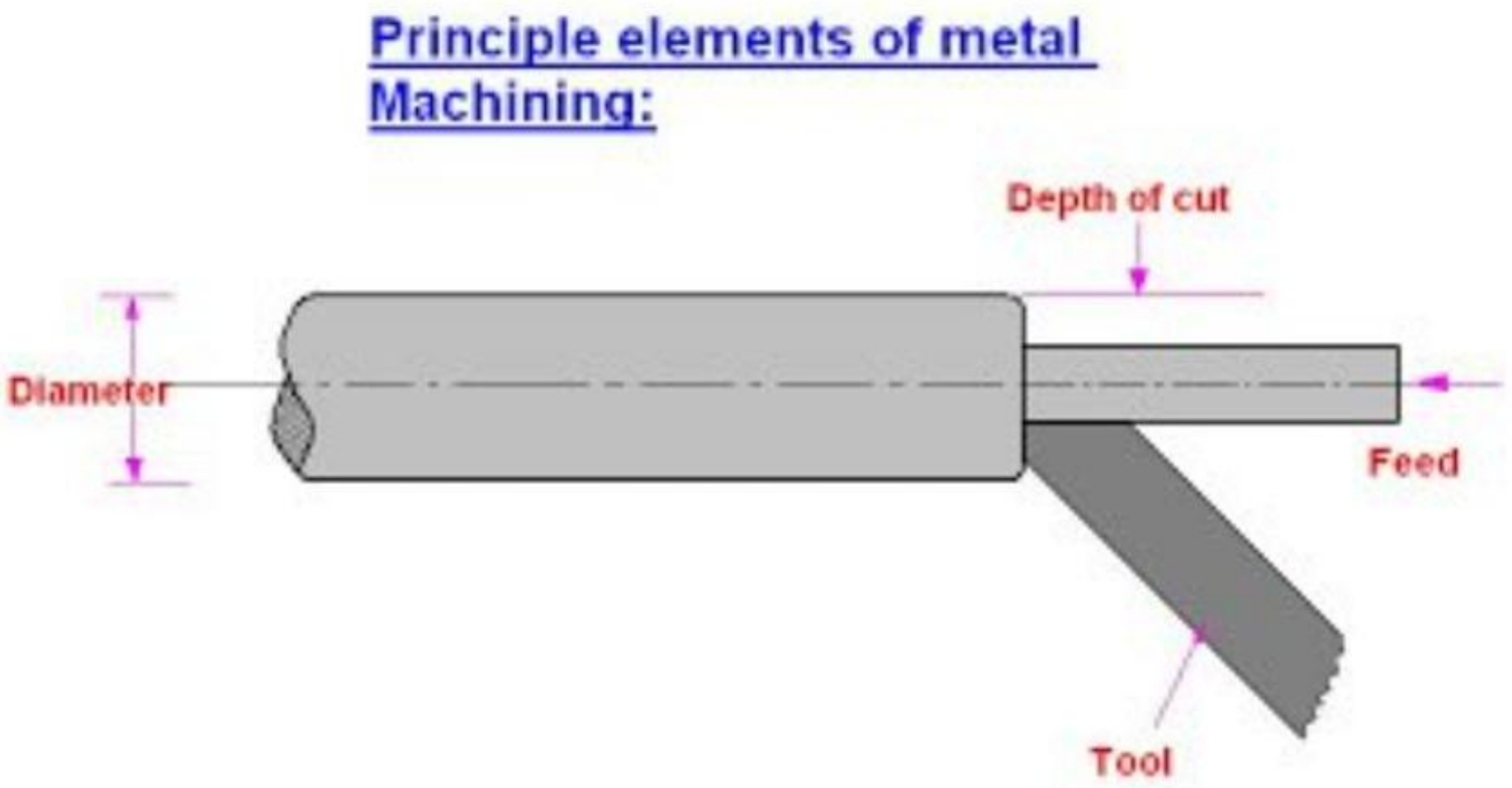


Operations on Lathe :
Cylindrical job
Cutting speed
N
Workpiece
Depth of cut (d)
Machined surface
Chuck
Feed
Chip
Tool
Depth of cut

DEPTH OF CUT

- The proper cutting speed for a given job depends upon the hardness of the material being machined, the material of the tool bit, and how much feed and depth of cut is required.
- Cutting speeds for metal are usually expressed in surface feet per minute, measured on the circumference of the work

DEPTH OF CUT



Principle elements of metal Machining:
Depth of cut
Diameter
Feed
Tool

DEPTH OF CUT

- The depth of cut is the distance that the tool bit moves into the work. usually measured in thousandths of an inch or millimeters.
- General machine practice is to use a depth of cut up to five times the rate of feed, such as rough cutting stainless steel using a feed of 0.020 inches per revolution and a depth of cut of 0.100 inch.
- Which would reduce the diameter by 0.200 inch.
- If chatter marks or machine noise develops, reduce the depth of cut.
- It is the total amount of metal removed per pass of the cutting tool. It is expressed in mm.
- It can vary and depend upon the type of tool and work material. Mathematically, it is half of the difference of diameters.

DEPTH OF CUT

Depth of cut (t) = D-d/2 mm

where, D = outer diameter, (mm)

d = Inner diameter (mm)

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FEED RATE

- **Feed Rate** is one of the most important factors to consider when implementing any CNC strategy.
- Simply put, feed rate is the speed at which the cutter engages the part and is typically measured in units/minute.
- Suggested cut feed rates will vary depending on the type of material you are cutting (i.e., aluminum, steel, wood, acrylic, etc.), the material of the cutter (carbide, high speed steel, ceramic, etc.) and many other cutting factors including desired surface and the characteristics of the CNC machine itself.

TOOL LIFE

- Every device or tool has its functional life. At the expiry of which it may function, but not efficiently.
- So it is also true with a cutting tool.
- During use, the tool losses its material, i.e., it gets worn out.
- As the wear increases, the tool losses its efficiency.
- So its life has to be defined and on expiry of its life, it should be reground for fresh use.

TOOL LIFE

The tool life can be defined in following different ways:

(i) The time elapsed between two successive grindings.

(ii) The period during which a tool cuts satisfactory.

(iii) The total time accumulated before tool failure occurs.

COOLANTS

- Machine coolants have been used extensively in metal cutting operations for the last 200 years.
- In the beginning, machine coolants consisted of simple oils applied with brushes to lubricate the machine tool. Occasionally, lard, animal fat or whale oil was added to improve the oil's lubricity.
- As cutting operations became more severe, machine coolant formulations became more complex.
- Today's machine coolants are special blends of chemical additives, lubricants and water formulated to meet the performance demands of the metalworking industry.

The Importance of Coolants in Machining

The critical functions of coolant in the machining process include:

- Reducing and removing the heat build-up in the cutting zone and workpiece
- Provides lubrication to reduce friction between the tool and removal of the chips
- Flushes away chips and small abrasive particles from the work area
- Protects against corrosion

Types of Coolants

Coolants are grouped into four main categories and have a variety of different formulations. Selecting coolant should be based on the overall performance it provides centered around your machining application and materials used.

Soluble Oils: The most common of all water-soluble cutting fluids and a great option for general purpose machining. The drawback is that they are prone to microbiological growth of fungus and bacteria if the coolant sump is not correctly maintained.

Synthetic Fluids: These types of fluids tend to be the cleanest of all cutting fluids because they contain no mineral oil and reject tramp oil. However, they provide the least lubrication.

Types of coolants

Semi-synthetic Fluids: Considered to be the best of both worlds, they have less oil than emulsion-based fluids, a less stinky smell, and retain much of the same lubricating attributes. This makes them usable for a broader range of machining.

Straight Oils: These are not water-miscible and have a composition of a mineral or petroleum oil base and contain lubricants like vegetable oils, fats, and esters. They provide the best lubrication but have the poorest cooling characteristics.

MACHINABILITY

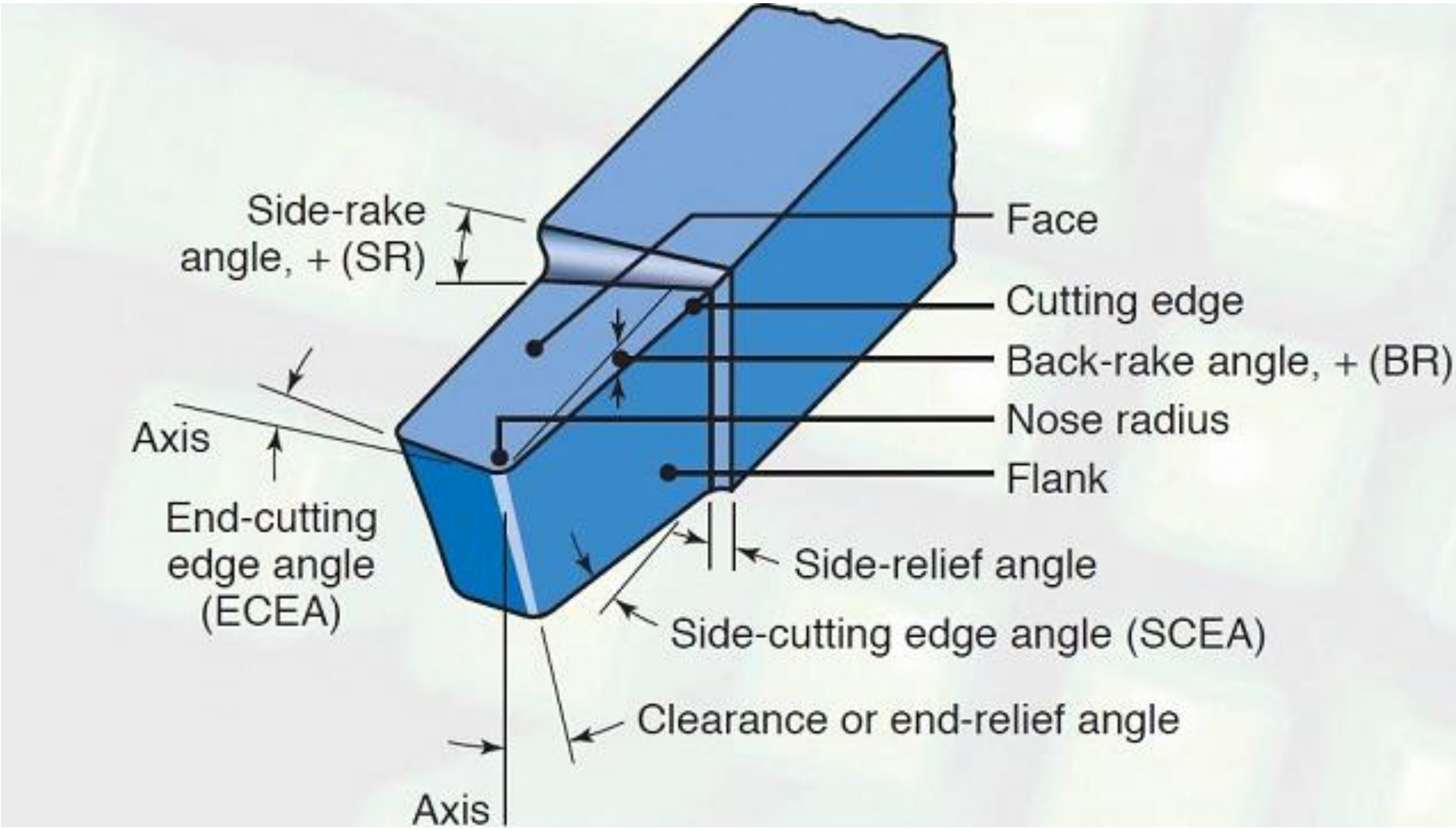
- The condition and physical properties of the work material have a direct influence on the machinability of a work material.
- The various conditions and characteristics described as "condition of work material," individually and in combinations, directly influence and determine the machinability.
- Operating conditions, tool material and geometry and workpiece requirements exercise indirect effects on machinability and can often be used to overcome difficult conditions presented by the work material.
- On the other hand, they can create situations that increase machining difficulty if they are ignored

Condition of Work Material

The following eight factors determine the condition of the work material:

- microstructure,
- grain size
- heat treatment
- chemical composition
- fabrication
- hardness
- yield strength
- tensile strength

MACHINABILITY



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LECTURE-5

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TOPICS TO BE COVERED

- Lathe Machine
- Types of lathe
- Description and function of lathe parts
- Lathe machine working
- Principle of working

LECTURE-5

LATHE MACHINE

LATHE MACHINE

- One of the oldest machine tools is a lathe machine. In 1797, an Englishman, Henry Maudslay, designed the first screw-cutting lathe which is the forerunner of the present day high speed, heavy duty production lathe.

Functions of the Lathe :

- To remove metal from a piece of work to give it the required shape and size is the main function of the lathe.
- This is accomplished by holding the work securely and rigidly on the machine.
- Then turning it against cutting tool which will remove metal from work in the form of chips.

TYPES OF LATHE

1. Speed Lathe

- Woodworking
- Centring
- Polishing
- Spinning

2. Engine Lathe

- Belt drive
- Individual motor drive
- Gear head lathe

TYPES OF LATHE

3. Bench Lathe

4. Toolroom Lathe

5. Capstan and Turret Lathe

6. Special purpose

- Wheel lathe
- Gap bed lathe
- T-lathe

7. Automatic Lathe

Description and function of lathe parts

1. The bed

   The lathe bed forms the base of the machine, the headstock and tailstock are located at either end of the bed and the carriage rests over the lathe bed and slides over it.

1. The Headstock

   The headstock is secured permanently on the inner ways at the left-hand end of the lathe bed.

1. The Tailstock

   The tailstock is located on the inner ways at the right-hand end of the bed.

1. Carriage

   The carriage of a lathe has various parts which serve to support, move and control the cutting tool.

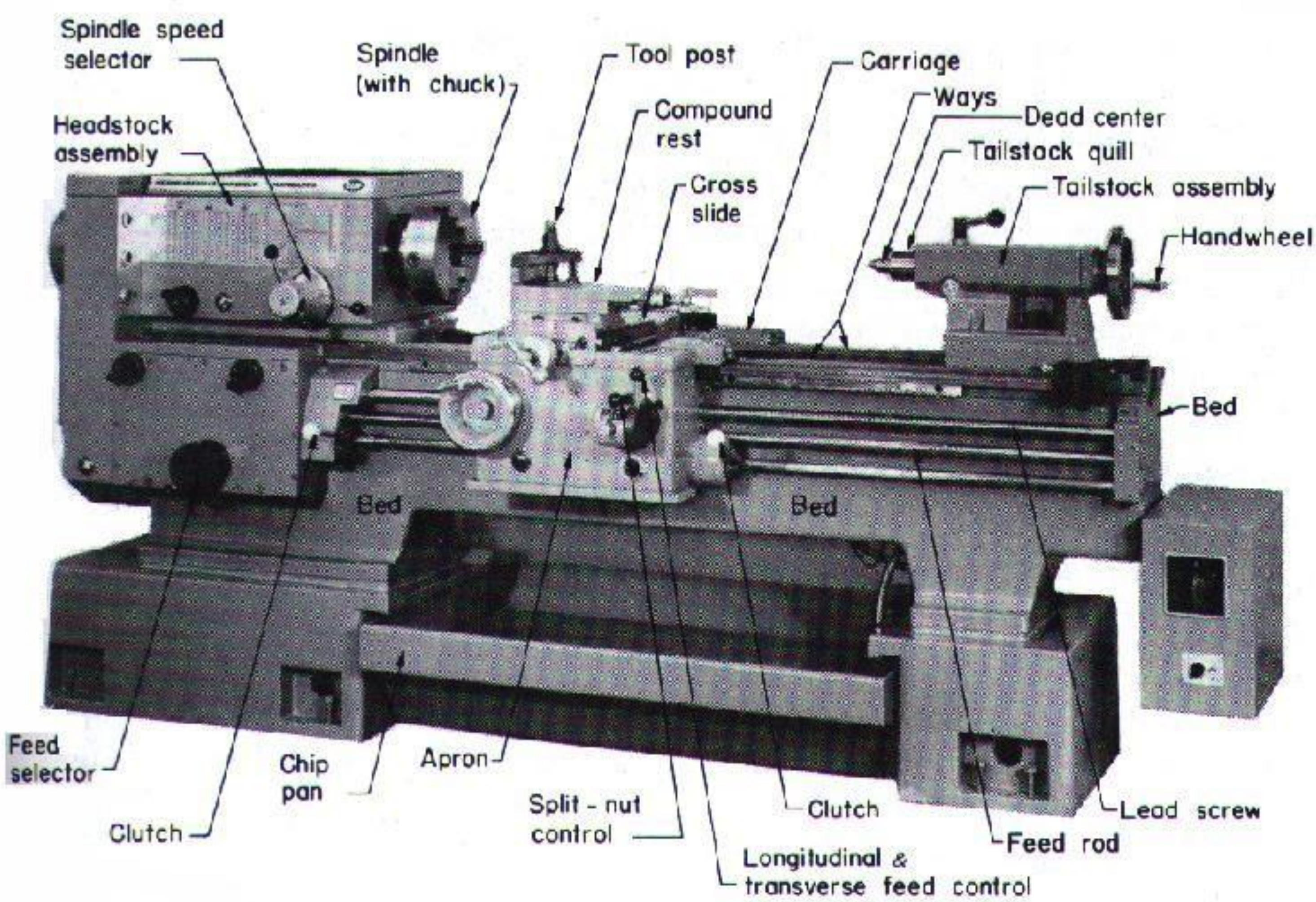
1. Feed Mechanism

   Feed is the movement of the tool relative to the work

Lathe machine working

- The lathe is a machine tool which holds the work piece between two rigid and strong supports called centers or in a chuck or face plate which revolves.
- In a tool post which is fed against the revolving work, the cutting tool is rigidly held and supported.
- With the cutting tool fed either parallel or at right angles to the work axis, the normal cutting operations are performed.

LATHE MACHINE



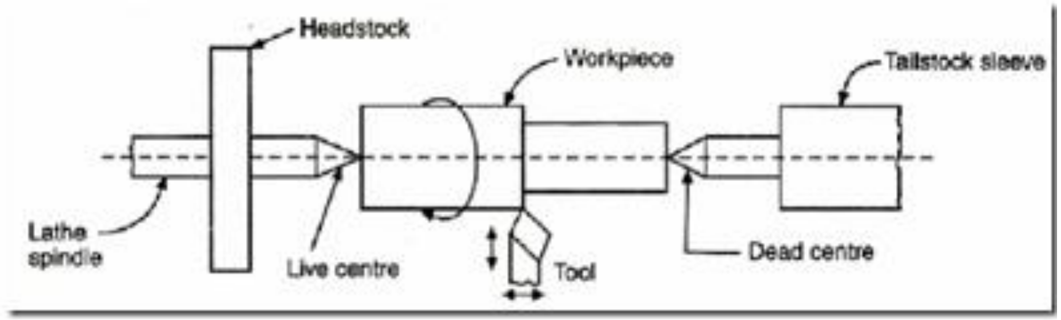
Working principle of Lathe

- A lathe is a machine tool which use to removes unwanted materials from a workpiece in the **form of chips** with the **help of a tool** that travels across the work piece and can be **fed deep** in work.
- When the tool is **moved parallel** to the work-piece then **the cylindrical surface** is formed.
- If the tool is **moved inclined** to the axis then it produces a **tapered surface** and so calls as taper turning.

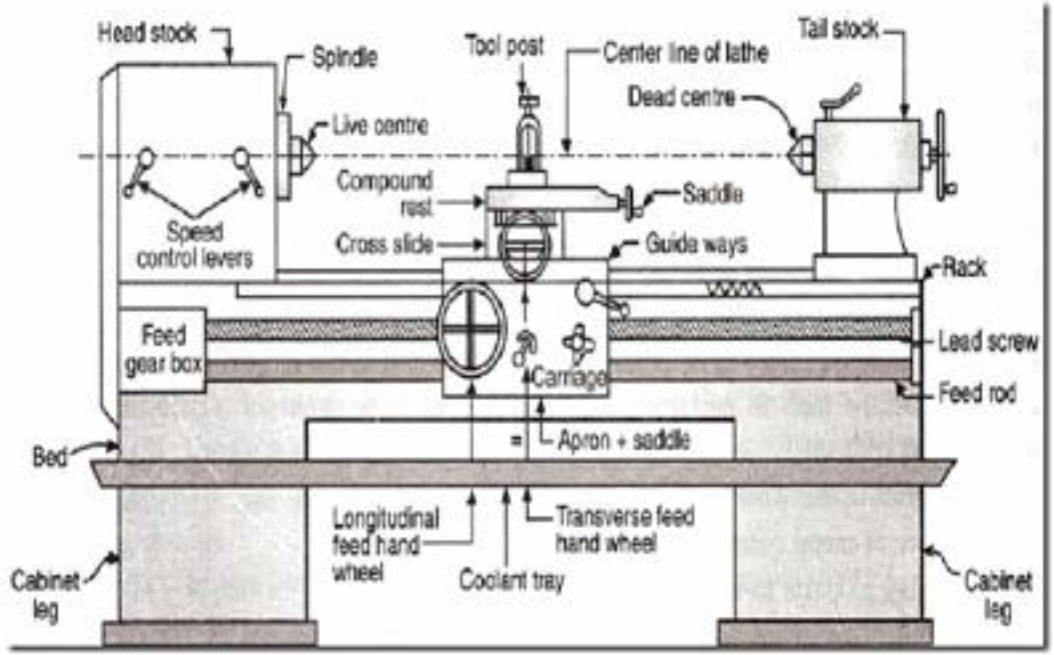
Working

- It holds the work between **two supports** so call as centers.
- **Face plate or Chuck** are using for holding the work.
- Face plate or Chuck are mounted **on the machine spindle**.
- The **cutting tool** is holding with the help of Tool post.
- The movement of the job is rotating about the **spindle axis**.
- Against the revolving work, the tool is feed.
- The **tool** moves either **parallel or inclination** to the work axis.

WORKING



Construction: The main parts of the lathe are the bed, headstock, quick changing gear box, carriage and tailstock.



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TOPICS TO BE COVERED

- Types of lathe
- Center or Engine Lathe
- Speed Lathe
- Capstan and Turret Lathe
- Tool Room Lathe
- Bench Lathe
- Automatic Lathe
- Special Purpose and
- CNC Lathe Machine
- Its specifications

LECTURE-6

Lathe machine-Types

Lathe Machine

- A lathe machine is a machine tool that is used to remove metals from a workpiece to give a desired shape and size.
- Lathe Machines are used in metalworking, woodturning, metal spinning, thermal spraying, glass working, and parts reclamation.
- The various other operations that you can perform with the help of Lathe Machine can include sanding, cutting, knurling, drilling, and deformation of tools that are employed in creating objects which have symmetry about the axis of rotation.

TYPES OF LATHE

Lathe machine tool which is used for removing the excess material from the workpiece to give required shape and size to the workpiece

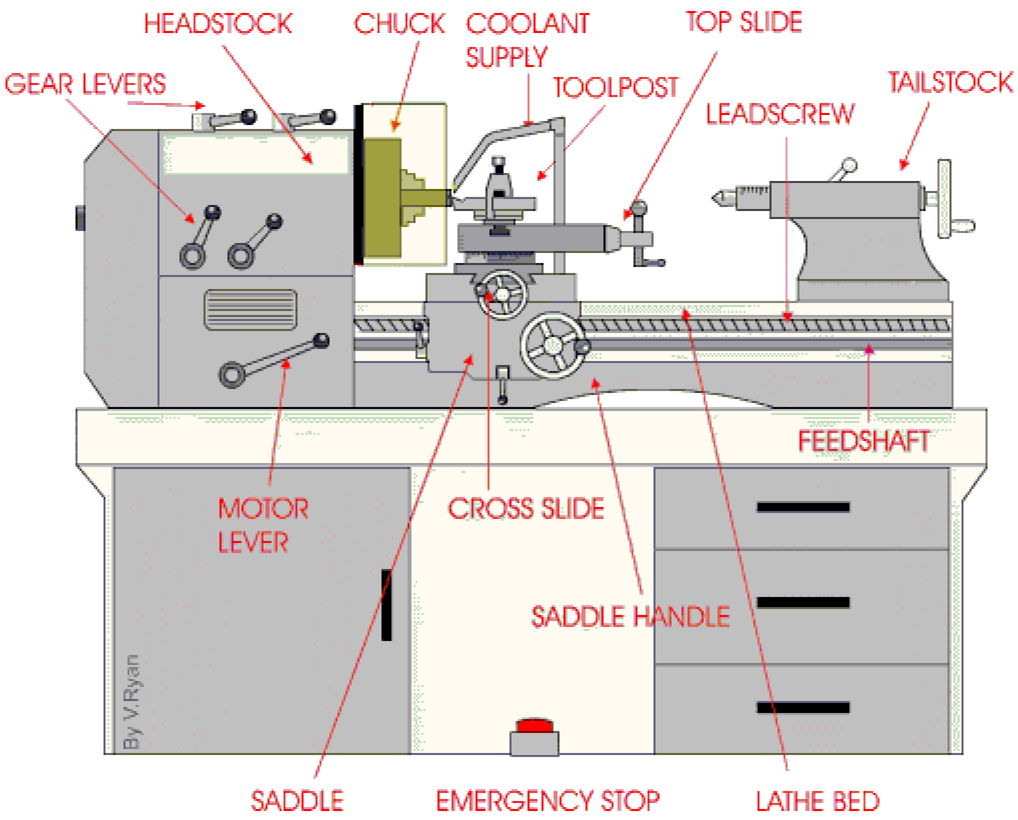
Lathe machine has been **categorized into the following types**:

- Center or Engine Lathe
- Speed Lathe
- Capstan and Turret Lathe
- Tool Room Lathe
- Bench Lathe
- Automatic Lathe
- Special Purpose and
- CNC Lathe Machine

Center or Engine Lathe Machine

- **Center or Engine Lathe Machine** is the most widely used **lathe machine** and still, it is, in every workshop, this machine is present.
- The operation like Turning, facing, grooving, Knurling, threading and more, such operations are performed on this type of machine.
- **Engine lathe machine** has all the parts such as bed, Saddle, headstock, and tailstock, etc. The headstock of an engine lathe is rigid and tailstock is moveable which is further used to support an operation like knurling.
- It can easily feed the cutting tool in both directions i.e. longitudinal and lateral directions with the help of feed mechanisms.
- **Center Lathe machines** are driven by the **gear mechanism or pulley mechanism**.
- It has three types of driven mechanisms, and those are **Belt-driven, Motor-driven, Gearhead type**.

CENTER OR ENGINE LATHE MACHINE



Speed Lathe

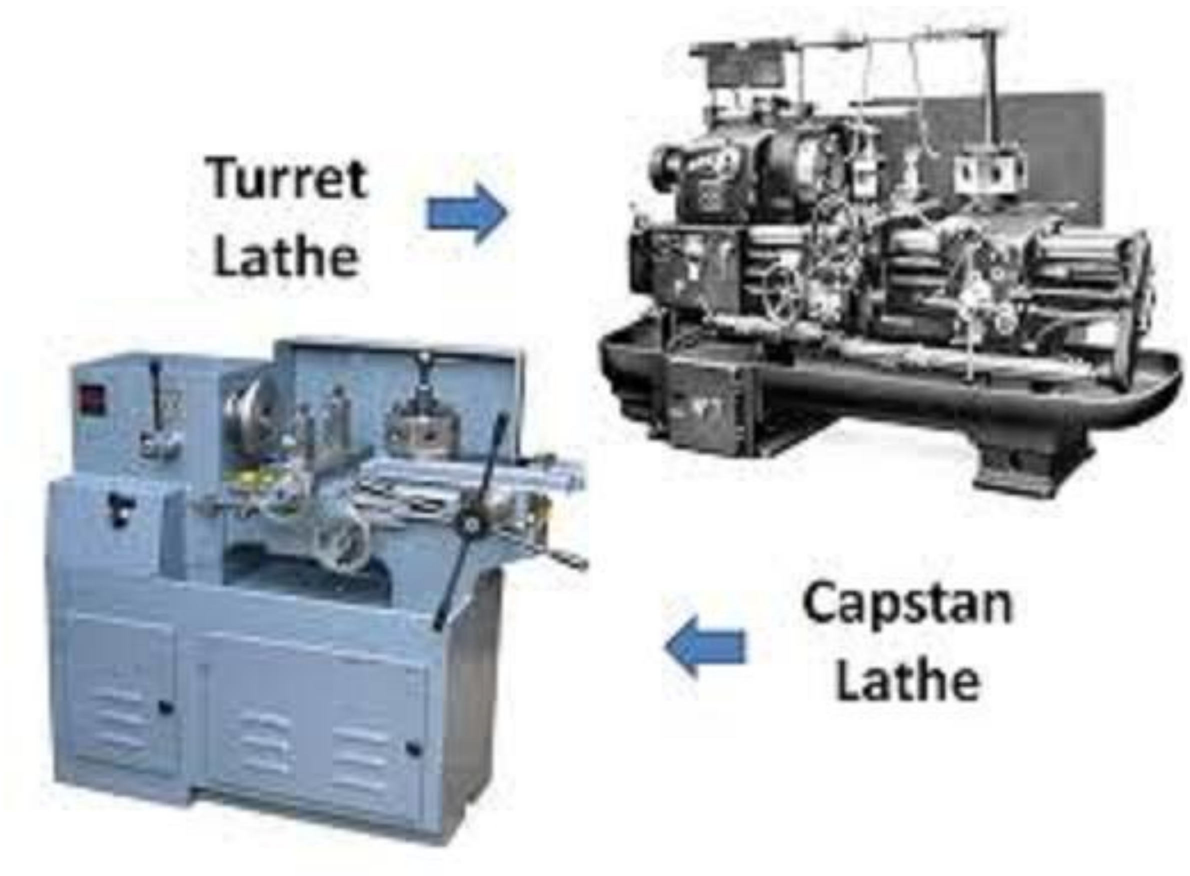
- **Speed lathe** is also called as **Wood Lathe**.
- As the name indicates "Speed" the machine works with high speed. The headstock spindle is rotating at a very high speed.
- The parts having like headstock, tailstock, but it's not having feed mechanism like center or engine lathe having.
- The feed we provide is manually operated.
- The speed ranges of this machine operated between **1200 to 3600 RPM**.
- Speed lathe is used for spinning, centering, polishing and machining of wood.

SPEED LATHE

Capstan and Turret Lathe

- This is an advanced technology of the manufacturing industry.
- The capstan and turret lathe machine used for Mass production (large Quantity) and it is a modified version of the engine lathe machine
- This machine is used where their sequence of operation is performed on the workpiece, there is no alternative operation performed on this machine.
- These machines provided by hexagonal turret head instead of the tailstock in which multiple operations (Turning, facing, boring, reaming) performed in a sequence without changing its tool manually, after each operation the turret rotated.
- It also consists of three tool post. It requires more floor space than other lathe machines.
- Capstan and turret lathe is using for only large jobs.
- The main advantage of using capstan and turret lathe is even less skilled operators can do a job.

Capstan and Turret Lathe



Tool Room Lathe

- The toolroom lathe machine operates to speed up to 2500 rpm.
- The parts are almost the same similar to engine lathe machine but the parts are built very accurately and should be arranged in proper sequence because this lathe is used for highly precious work with very fewer tolerances.
- It is mainly used in grindings, working on the tool, dies gauges and in machining work where accuracy is needed.

Tool Room Lathe

Bench Lathe

- Bench lathe machines are mounted on the bench.
- This type of lathe machine is small in size and use for very small precision work.
- It has all the similar parts of engine lathe and speed lathe.

Bench Lathe

Automatic Lathe

- As the name indicates "Automatic lathe" performs work automatically.
- Standard lathes have some drawbacks i.e. they are not used for mass production.
- But automatic lathes are used for mass production. Some mechanisms are responsible for the automation in it.
- Here there is no need to change the tool manually because it changes automatically.
- Having this machine the main advantage is that a single operator can handle machines more than 4 to 5 machines at a time.
- These types of lathes are high speed and heavy-duty.

Automatic Lathe

Special Purpose Lathe

- As the name indicates “special purpose lathe” the machine performs the special types of operation which can not be performed on standard and other machines.
- It is known for the heavy-duty production of identical parts.
- Some examples of special lathes include Vertical lathes, Wheel lathes, T-lathe, Multi Spindle lathes, Production lathes, Duplicate or tracer lathes, etc.
- Wheel lathe is used for machining of journals and rail rods.
- It is also used for turning the threads on locomotive wheels.
- The “T -lathe” is used for machining rotors for jet engines.
- The axis of the lathe bed is at right angles to the axis of the headstock spindle in the form of a T.

Special Purpose Lathe

CNC Lathe Machine

- CNC stands for **Computerized numerically controlled**.This is widely used as a lathe in the present time because of its fast and accurate working. It is one of the most advanced types.
- It uses computer programs to control the machine tool. Once the program is fed into the computer as per the program it starts operation with very high speed and accuracy.
- Even do preplanned programmed machine is there in which once code is set for the various operations it can starts operation without changing code in the next time.
- A semi-skilled worker can easily operate this after the initial setup is done.These types of lathes are also used for mass production like capstan and turret but there is no programmed fed system.
- The components manufactured by these lathes are very accurate in dimensional tolerances.

CNC Lathe Machine

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TOPICS TO BE COVERED

- Operations of lathe
- Work Holding Devices
- Carriers and catch plates
- Face plates
- Angle plates
- Mandrels
- Rests
- Tool Holding devices

LECTURE-7

Work and tool holding devices

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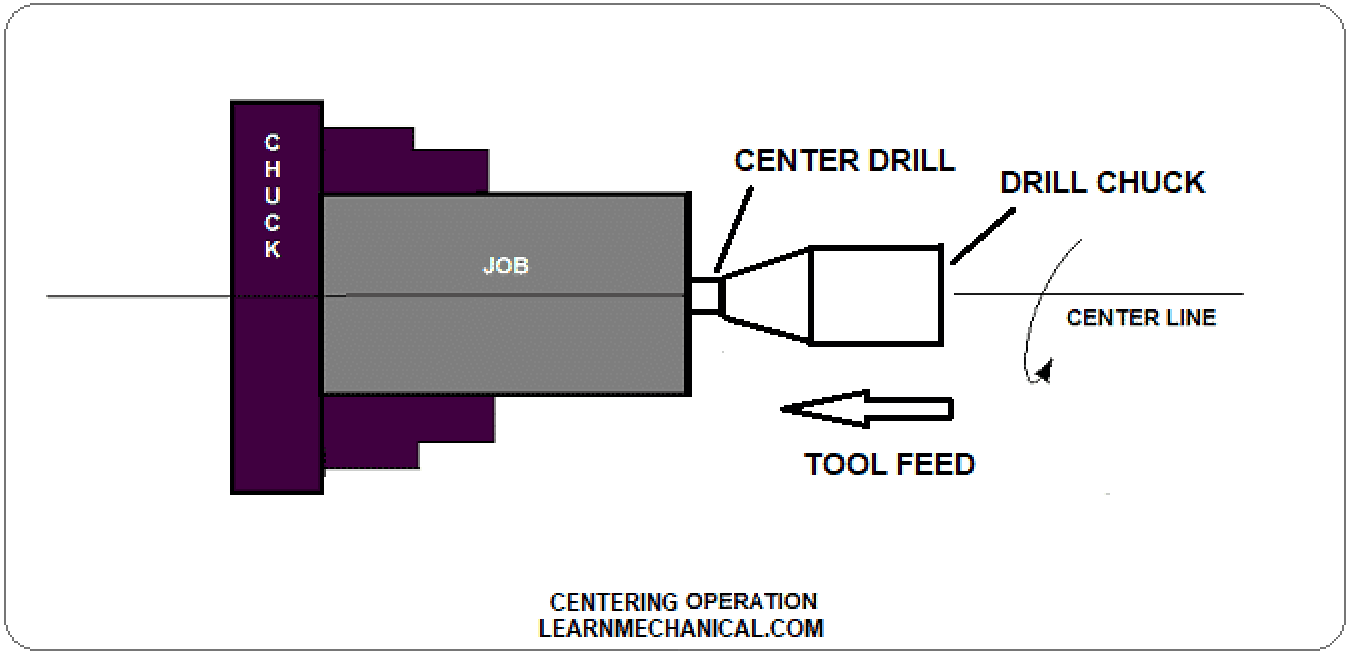
Operations of Lathe

A Lathe Machine consists of the following operation:

- ***Centering***
- ***Facing***
- ***Turning***
- ***Chamfering***
- ***Knurling***
- ***Thread cutting***
- ***Drilling***
- ***Boring***
- ***Reaming***
- ***Spinning***
- ***Tapping***
- ***Parting off***

Centering operation in the lathe

- We use this operation for producing a conical hole in the face of the job to make the bearing support of the lathe center when the job is to hold between two centers. (Head-stock and Tail-stock).



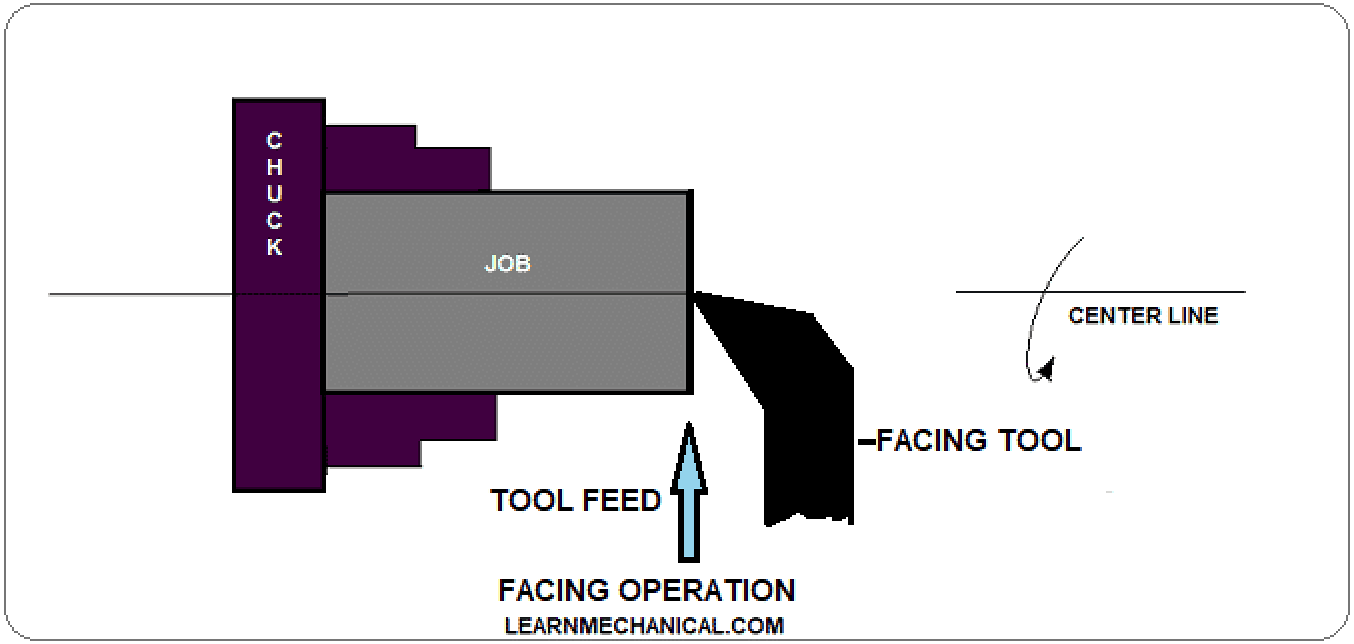
Facing operation in the lathe

Facing operation is for making the ends of the job to produce a smooth flat surface with the axis of operation or a certain length of a job.

In this operation,

1. Hold the job on Head-stock spindle using Three or four-jaw chuck.
2. Start the machine on desire RPM to rotate the job.
3. Give a desirable feed on the perpendicular direction of the axis of the job

Facing operation in the lathe



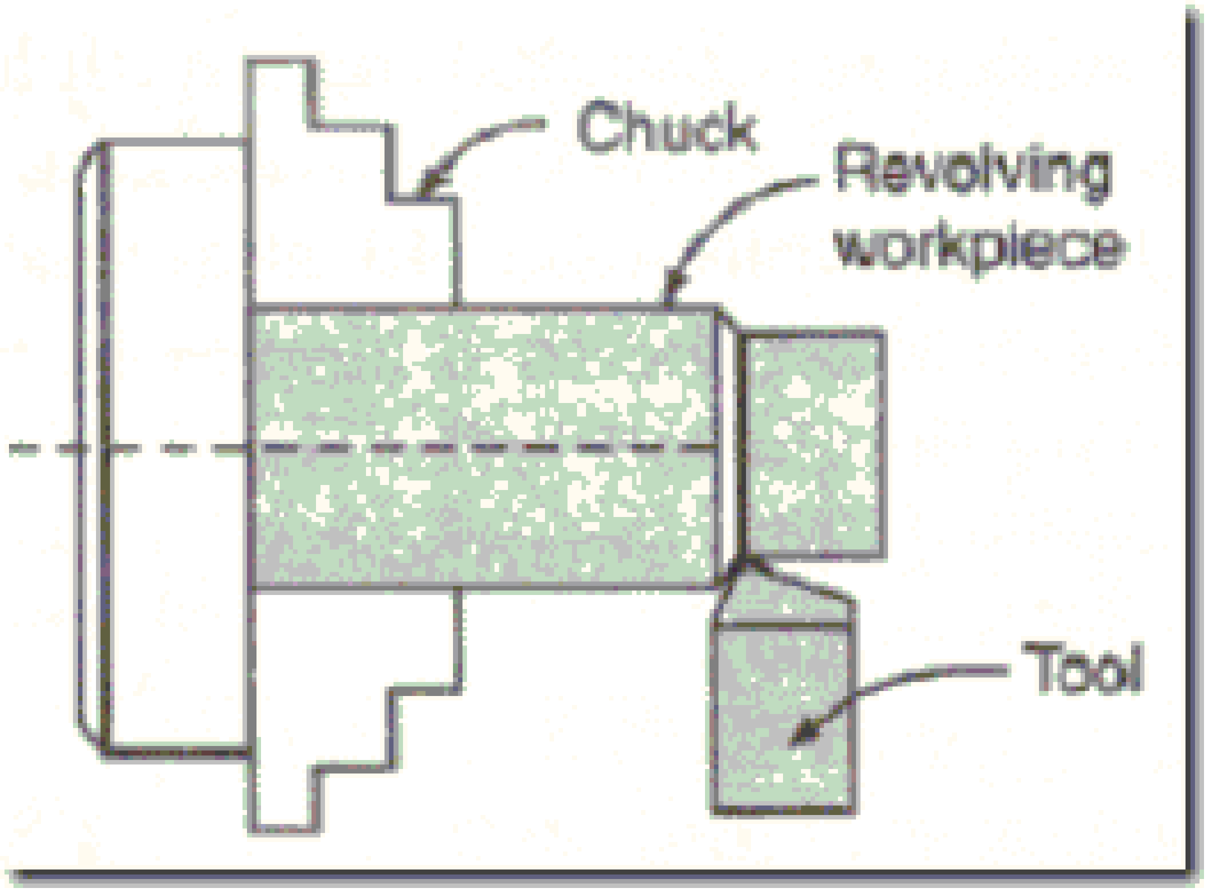
Turning operation in the lathe

The operation by which we remove the excess material from the workpiece to produce a cone-shaped or a cylindrical surface.

There are **several types of turning operations**, those are:

1. *Straight turning*
2. *Shoulder turning*
3. *Rough turning*
4. *Finish turning*
5. *Taper turning*
6. *Eccentric turning*

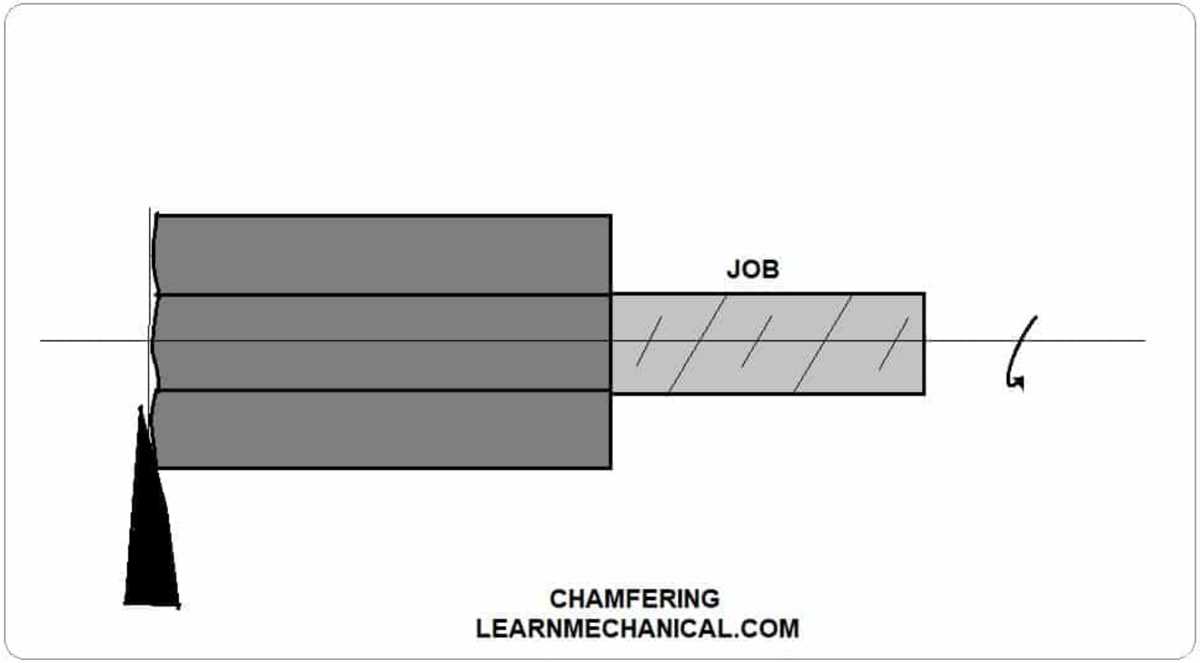
Turning operation in the lathe



Chamfering operation

Chamfering is used for beveling the end of a job to remove burrs, to look better, to make a passage of the nut into the bolt.

This operation is done after thread cutting, knurling, rough turning



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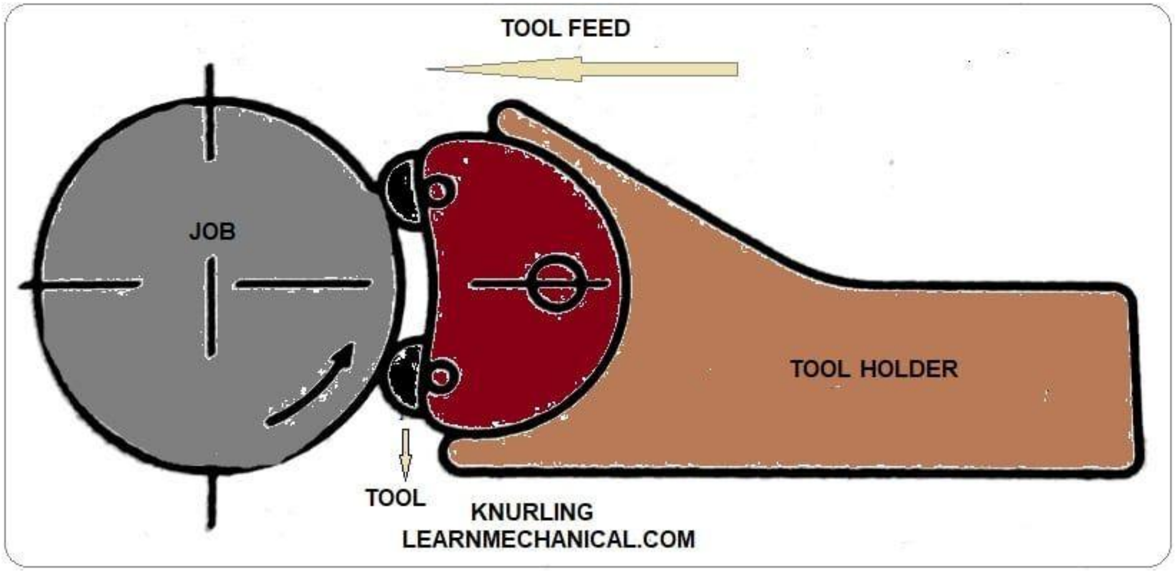
Knurling operation

- It is the process of producing a rough surface on the workpiece to provide effective gripping.
- **Knurling tool** is held rigidly on the tool post and pressed against the rotating job so that leaving the exact facsimile of the tool on the surface of the job



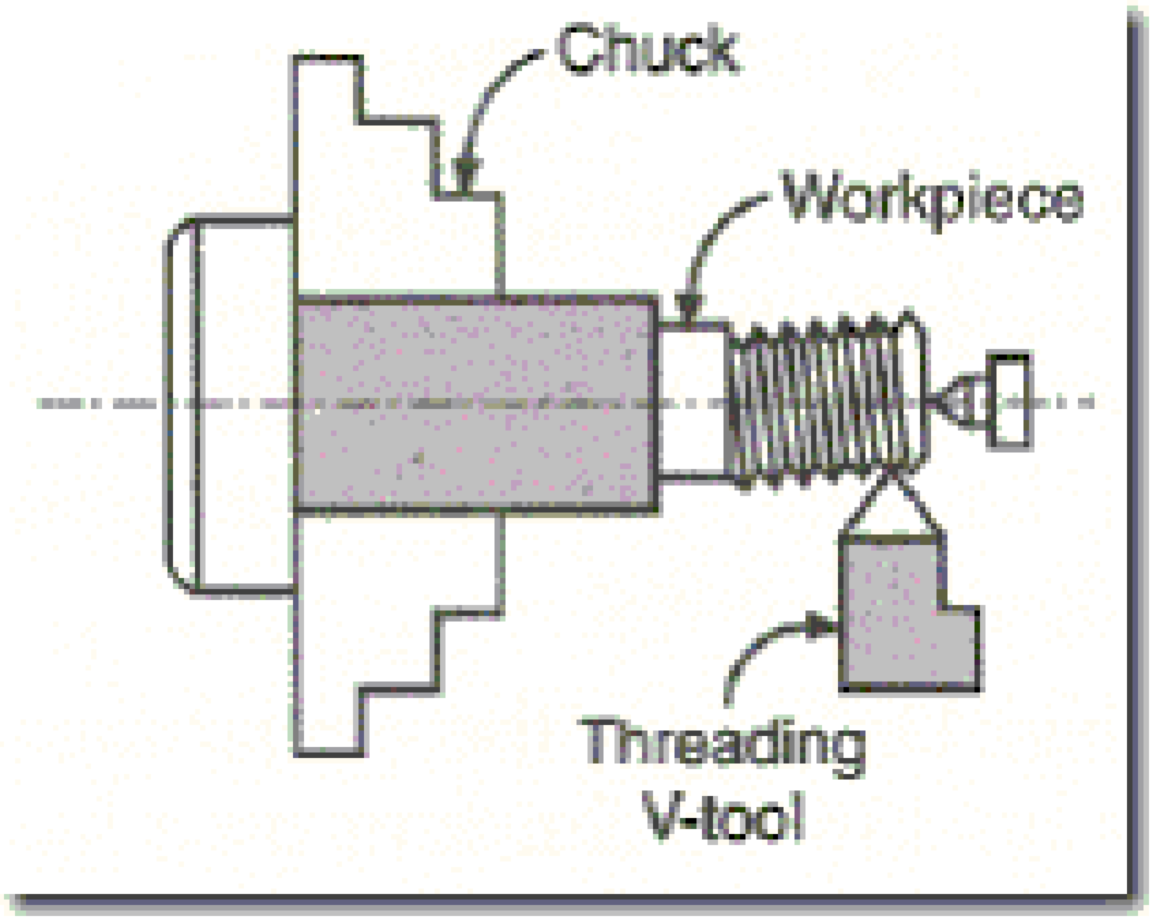
Thread cutting operation

- It is the operation that is used to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinally when the job revolved between the two centers.

Tool setting for thread cutting operation:

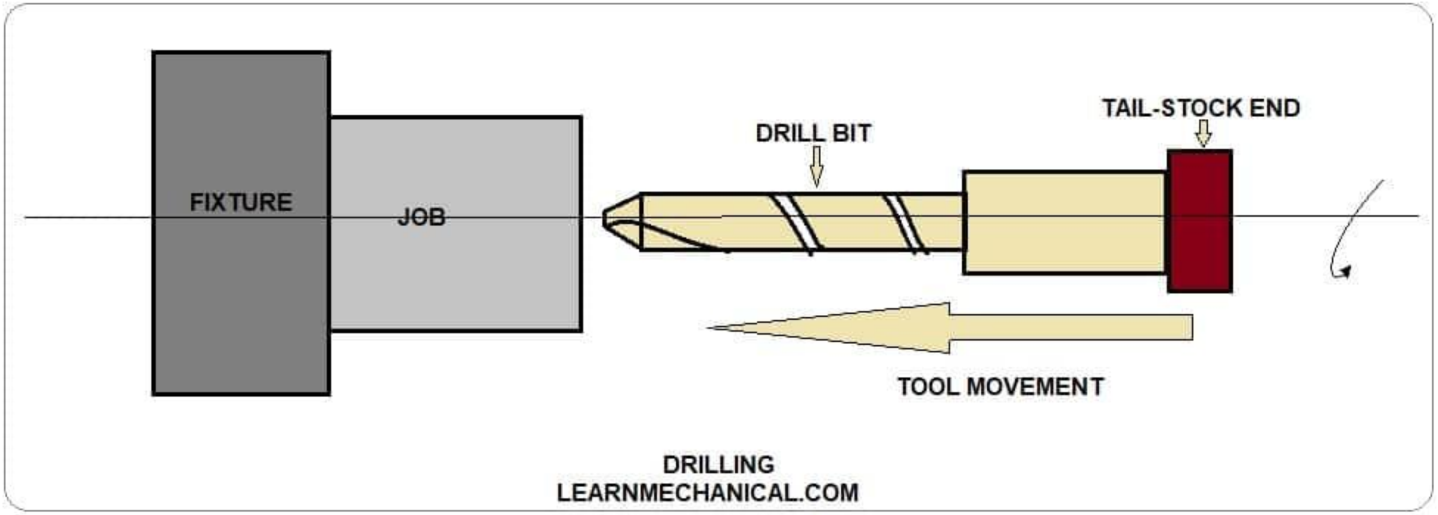
- The tool should be set exactly to the height of the centerline of the job and at 90 degrees to the job.
- Tool setting gauge is used for this purpose.

THREAD CUTTING OPERATION



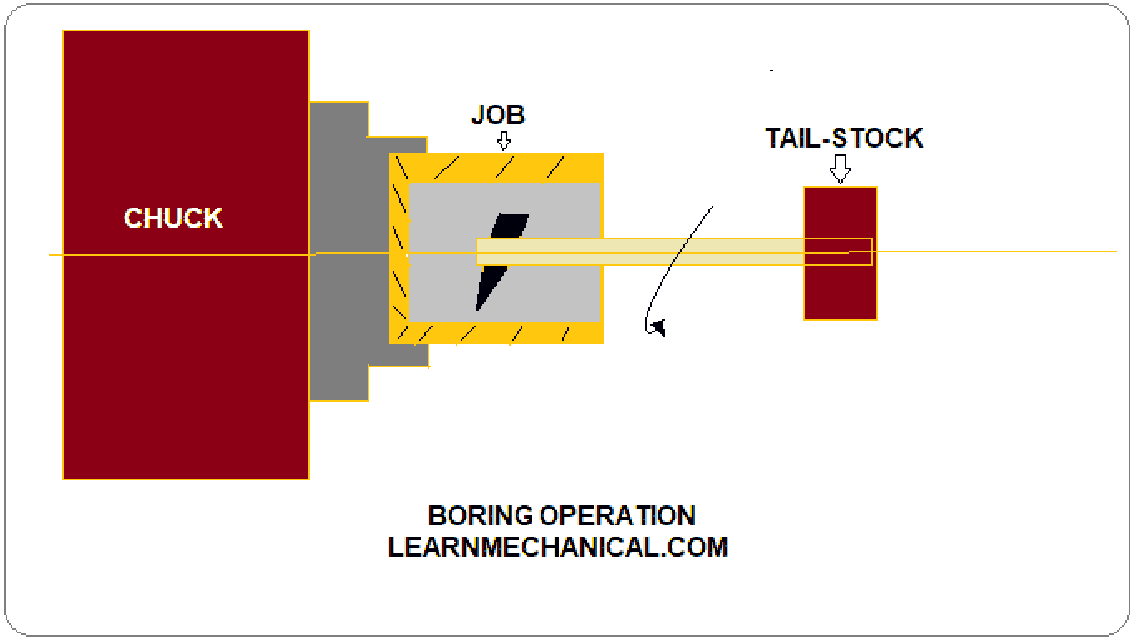
Drilling operation

- **Drilling** is an operation by which we can make holes in a job.
- In this operation, the job is rotated at the turning speed on the lathe axis and the drilling tool fitted on the tail-stock spindle. And the tail-stock is moved towards the job by hand feed.



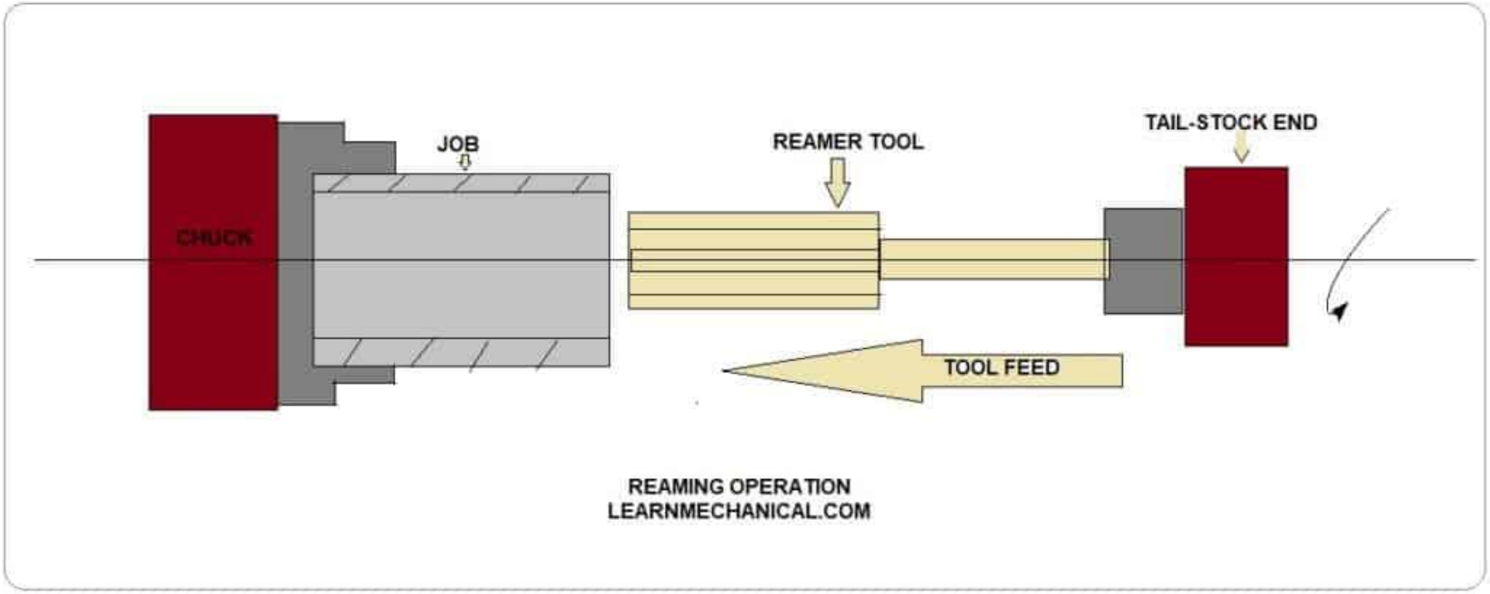
Boring operation

- In this operation, we can enlarge the diameter of the existing hole on a job by turning inside with some farm tool known as a boring tool.The boring tool is also fitted on tail-stock



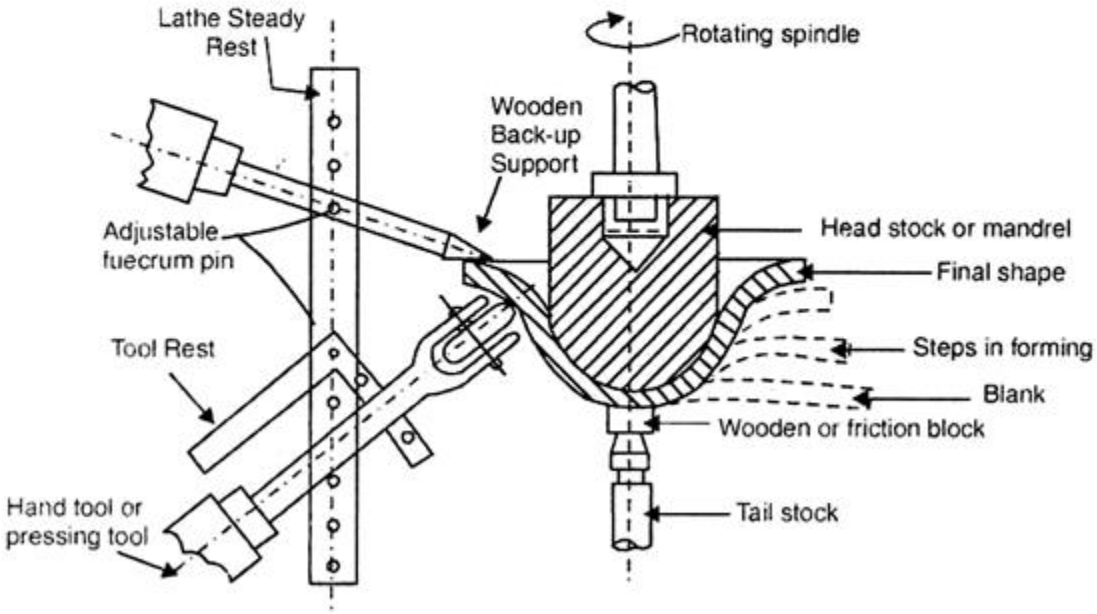
Reaming operation

Reaming is the operation for sizing or finishing a drilled hole to the required size by a tool called reamer.This tool is fitted on tail-stock.



Spinning operation

- In this operation, the job of this sheet metal is held between the former and the tail-stock center rotates at high speed with the former.
- The long round nose forming tool rigidly fixed on special tool post presses the job on the periphery of the former.
- So the job is taken exactly the shape of the former.This is a chipless machining process.

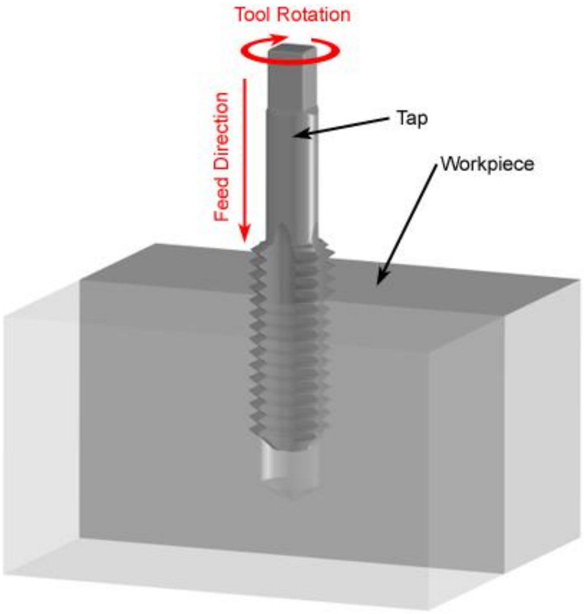


Tapping operation

We use this operation for creating internal threads within a hole by means of a tool called tap.

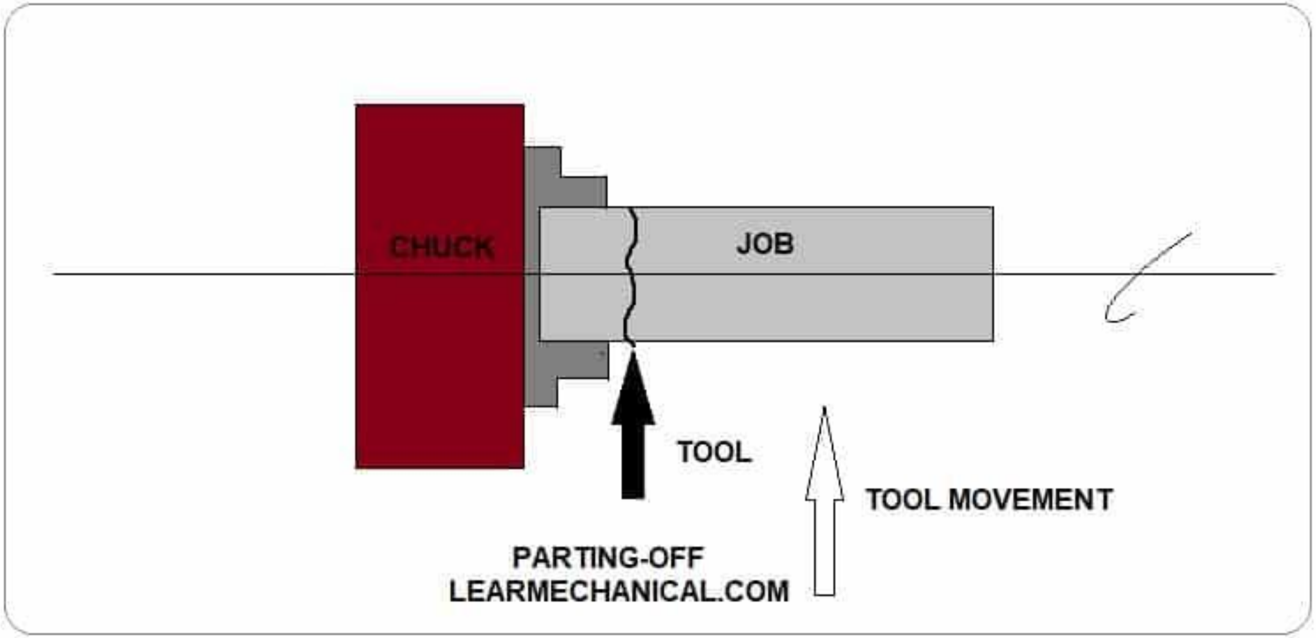
Three taps are generally used in an internal thread.

1. *Taper Tap*
2. *Second Tap*
3. *Plug Tap*



Parting-off operation

- It is the operation of cutting off a bar type job after complete the machining process. In this operation a bar type job is held on a chuck, rotates at turning speed, a parting off tool is fed into the job slowly until the tool reaches the center of the job.



Specification of a Lathe

A Lathe is generally specified by:

1. Swing- the largest work diameter that can be swung for the lathe bed.
2. The distance between the headstock and tailstock center.
3. Length of the bed in a meter.
4. The pitch of the lead screw.
5. Horsepower of the machine.
6. Speed range and the number of speeds of HS spindle.
7. The weight of the machine in a tonne.

Work Holding Devices Being used on Lathe

As we know the lathe is one of the oldest and highly important machine tool. There is vast number of applications of this machine tool. So for facilitating the easy machining of the workpiece it should be held tightly and securely. For this purpose many types of accessories are being used for facilitating easy holding of the worKpiece.

Some of the work holding devices are

1) Carriers and catch plates

2) Face plates

3) Angle plates

4) Mandrels

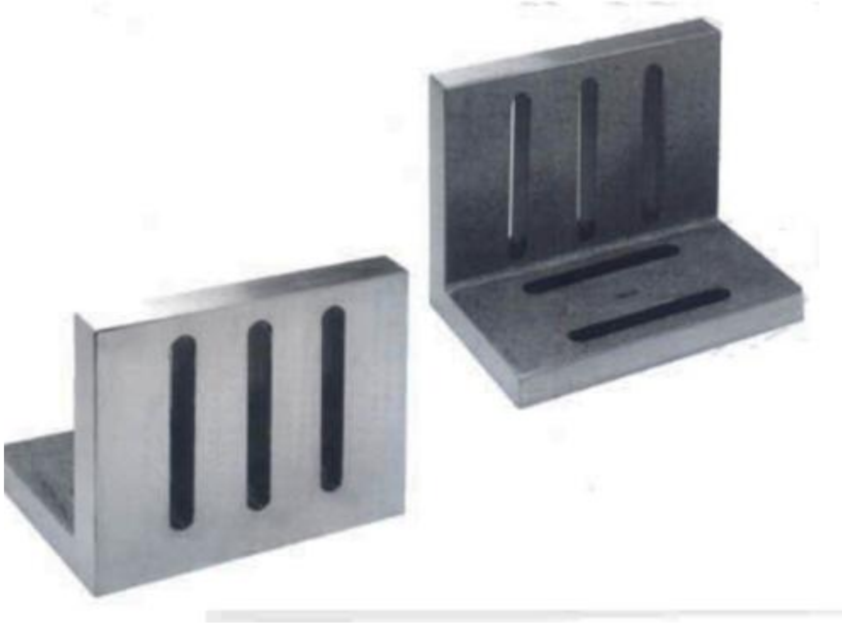
5) Rests

Carriers and catch plates

These are in general used for driving the work piece when it is held in between two centers namely head stock and tail stock. Carriers are also called as the driving dogs. These are attached to the work piece by the help of setscrews. Where as the catch plates are pinned to the headstock.

Angle plates

These are used along with faceplates for maintaining the given work piece horizontal i.e. perpendicular to the tool used. Angle plates consist of two faces, which are highly machined, and these also have the provision of holes for the easy clamping of the work piece to it.



Mandrels

This type of work holding devices are employed for holding previously drilled or bored hole so as to facilitate effective outer surface machining. The work is loaded over the mandrels between the centers. The ends of the mandrels are made slightly smaller than the original diameter. This is done for effective gripping of the mandrel in the chuck or any other holding device. In general the material used for the manufacturing of the mandrels is plain carbon steel. Various types of mandrels are in usage. Various types of mandrels are

1) Plain mandrels

2) Step mandrels

3) Collar mandrels

4) Screwed mandrels

5) Cone mandrels

6) Gang mandrels

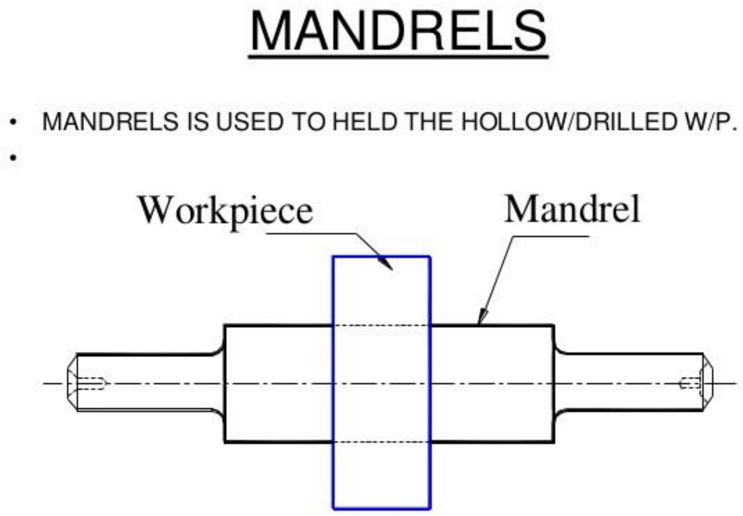
7) Expansion mandrels

Plain mandrels

This type of mandrels finds a numerous number of applications in shops where identical pieces are to be generated. The body of these mandrels has generally a tapered shape. The difference in the tapped diameter is of 1 to 2 mm and the length varies between 55mm to 430mm. the tapper is provided for facilitating high end gripping for holding the work piece.

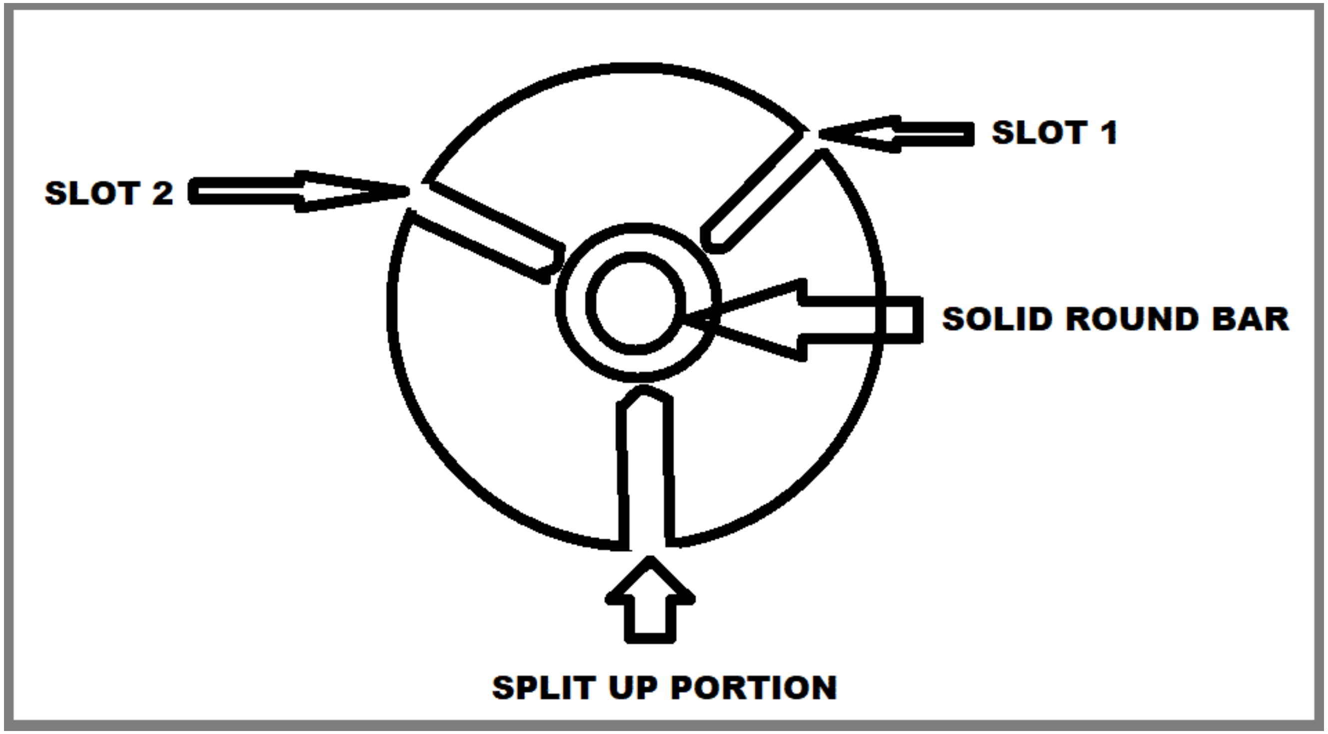
Step mandrel

A special type of mandrel, which facilitates faster processing by holding various sized jobs without replacing the mandrel. This type of mandrels finds applications in repair shops and generally used for turning collars, washers and odd sized jobs.



Collar mandrel

A collar mandrel has a collar arrangement, which is fixed and may have size larger than that of the 100mm. this type of construction is a type of optimizing the material being used.



Screwed mandrels

These mandrels have a thread cut engraved on one side along with a collar. Such type of mandrels is called as screwed mandrels. Screwed mandrels are used when work pieces having internal threads are to be machined. The size of the threads to be engraved on the screwed mandrels depends on the type of work piece, which is going to fit over it.

Cone mandrel

Cone mandrels have a cone shaped piece attached at one of the mandrel. This type of arrangement allows the mandrel to handle a variety of work pieces having a varying internal cross sectional diameter. The workpiece is held tightly by fixing a nut at the other end of fixing the work piece to the mandrel. Too tight fitting of the workpiece over the cone may damage the internal surface finish of the workpiece along with the damage to the cone shape of the mandrel.

Gang mandrel

Gang mandrel is generated by some of the optimizers so as to reduce the material. This type of mandrel can facilitate machining for work pieces of various diameters. The gang mandrels consist of a fixed collar at one end and removable mandrels at the other end which is fixed by the help of the threads engraved both on the mandrel and also on the internal surface of a hallow mandrel. This mandrel can be used for machining various diameter pieces by just removing and fixing various collars over the thread. The friction between the walls of collar and sides of work piece is enough to hold the work piece tightly and hence facilitating is a high end machining.

Expansion mandrel

This is a special type of mandrel, which has a central tapered pin. Over this tapered pin a sleeve is arranged when this sleeve is moved over it form one corner to other the size increases or decreases. This type of mandrels is best used when a varying diameter pieces are to be hold without much difficulty.

Chucks

A chuck is a work holding device. It is used for holding work over a lathe machine, which is having large length and small diameter, and also for jobs, which are unable to mount on between the centers i.e., head stock and tail stock centers. A chuck is also employed when a non-axis symmetrical object is to be mounted over the lathe. The chucks are most commonly used work holding devices. These are fixed directly to the spindle of the lathe by means of screws and a back plate. In general there are various types of chuck, which have their own importance and unique applications

Types of chucks

- Four jaw chuck or independent chuck
- Three jaw chuck or self-centering chuck
- Air or hydraulic operated chuck
- Magnetic chuck
- Collet chuck
- Combination chuck
- Drill chuck

Rests

Rest is a work holding device, which is used to hold the work piece when the work piece of very long length are to be held. In general when a long piece is to be held it may have directly held then there arises deflection in the work piece due its own weight. So to prevent the deflection in the work piece rests of various types are used. Some of the rests being used are

1) Steady rest

2) Follower rest

TOOL HOLDING DEVICES

Workpieces are held in lathe with the assistance of chucks, faceplates, or lathe centers. A lathe chuck is a device that exerts pressure on the workpiece to hold it secure to the headstock spindle or tailstock spindle. Commonly used with the lathe are the independent chuck (4 Jaw),the universal scroll chuck (3 Jaw), and the collet chuck.

Independent Chuck - (4 Jaw)

- The independent chuck has four jaws which are adjusted individually on the chuck face by means of adjusting screws.
- The chuck face is scribed with concentric circles which are used for rough alignment of the jaws when chucking round workpieces.
- The final adjustment is made by turning the workpiece slowly and using dial indicators to determine its concentricity and to the desired tolerances.
- The jaws of the independent chuck may be used as in the figure shown, or may be reversed so that the steps face in the opposite direction; thus, workpieces can be gripped either externally or internally.

Independent Chuck - (4 Jaw)

- The independent chuck can he used to hold square, round, octagonal, or irregular shaped workpieces in either a concentric or eccentric position due to the independent operation of each jaw.
- Because of its versatility and capacity for fine adjustment, the independent chuck is commonly used for mounting workpieces that require extreme accuracy.

Universal Scroll Chuck - (3 Jaw)

- The universal scroll chuck has three jaws which move in unison as an adjusting pinion is rotated.
- The advantage of the universal scroll chuck is its ease of operation in centering the work for concentric turning.
- This chuck is not as accurate as the independent chuck but, when in good condition, it will centre the work automatically within 0.003 of an inch of complete accuracy.
- The jaws are moved simultaneously within the chuck by means of a scroll or spiral threaded plate.

Universal Scroll Chuck - (3 Jaw)

- The jaws are threaded to the plate and move an equal distance inward or outward as the scroll is rotated by means of the adjusting pinion.
- Since the jaws are individually aligned on the scroll, the jaws cannot be reversed.
- However, the chuck is usually supplied with two sets of jaws which can be interchanged.
- The universal scroll chuck can be used to hold and automatically centre round or hexagonal workpieces.
- Having only three jaws, the chuck cannot be used effectively to hold square, octagonal, or irregular shapes.

Collet Chuck

- The collet chuck is the most accurate means of holding small workpieces in the lathe.
- The collet chuck consists of a spring machine collet and a collet attachment which secures and regulates the collet on the headstock spindle of the lathe.
- The spring machine collet is a thin metal bushing with an accurately machined bore and a tapered exterior.
- The collet has three lengthwise slots to permit its sides to be sprung slightly inward to grip the workpiece.
- To grip the workpiece accurately, the collet must be no more than 0.001 inch larger or smaller than the diameter of the piece to be chucked.

Collet Chuck

- For this reason, spring machine collets are generally supplied in sets with various capabilities in 1/16, 1/32, or 1/64 inch increments.
- For general purposes, the spring machine collets are limited in capacity to 1 inch in diameter.
- The collet attachment which, with the spring machine collet, forms the collet chuck and consists of a collet sleeve, a draw bar, and a handwheel or hand lever to move the draw bar.
- The collet is fitted to the right end of the headstock spindle. The draw bar passes through the headstock spindle and is threaded to the spring machine collet.
- When the draw bar is rotated by means of the handwheel, the collet is pulled inward and the collet walls are cammed together by contact with the collet sleeve, tightening the chuck to the workpiece

ASSIGNMENT QUESTIONS

IMP QUESTIONS FOR UNIT-1

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COMPUTER INTEGRATED MANUFACTURING TECHNOLOGIES

3RD YEAR SEM-1 BTECH MECHANICAL ENGINEERING (R18A0312)

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COURSE OBJECTIVES

UNIT - 1	**CO1:** Learn about geometry of metal cutting theory, mechanism of chip formation and mechanism of orthogonal cutting and merchants force diagram
UNIT - 2	CO2: Learn about ways to reduce the surface roughness by using different machining process
UNIT - 3	CO3: To write APT and CNC programming concepts
UNIT - 4	CO4: Learn the concepts of DNC Systems and Post Processors
UNIT - 5	CO5: To know about Computer aided process planning and computer aided inspection and Quality control

UNIT 2

SHAPING, SLOTTING AND PLOTTING MACHINES

CO2: Learn about ways to reduce the surface using different Machining Processes.

UNIT – II (SYLLABUS)

SHAPING, SLOTTING AND PLANING MACHINES

- Principles of working
- Classifications

Drilling and Boring machines

- Principles of working
- Classifications
- Types

COURSE OUTLINE

LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning Objectives
1	Shaping, slotting and planning machines. Principles of working	Shaping, slotting and planning machines	• Learn the working principles of shaping, slotting and plotting machines
2	Classifications, operations performed & machining time calculations	Classifications of Shaping, slotting and planning machines	• Understanding the types and uses of Shaping, slotting and planning machines
3	Drilling machine working principle, specifications and types	Drilling machine	• Working of drilling machine and its types
4	Drilling and Boring machines operations performed, tool holding devices	Operations performed using drilling and boring machines	• Understand the main uses of drilling and boring machines
5	Boring machines-Fine boring, jig boring	Types of boring machines	• Operations of fine and jig boring and its uses
6	Deep hole drilling machine	Deep hole drilling machine concepts	• Operations of deep hole drilling machines and its uses

LECTURE 1

Shaping machines

TOPICS TO BE COVERED

- Principles of working
- classifications
- operations performed

LECTURE 1

Shaping Machine

Shaping Machine

- A **shaping machine** is **used** to **machine** surfaces. It can cut curves, angles and many other shapes.
- The tool feed handle can be turned to slowly feed the cutting tool into the material as the 'ram' moves forwards and backwards.
- In a standard **shaper**, cutting takes place during the forward stroke of the ram and the backward stroke remains idle.
- The forward and backward motion is obtained by “Quick Return Mechanism”.
- The depth of the cut is adjusted by moving the tool downwards towards the **work** piece

PRINCIPLE OF WORKING

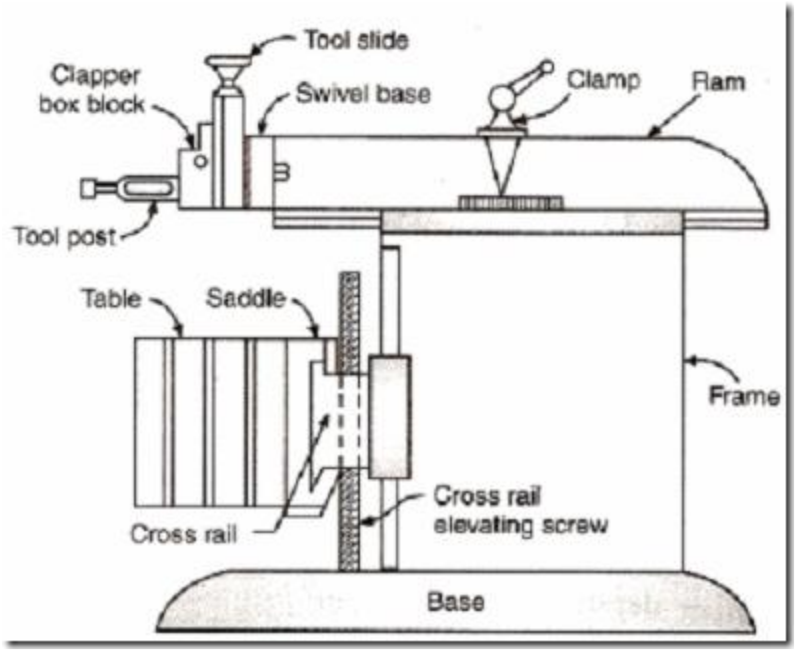
The shaper is a machine tool used primarily for:

1. Producing a flat or plane surface which may be in a horizontal, a vertical or an angular plane.

2. Making slots, grooves and keyways

3. Producing contour of concave/convex or a combination of these

SHAPER MACHINE



WORKING PRINCIPLE

- The job is rigidly fixed on the machine table. The single point cutting tool held properly in the tool post is mounted on a reciprocating ram.
- The reciprocating motion of the ram is obtained by a quick return motion mechanism.
- As the ram reciprocates, the tool cuts the material during its forward stroke.
- During return, there is no cutting action and this stroke is called the idle stroke.
- The forward and return strokes constitute one operating cycle of the shaper.

CONSTRUCTION

The main parts of the Shaper machine is Base, Body (Pillar, Frame, Column), Cross rail, Ram and tool head (Tool Post, Tool Slide, Clamper Box Block).

Base: The base is a heavy cast iron casting which is fixed to the shop floor. It supports the body frame and the entire load of the machine. The base absorbs and withstands vibrations and other forces which are likely to be induced during the shaping operations.

Body (Pillar, Frame, Column): It is mounted on the base and houses the drive mechanism compressing the main drives, the gear box and the quick return mechanism for the ram movement. The top of the body provides guide ways for the ram and its front provides the guideways for the cross rail.

Crossrail: The cross rail is mounted on the front of the body frame and can be moved up and down. The vertical movement of the cross rail permits jobs of different heights to be accommodated below the tool. Sliding along the cross rail is a saddle which carries the work table.

Ram and tool head: The ram is driven back and forth in its slides by the slotted link mechanism. The back and forth movement of ram is called stroke and it can be adjusted according to the length of the workpiece to be-machined.

CLASSIFICATIONS OF SHAPER MACHINE

The **shaper machine** is a reciprocating type of machine basically used for producing the horizontal, vertical or flat surfaces. The shaper holds the single point cutting tool in ram and workpiece is fixed in the table.

During the forward stroke, the ram is holding the tool is reciprocating over the workpiece to cut into the required shape. During the return stroke, No metal is cutting. In the shaper machine, the rotary motion of the drive is converted into reciprocating motion of ram holding the tool.

Therefore in order to reduce the total machine time, It allows the ram holding the tool should move slower during forwarding cutting stroke and it comes faster in return stroke. This can be achieved by a mechanism called a **quick return mechanism.**

TYPES OF SHAPER MACHINE

Types of Shaper Machines

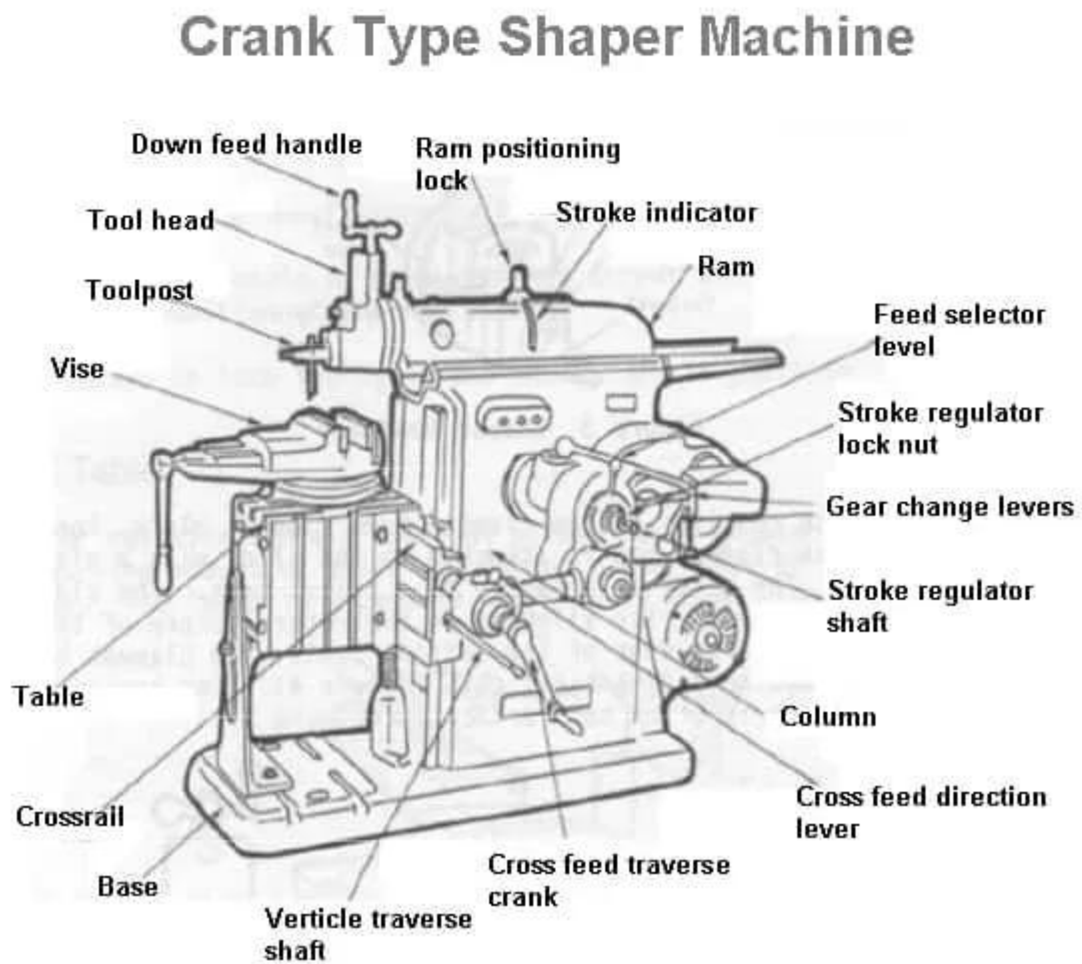
Following are the different **types of shaper machine**

1. Based on the type of driving mechanism.
    1. Crank type shaper.
    2. Geared type shaper.
    3. Hydraulic type shaper.
2. Based on ram travel.
    1. Horizontal shaper
    2. Vertical shaper.
3. Based on the table design.
    1. Standard shaper.
    2. Universal shaper.
4. Based on cutting stroke.
    1. Push cut type
    2. Draw cut type

Crank Type Shaper Machine

- These are very common types of shaper machines, which is using to hold the workpiece on the table.
- The tool is reciprocating in motion equal to the length of the stroke desired while the work is clamped in position on an adjustable table.
- In construction, the crank shaper employs a crank mechanism to change the circular motion of a large gear called “bull gear” incorporated in the machine to reciprocation motion of the ram.
- It uses a crank mechanism to convert the circular motion of the bull gear into reciprocating motion of the ram.
- The ram carries a tool head at its end & provides the cutting action.

Crank Type Shaper Machine

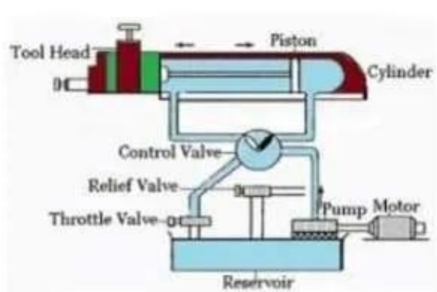


Gear Type Shaper Machine

- In these types of shaper machines, the ram is reciprocating. The ram is affecting due to reciprocating motion with the rack and pinion.
- The rack teeth are cut directly below the ram mesh with the spur gear.
- The speed and the direction in which the machine will traverse depend on the number of gears in the gear train.
- This type of shaper machines is not widely using in any industry.

Hydraulic Shaper Machine

- In these types of shaper machines, the reciprocating motion of the ram is provided by the hydraulic mechanism.
- The Hydraulic shaper uses the oil under high pressure. The end of the piston rod is connected to the ram.
- The high-pressure oil first acts on one side of the piston and then on the other causing the piston to reciprocating and the motion is transmitted to the ram.
- The main advantages of this type of shaper machine are that the cutting speed and force of the ram drive are constant.
- From start to end of the cut without making noise and operates quietly.



Hydraulic Type Shaper Machine

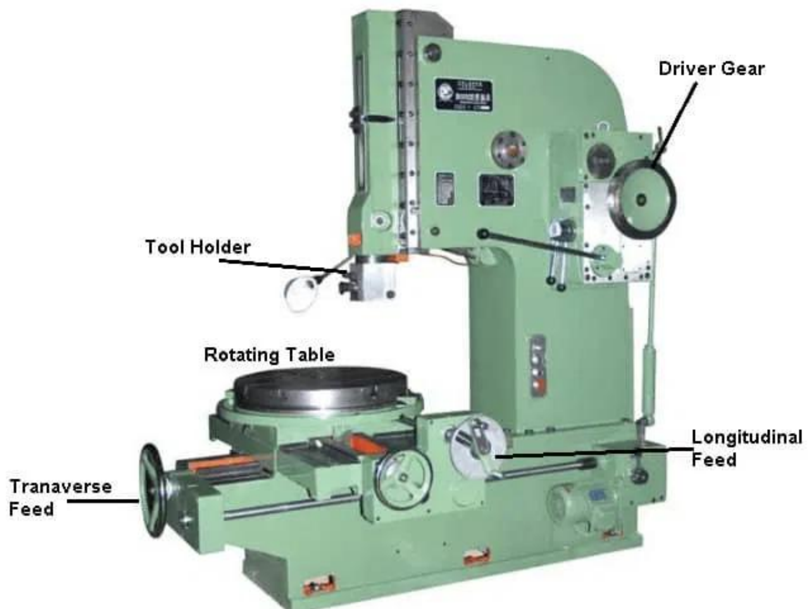
Horizontal Shaper Machine

In these types of shaper machines, the ram is reciprocating. The ram holding the tool in a horizontal axis and reciprocate. This type of shaper is using for the production of flat surfaces, external grooves, keyways etc.

Horizontal Shaper Machine

Vertical Shaper Machine

In these types of shaper machines, the ram reciprocating in verticle plane. In this, the table holds the workpiece. Verticle shapers maybe crank driven, rack-driven, screw-driven or hydraulic power-driven.The vertical shaper is very convenient for machining internal surfaces, keyways, slots or grooves. The workpiece can move in any given directions such as the cross, longitudinal or rotary movements.



Vertical Type Shaper Machine

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LECTURE 2

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TOPICS TO BE COVERED

- Principle of working
- classifications

LECTURE 2

Slotting Machine

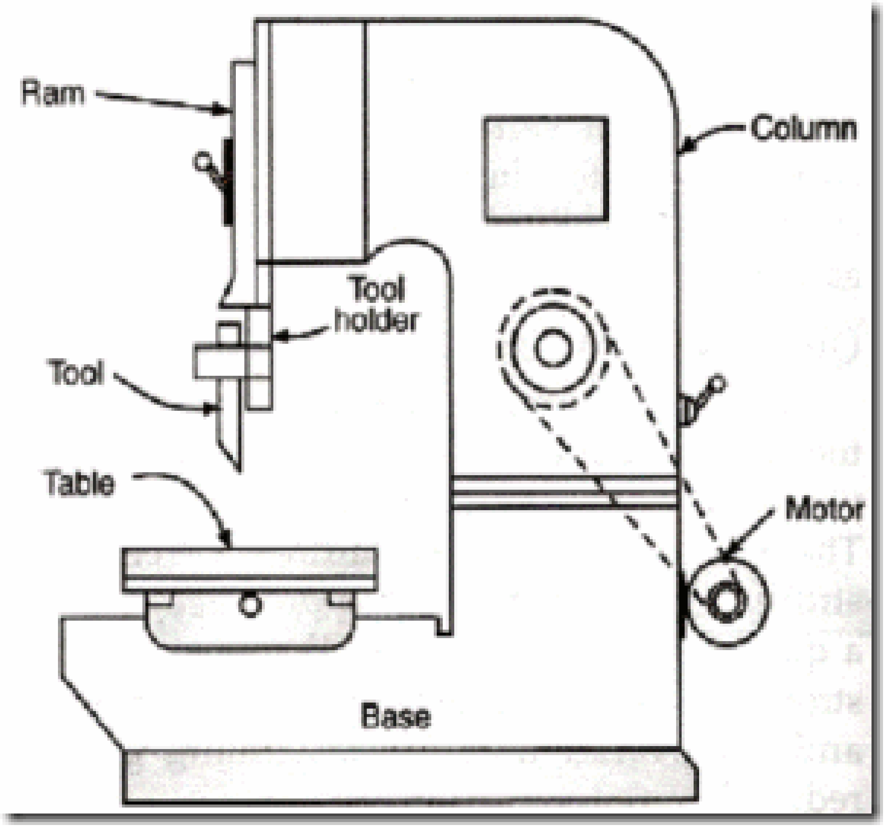
Slotting Machine

The slotting machine is a reciprocating machine tool in which, the ram holding the tool reciprocates in a vertical axis and the cutting action of the tool is only during the downward stroke.

The slotter can be considered as a vertical shaper and its main parts are:

1. Base, column and table
2. Ram and tool head assembly
3. Saddle and cross slide
4. Ram drive mechanism and feed mechanism.

SLOTTING MACHINE



CONSTRUCTION

- The base of the slotting machine is rigidly built to take up all the cutting forces.
- The front face of the vertical column has guide ways for Tool the reciprocating ram. The ram supports the tool head to which the tool is attached.
- The workpiece is mounted on the table which can be given longitudinal, cross and rotary feed motion.
- The slotting machine is used for cutting grooves, keys and slotes of various shapes making regular and irregular surfaces both internal and external cutting internal and external gears and profiles.
- The slotter machine can be used on any type of work where vertical tool movement is considered essential and advantageous.

CONSTRUCTION

The different types of slotting machines are:

1. **Punch slotter**: a heavy duty rigid machine designed for removing large amount of metal from large forgings or castings

2. **Tool room slotter**: a heavy machine which is designed to operate at high speeds. This machine takes light cuts and gives accurate finishing.

3. **Production slotter**: a heavy duty slotter consisting of heavy cast base and heavy frame, and is generally made in two parts.

Hydraulic Drive (Greater speed Flexibility, Smoother operation, Stroke length can be adjusted)

Variable Speed Motor Drive (In this Multi-speed arrangement)

Hydraulic Drive:

A speed motor drives a hydraulic pump that delivers oil at a constant pressure to the line.

A regulating valve admits oil under pressure to each end on the piston alternately.

At the same time allowing oil from the opposite end of the piston to return to the reservoir.

Working Principle of Slotter Machine

The **working of the Slotter machine** is similar to the shaper machine do but the main difference between them is the Shaper machine works horizontally whereas Slotter machines work vertically.

Now the ram is connected to the crank and crank connected to the gears. So what happened here is when we increase or decrease the gear speed, the rotation of crank increases and decreases. And as per these, the ram moves up and down.

We have attached the workpiece into the work table and manually we bring the ram near to the workpiece and according to the ram we adjust the worktable and then we have to clamp it.

Now we supply the power as per gear the crank rotates and the crank is connected to the ram so ram moves up and down.

During down (ram moves down) the cutting stroke takes place and while moving up or return stroke there is no cut.

If we have to cut at the different sections then manually we give feed to the work table and as per requirement, it cuts.

Slotter Machine Operations

It is used for various operations like:

- Internal and external Flat surface Machining.
- The internal recess of circular, semi-circular, concave and convex surfaces.
- Internal and External Circular surfaces Machining.
- Blind Holes Internal machining.
- For shaping internal and external forms or profiles.
- The machine operates vertical, Horizontal and at Some angle too (Inclined Surfaces).
- Irregular surface machining.
- Machining operation of Dies and Punches.
- The operation like slots, grooves, splines, and keyways for both internal and external surfaces.
- Internal and external gear teeth machining.

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LECTURE 3

TOPICS TO BE COVERED

- INTRODUCTION
- CLASSIFICATION
- WORKING PRINCIPLE
- OPERATIONS PERFORMED

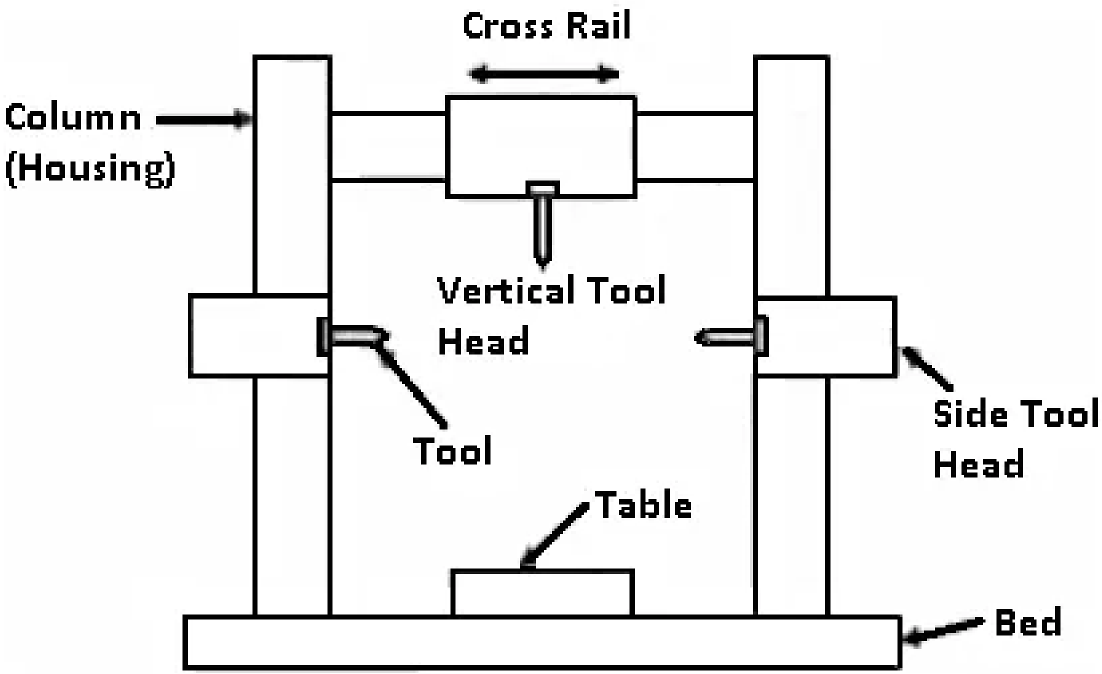
LECTURE 3

PLANING MACHINE

PLANER MACHINE

The **planer machine** is similar to a shaper machine. It intended to produce plane and flat surfaces by a single-point cutting tool. **A planer machine is very large** and massive compared to a shaper machine. It is capable of a machining heavy workpiece, which cannot be fit on a shaper table.

PLANER MACHINE



PLANER MACHINE

PLANER MACHINE

The fundamental **difference between a shaper and a planer** is that

- **In a planer**, the work which is supported on the table reciprocates over the stationary cutting tool and the feed is provided by the lateral movement of the tool.
- **In a shaper**, the tool which is mounted upon the ram reciprocates. And the feed is given by the crosswise movement of the table.

CLASSIFICATION

Types of Planer Machine

Following are the five types of planer machine:

1. Standard or Double housing type planer machine
2. open side type planer machine
3. Pit planer machine
4. Edge or plate type planer
5. Divided table planer

PARTS

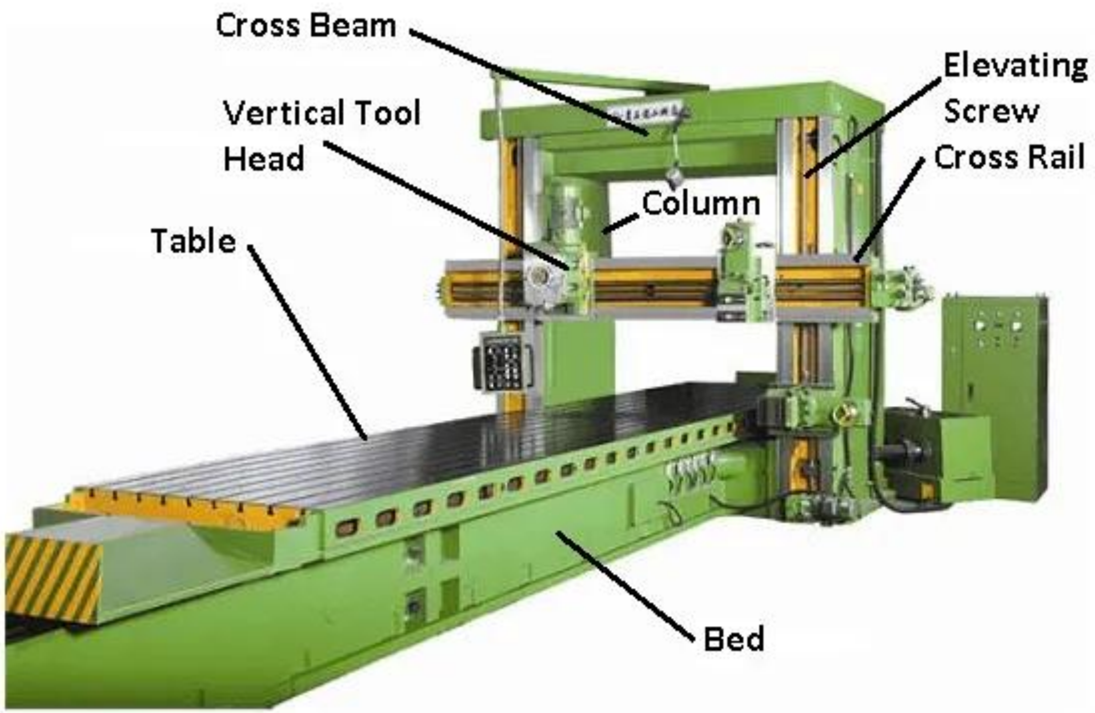
Parts of Planer Machine

Following are the six main parts of the planer machine:

1. Bed
2. Table
3. Housing or Column
4. Cross rail
5. Tool head
6. Driving and Feed Mechanism

. Standard or Double Housing Planer Machine

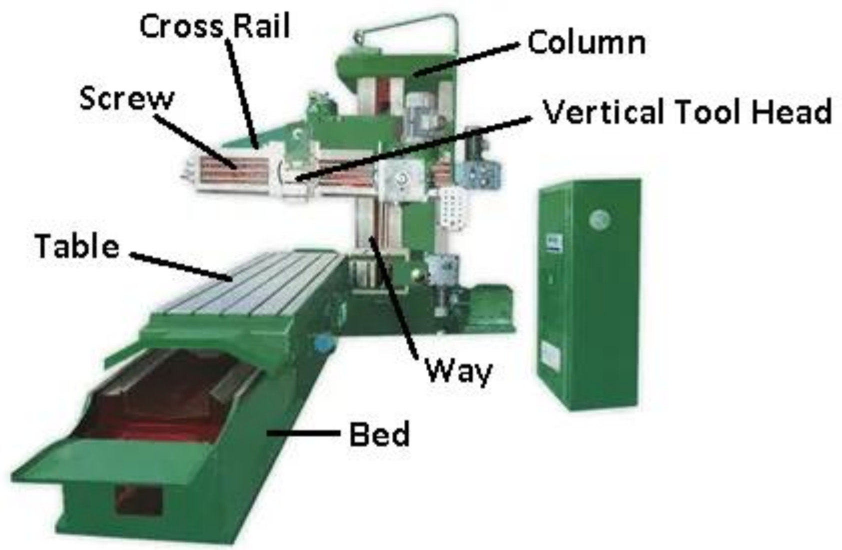
The **standard or double housing planer** is the most widely used types of planer machine in workshops. **A double housing planer** has a long heavy base on which a table reciprocates on accurate guideways.



DOUBLE HOUSING PLANER

Openside Planer Machine

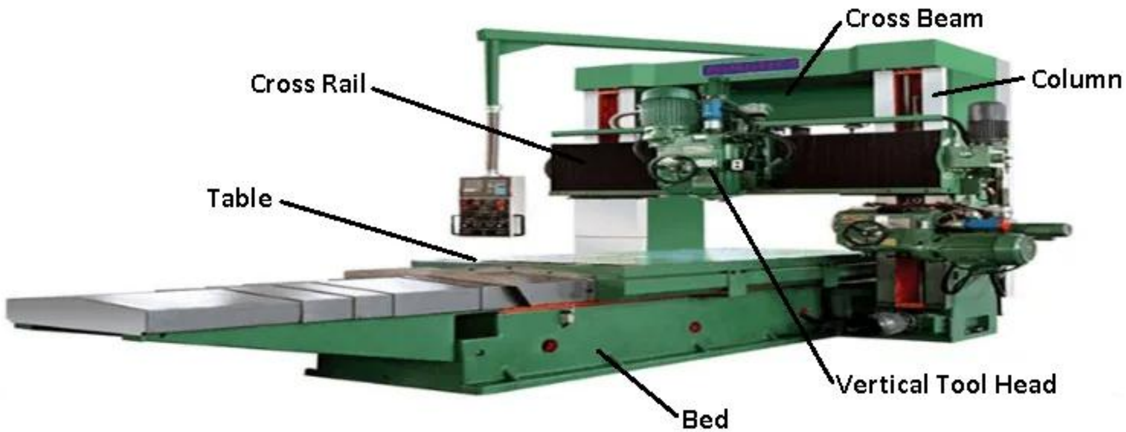
An openside planer has a housing only on one side of the base. And the Crossrail is suspended from the housing as a cantilever. This feature of the machine allows the large and wide workpiece to be clamped on the table and reciprocated over the cutting tool.



OPEN SIDE PLANER

Pit Planer Machine

A pit type planer is massive in construction. It differs from an ordinary planer. In this the table is stationary and the column carrying the Crossrail reciprocates on massive horizontal rails mounted on both sides of the table.



PIT PLANER

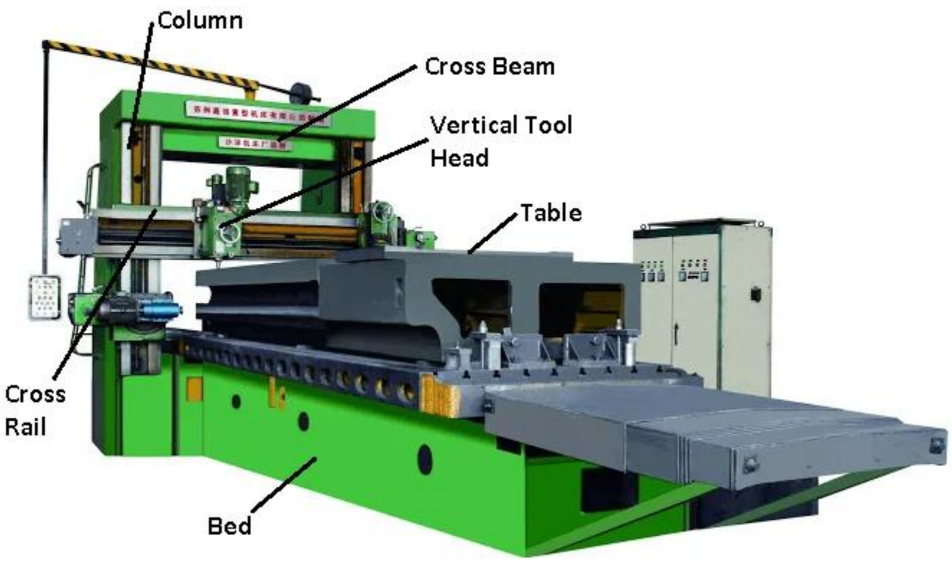
Edge or Plate Planer

The design of a plate or edge planer is totally unlike that of an ordinary planer. It is specially intended for squaring and bevelling the edges of steel plates. Also used for different pressure vessels and shipbuilding works.

Divided Table Planer

This type of planer has two tables on the bed which may be reciprocated separately or together.

This type of design saves much of idle time while setting the work. The setting up of a large number of identical workpieces on the planing machine table takes quite a long time. It may require as much time for setting up as may necessary for machining.



DIVIDED TABLE PLANER

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LECTURE 4

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TOPICS TO BE COVERED

LECTURE 4

- INTRODUCTION
- CLASSIFICATION
- WORKING PRINCIPLE
- OPERATIONS TO BE PERFOMED

DRILLING MACHINE

A **drilling machine** is one of the important machine tools in the workshop

Drilling is a material-removing or cutting process in which the tool uses a drill bit to cut a hole of circular cross-section in solid materials.

This is the most common machining process, one estimate is that 75% of all metal cutting material removed comes from the drilling operation.

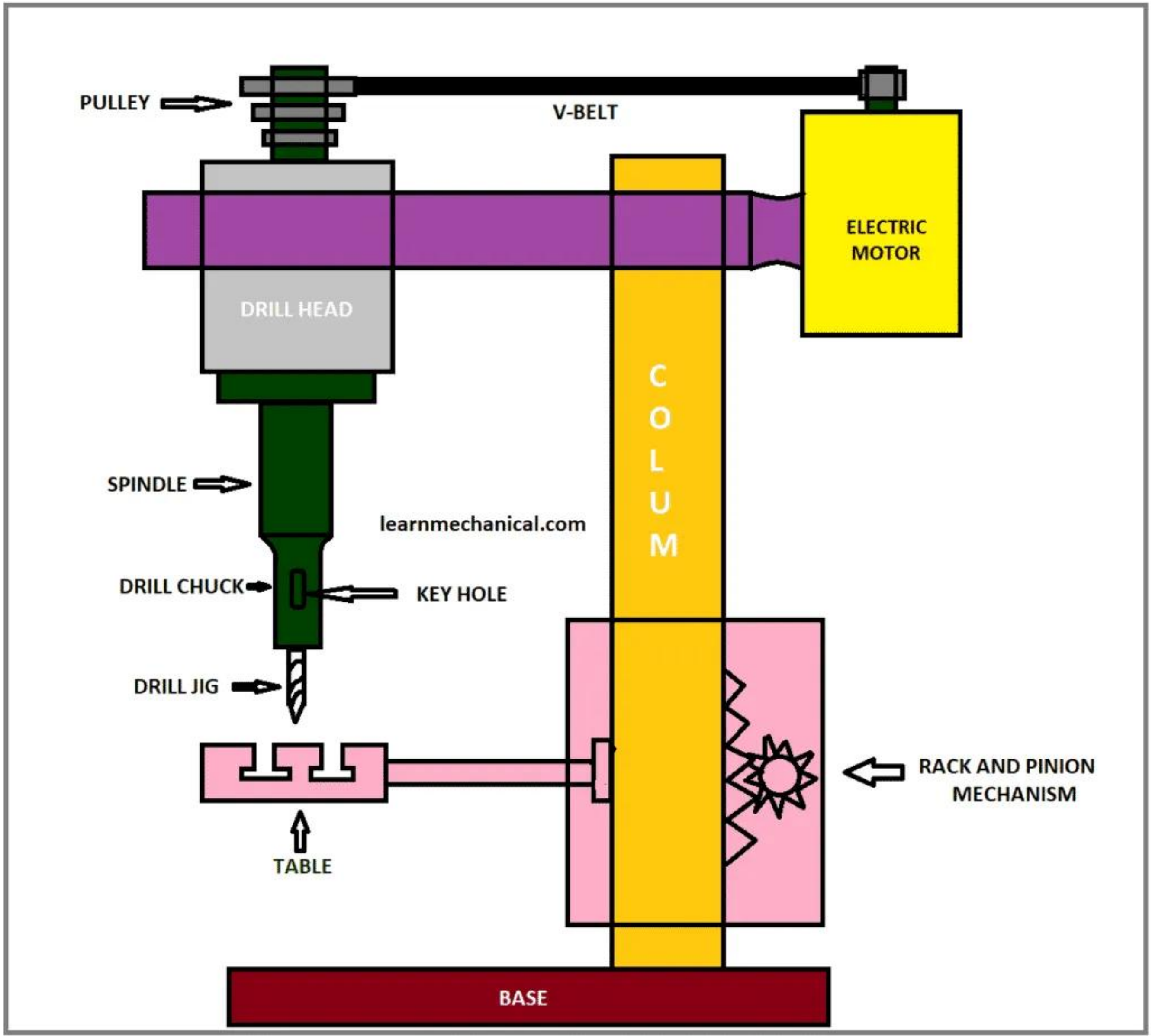
DRILLING MACHINE

Drilling Machine Main Parts

A drilling machine consists of the following parts:

- Base
- Column or Pillar
- Arm
- Worktable
- Drill head
- Feed Mechanism
- Spindle
- Drill jigs
- Chuck
- Electric Motor
- Pully or gears

DRILLING MACHINE



Base

It is one of the main parts of a drilling machine, it **carries the entire weight of the machine, and transfer the weight to the ground**.

The base of a drilling machine is generally made of cast iron or steel, and it is very rigid.

At the top of the base, there are some slots provided to support the big jobs.

And on one side of the base, a radial column or a pillar is situated.

The base is generally bolted with the ground or in some case the base is supported by two or four legs.

Column or pillar

The column or pillar is situated on one side of the base. In general, we **use a radial column so that the movement of the arm is possible in a clockwise or anti-clockwise direction**.

The column is also made of cast iron or steel and is also very rigid so that it can carry the load of the arm as well as a drill head.

Upper arm

At the top of the column, there is an upper arm, which carries the **drill head and also the house of the driving mechanism**. The upper arm is also made of the same material as the base. To make the structure rigid.

In some drilling machine, a guideway is provided so that the drill head can slide over this.

Worktable

The worktable is generally made of cast iron and it is mounted on the column. **T-slots are provided at the top surface of the table may be in some table there is a vice which also helps to hold the job**.

The table can move up and down as also right or left according to the job and tool arrangement. The up and down motion of the table can be given by hand as well as by some electrical mechanism. We use a **rack and pinion mechanism** for a vertical moment of the table.

The shape of the table can be **rectangular or also circular**.

Drill head

One side of the arm a drill head is mounted, a drill head is consist of **various feed and driving mechanism**.

A drill chuck is mounted over it. A drill head can slide up and down as per the requirement of the job.

A V-types belt is provided to transfer the power from the motor to the pulley and from pulley, the mechanical power is transferred to the drill head.

Feed Mechanism

In a drill machine, we use an **electric motor, V-belt, and pulley to transfer the power from the motor to the spindle**.

For the up and down motion of the drill head, we use hand and as well as automatic feed by an electrical motor. Here also a rack and pinion are used to convert the rotational movement from electrical motor or by hand to the straight-line movement.

Spindle

It is a **circular taper shaft which helps to hold the drill chuck**. It is made of high carbon chromium steel or stainless steel or steel alloys.

It transfers the **rotary motion from drill head to drill jigs**.

There is a **keyhole provided** on the spindle to change the drill chuck.

The spindle also can move up and down with the help of rack and pinion mechanism.

Chuck

The chuck is mounted on the lower end of the spindle, it **holds the drill jig**. Here also a **keyhole is provided** to change the drill jigs.

Drill chucks are generally **self-centering**. In a drill machine, we use **three-jaw chuck**. And it is made of special alloy steel

How does Power Transmission happen in the Drilling machine?

The power transmission in the drilling machine used to transmit power for its working.

This power is supplied from the **electric motor**.

The process of transmission takes place with the help of the v-bolt and the pair of pulley stacks opposite to each other.

The speed of the spindle is fixed or controlled with the help of the pulley stacks.

Let’s jump to the **types of Drill machine section**.

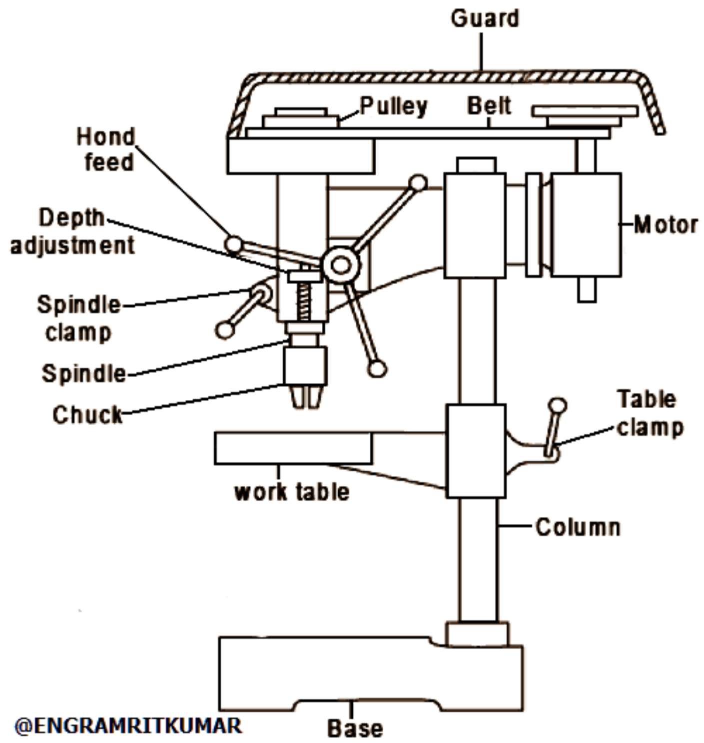
Drilling Machine Types

In the market there are various **types of Drilling machine** available, here I mention **some of the popular types of drilling machine**s.

- Sensitive Drilling Machine
- Vertical or Pillar
- Radial Arm
- Gang Type
- Multi-Spindle
- Numerically control
- Special Purpose Drilling Machine

Sensitive Drilling Machine

The **sensitive drilling machine** has only a hand-feed mechanism for feeding the tool into the workpiece. This enables the operator to feel how the drill is cutting and accordingly he can control the down feed pressure.



Vertical or Pillar Drilling Machine

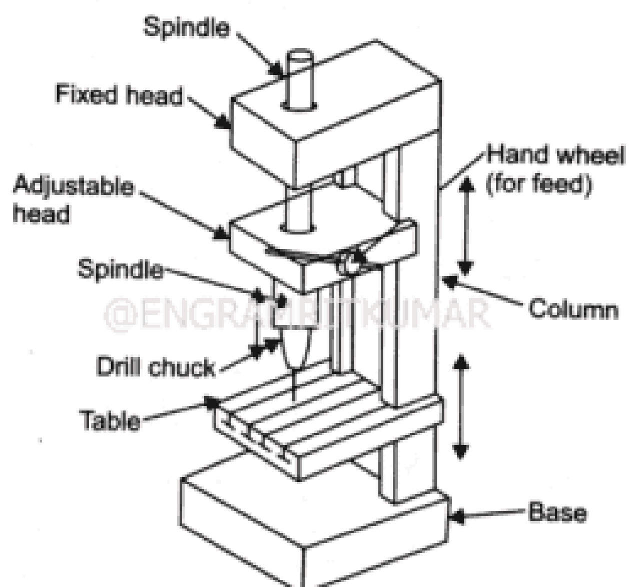
Vertical or Pillar Drilling Machine is free standing and is of a far heavier construction able to take larger drills.

It has a heavy frame to support a wider range of work.

The table height is adjustable and power speed and feeds are available.

The larger drills normally have a taper shank located within taper bore in the spindle end. These tapers are standardized as Morse tapers.

Vertical or Pillar Drilling Machine



Pillar Drilling Machine

Radial Arm Drilling Machine

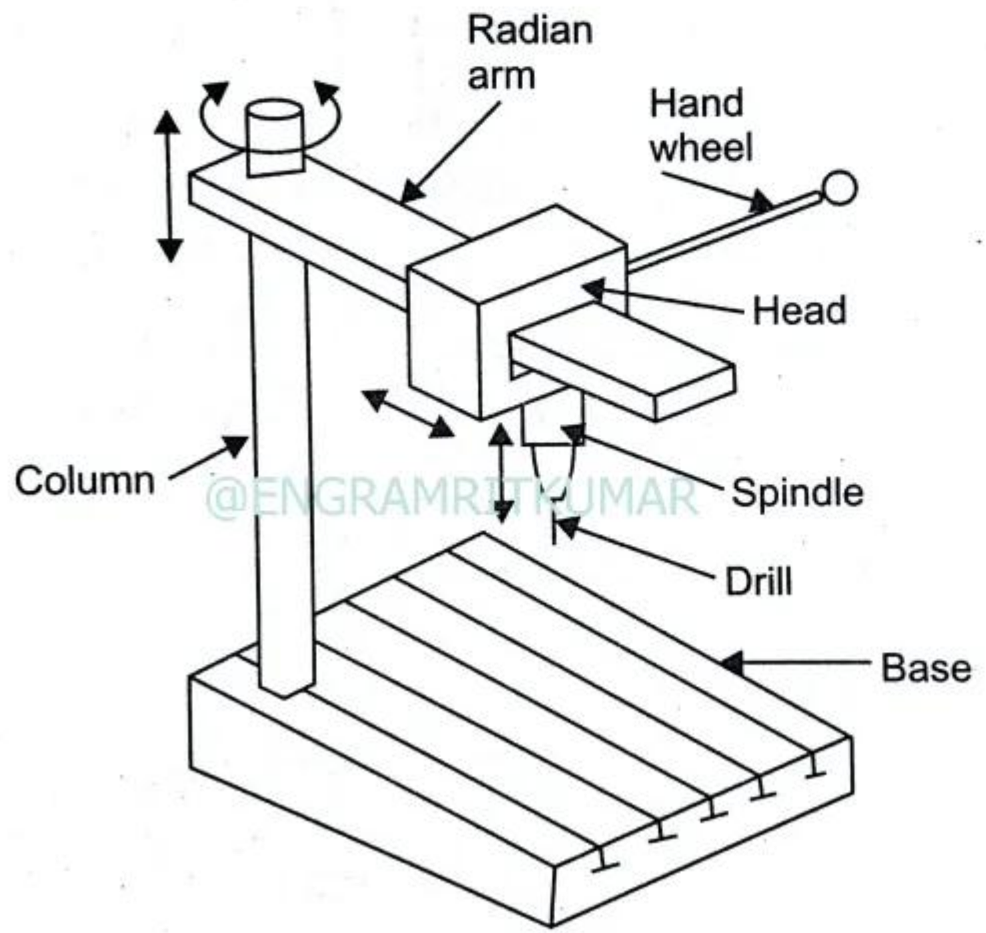
The **radial drill machine** is free-standing and the workpiece is clamped in the position on the base. It is used for heavy large and heavy work.

The arm is power-driven for the height location. The drill head is positioned using motorized drives and it transverse the swinging arm.

The workpiece remains stationary o the machine base or worktable.

The machine spindle is moved to the location required.

Radial Arm Drilling Machine



Radial Arm Drilling machine

Gang Type Drilling Machine

In **the Gang type Drilling Machine**, several spindles/ or stations are mounted on one long table as shown in the figure.

Multi-spindle Drilling Machine

In the **Multi-spindle drilling machine,** there are many spindles mounted on one head to allow many holes to be drilled simultaneously.

Numerical Control Drilling Machine

N**umerical control drilling machine** can automatically change tooling with a **turret or automatic tool changer**.

Speeds, feeds, and table position is controlled using a computer program.

Numerical Control Drilling Mchine

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TOPICS TO BE COVERED

- TWIST DRILL NOMENCLATURE

LECTURE-5

DRILLING MACHINE CONTEXT

Twist drill nomenclature

It is designed with cones like internal structure, narrow at the top of the web with a gradually increasing thickness to the shank.

It is a multi-point cutting tool. I also wrote an article on the single-point cutting tool you can check that too.

Properties of twist drill

Axis:

The imaginary straight line which forms the longitudinal centerline of the drill.

Back taper:

A slight decrease in diameter from front to back in the body of the drill.

Body:

The portion of the drill extending from the sank or next to the outer corners of the cutting lips.

Body Diameter clearance:

That portion of the land that has been cut away so it will not rub against the wall of the hole.

Chisel Edge:

The edge at the end of the web that connects the cutting lips.

Properties of twist drill

Chisel Edge Angle:

The angle included between the chisel angle and the cutting lips as viewed from the end of the drill.

Clearance Diameter:

The diameter over the cutaway portion of the drill lands.

Drill Diameter:

The diameter over the margins of the drill measured at the point.

Flutes:

Helical or Street grooves cut or formed in the body of the drill to provide cutting lips, to permit removal of chips and to allow cutting Fluids to reach the cutting lips.

Properties of twist drill

Flute Length:

The length from the outer corners of the cutting lips to the extreme back and of the flutes; it includes the sweep of the tool used to generate the flutes and, therefore does not indicate the usable length of the flutes.

Helix Angle:

The angle made by the leading edge of the land with a plane containing the axis of the drill.

Land:

The peripheral portion of the body between adjacent flutes.

Land Width:

The distance between the leading edge and the hill of the land measured at the right angle to the leading edge.

Properties of twist drill

Lead:

The axial advance of the leading edge of the land in one turn around the circumference.

Lips:

The cutting edge of a two-flute drill extending from the chisel edge to the periphery.

Lip Relief:

The axial relief on the drill point.

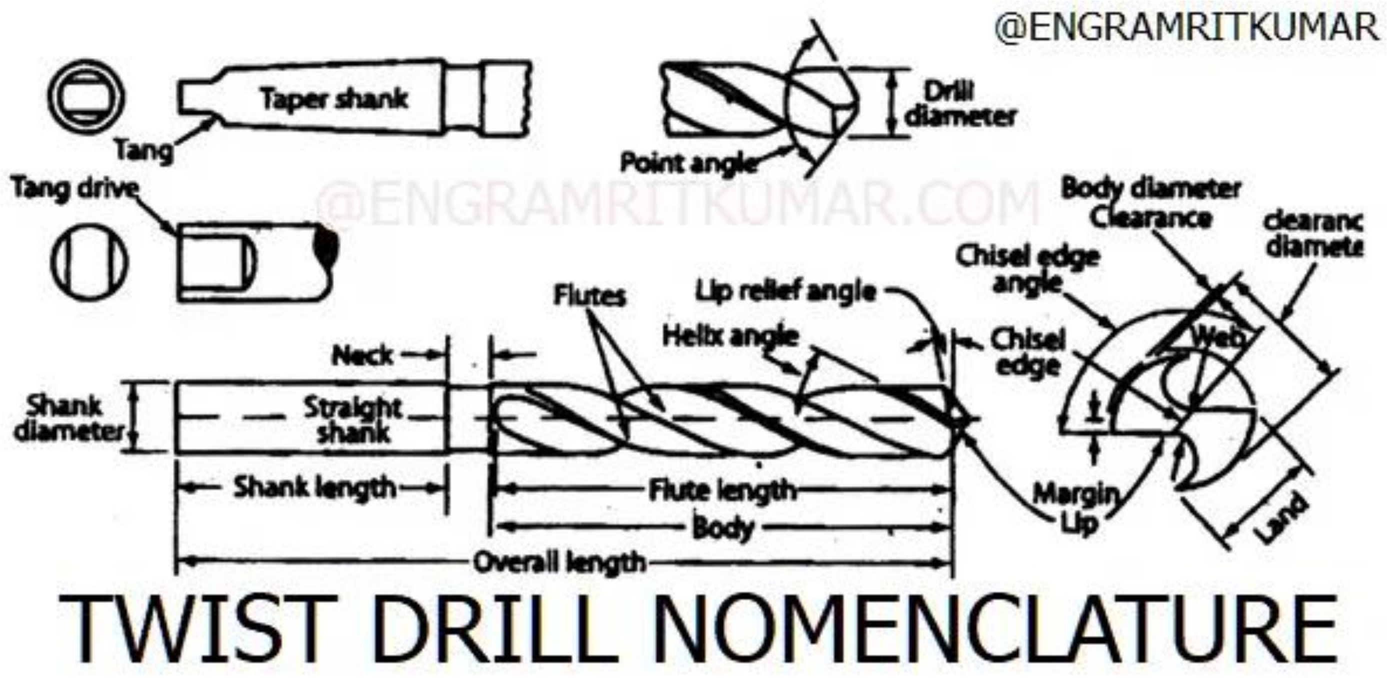
Lip Relief Angle:

The axial relief angle at the outer corner of the lip; it is measured by projection onto a plane tangent to the Periphery at the outer corner of the lip.

Margin:

The cylindrical portion of the land which is not cut away to provide clearance.

TWIST DRILL NOMENCLATURE



Drilling Machine Operation

These are the following **operations that can be performed in the Drilling machine.**

- Plane drilling operation
- Core drilling operation
- Step drilling operation
- Boring operation
- Counter boring operation
- Reaming operation
- Countersinking operation
- Spot facing operation
- Tapping operation
- Trepanning operation

Drilling operation

When we need a **circular hole in a workpiece of any size** there, we can use drilling operation, by a drilling operation you can form any size of holes in a workpiece. Although you can use a lathe for drilling operation too, drill machine is an appropriate machine to do holes in a workpiece.

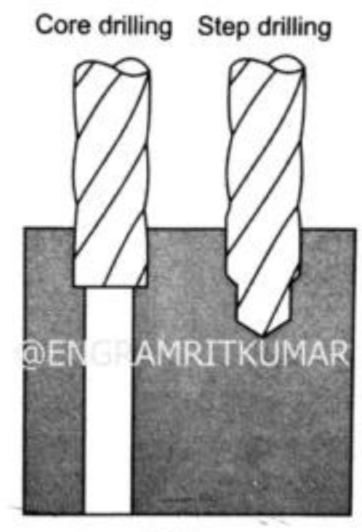
The cutting tool we used for this type of operation is drill bit. A drill bit is a multipoint rotary cutting tool which helps to remove material from a workpiece

Core Drilling

- When sand castings are made, cores are used to displace the metal where holes are desired. When cast the molten metal flows around the core.
- After the metal solidifies the casting is removed from the mold and the core disintegrates leaving the desired holes.
- The holes are usually quite rough and require heavy body drill to clean up the sidewall of the whole.

Step Drilling

More than one diameter can be ground on the drill body which saves an extra operation.



Core and step drilling operations.

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LECTURE-6

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TOPICS TO BE COVERED

LECTURE-6

- BORING
- WORKING PRINCIPLE
- TYPES
- DEEP HOLE DRILLING MACHINE

BORING

- **Boring machine**, device for producing smooth and accurate holes in a workpiece by enlarging existing holes with a bore, which may bear a single cutting tip of steel, cemented carbide, or diamond or may be a small grinding wheel.
- Single-point tools, gripped in a boring head attached to a rotating spindle, are moved circularly against the sides of the existing holes.
- The diameter of the hole swept out by the tool is controlled by adjustment of the boring head.

BORING MACHINE

BORING MACHINE

- There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end (which works for both, through holes and blind holes).
- **Line boring** (line boring, line-boring) implies the former.
- **Backboring** (back boring, back-boring) is the process of reaching through an existing hole and then boring on the "back" side of the workpiece (relative to the machine headstock).
- Because of the limitations on tooling design imposed by the fact that the workpiece mostly surrounds the tool, boring is inherently somewhat more challenging than turning, in terms of decreased toolholding rigidity, increased clearance angle requirements (limiting the amount of support that can be given to the cutting edge), and difficulty of inspection of the resulting surface (size, form, surface roughness). application.

BORING MACHINE

- These are the reasons why boring is viewed as an area of machining practice in its own right, separate from turning, with its own tips, tricks, challenges, and body of expertise, despite the fact that they are in some ways identical.
- The first boring machine tool was invented by John Wilkinson in 1775.[1]
- Boring and turning have abrasive counterparts in internal and external cylindrical grinding.
- Each process is chosen based on the requirements and parameter values of a particular

Features of Boring Machines

i. Headstock:

This is most important unit of the machine. The entire machine is built around it. It supports, drives and feeds the tool. It may contain one or two spindles. One spindle is heavy and slow moving for the heavier operations of boring, or drilling.

The other spindle is lighter and faster for drilling and tapping small holes and end mill work. Spindle rotation is reversible in either case for backing out tools and for right and left hand cutters.

ii. Column:

The column provides support for the headstock and guides it up and down accurately by means of ways. It is heavily constructed and is hollow to house the counterweights which balance the headstock and make it easier to move. Columns are keyed, dowelled, and bolted to bases. Some columns are stationary whereas others move with their bases.

Features of Boring Machines

iii. The Column Base:

The base supports and secures the column. It houses the various gears and driving mechanisms. On floor type machines the column base is mounted so that the spindle is at right angle to the ways of the run way. On planer type machines, the spindle is parallel to the ways of the run way.

iv. End Support:

For operations involving the use of long boring bars and heavy tools, an out board bearing is utilised to support the end of the bar. There is an open and a closed type of end support. On table and planer type machines, the bearing block travels in synchronism with the headstock of the machine. When such an end support is used with floor type machines, it is adjusted separately from the headstock and aligned by means of an accurate scale and vernier.

v. Run Ways:

These are used on floor or planer type machines to carry the main column, end-support column, and in some cases, a rotary table. When the column base, column and headstock are traversed as a complete unit, the member upon which it travels is called a run way and not a bed.

Features of Boring Machines

vi. Table and Saddle:

The chief function of the table is to provide a support for holding the workpiece. It also provides a means of locking and clamping the work. It is equipped with suitable ranges of feeds as well as rapid traverse.

The table usually traverses at right angles to the axis of the spindles unless provided with saddle. The function of the saddle is to provide a compound movement of the table, so that it can move axially as well as transversely to the spindle.

vii. Bed:

It may be cast in one or several pieces. It serves to support the column and headstock, the end supports, the table, the saddle and the various feed and control shafts. It contains all the necessary feeding mechanisms for the table as well as a coolant tank.

Types of Boring Machines

A. Horizontal Boring Machine:

The horizontal boring mill is also known as horizontal boring, drilling and milling machine, and is intended to perform operations on relatively large pieces which cannot be rotated easily, are irregular and unsymmetrical, and require operations on many surfaces.

Fig. shows the main features of a horizontal boring machine. It also indicates the relative movements of its sliding and rotating elements. It may be noted that the main spindle can be rotated in either direction. It is possible to feed the main spindle axially. The work table can be traversed along and across the machine bed.

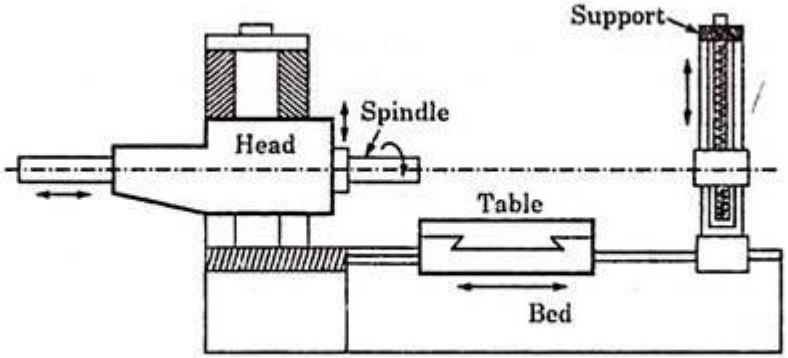

Fig. 18.40. Horizontal Boring Machine.

TYPES OF BORING MACHINE

B. Vertical Boring Machine:

There are two types of vertical boring machines, viz.,

i . Standard vertical boring mill and

ii. Vertical turret lathe.

Standard vertical boring mill is the largest of the machine tools. It is used to machine inside and outside diameters and facing large pieces which are more or less symmetrical such as large ring-gear blanks, steam turbine castings, water turbine runners, locomotive tires, tables for machine tools, flanges for large pipes and pressure vessels. The size of such a machine is given by the diameter of the largest workpiece which can be machined.

Vertical turret lathe is basically a vertical boring mill and has turrent arrangement of holding the tools. It can do essentially the same jobs, but on a smaller scale. The machine looks like a turrent lathe, with its head stock resting on the floor and its axis vertical. The table is usually called a chuck because of its adjusting jaws for work clamping.

The distinguishing feature of the machine, however, is its five sided turrent, or tool holder mounted on the cross rail. It has five tool positions which enable successive tools to be brought into position without demounting. The typical jobs which can be machined include boring and turning rail road wheels, locomotive cross-heads, large pistons, rings and gear blanks, bowls and many other similar round and symmetrical pieces.

TYPES OF BORING MACHINE

C. Other Boring Machines:

Two-spindle vertical way type drilling and boring machine

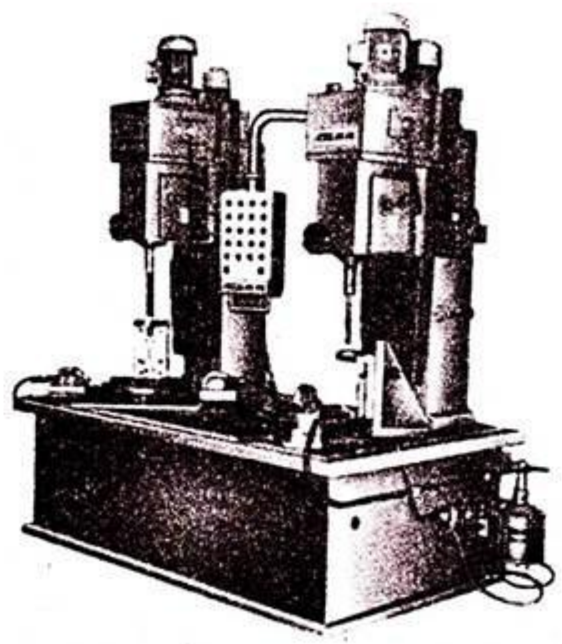

Fig. 18.41. 2-spindle vertical way type drilling and boring machine.

TYPES OF BORING MACHINE

Double Ended Machine

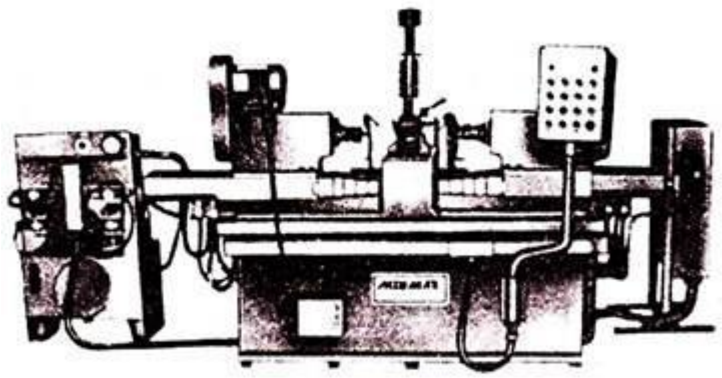

Fig. 18.42. Double ended boring machine.

TYPES OF BORING MACHINES

Fine Boring Machines

These are precision boring machines designed for high accuracy and surface finish. Boring spindle is very precisely supported on ball, roller, hydrostatic or air bearings. Often, diamond tools are used. These are available in horizontal (single end or double end type) and vertical spindle fashions. Axial feed is given by cam or hydraulic cylinder. Recirculating ball screw drive is used for feeding to achieve higher position accuracy in numerically controlled boring machines.

Boring Tools

Boring tools are held in boring tool holders which may be either fixed or rotating type. Fixed holders are used in work-rotating machines and rotating holders in tool rotating machines. Size of boring bar should be such as to provide maximum rigidity and also permit sufficient clearance for disposal of chips. Normally boring bar diameter is taken as 0.7 x bore diameter. It should have minimum overhang.

Various types of boring tool holders are:

i. Adjustable Boring Bars:

These are built with cartridges (to hold throwaway type inserts) adjustable in axial and radial directions by set screws.

ii. Damped Boring Bars:

In it, dampers are provided at the feed end to absorb vibrations.

iii. Line Boring Bars:

These are used for long bores and can accommodate fly cutters, tool blocks, cartridges etc. These are supported at the feed end in suitable bearings.

BORING TOOLS

iv. Boring Head:

It is more rigid boring tool holder and is used for roughing and finishing of large bore (100 to 500 mm). Provision to offset cutting axially and radially exists. Two cutters can be mounted radially at 180° to have balanced cutting.

v. Boring and Facing Heads:

This enables boring of large bores and facing of seating surfaces at right angles to the bore. Radial tool feeding facility also exists.

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COURSE OBJECTIVES

UNIT - 1	**CO1:** Learn about geometry of metal cutting theory, mechanism of chip formation and mechanism of orthogonal cutting and merchants force diagram
UNIT - 2	CO2: Learn about ways to reduce the surface roughness by using different machining process
UNIT - 3	CO3: To write APT and CNC programming concepts
UNIT - 4	CO4: Learn the concepts of DNC Systems and Post Processors
UNIT - 5	CO5: To know about Computer aided process planning and computer aided inspection and Quality control

UNIT 3

COMPUTER AIDED PROGRAMMING

CO3:.To write APT and CNC programming concepts

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UNIT – III (SYLLABUS)

APT PROGRAMMING

- General Information
- Examples of Apt programming
- NC programming

CAD/CAM SYSTEMS

- Tooling
- Inter changeble tooling system

COURSE OUTLINE

LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning Objectives
1	Computer aided Programming-Basics	Concepts of CAP	• Understanding various programming languages and codes used for manufacturing
2	APT Programming and examples	Automatically programmed tool	• Write a program using APT and few examples on drilling and milling
3	NC programming and examples	Numerical control programming	• Programs for drilling, milling and cutting using NC codes ie G and M codes
4	Automatic tool path generation, tooling for CNC,Interchangeable tooling systems	CNC basics	• Understanding tool path and automated tool path generation • Tooling for CNC
5	Preset and Qualified tools, coolant fed tooling system, Modular featuring	Preset and Qualified tools	• Understand the concepts of coolants in CNC • Importance of preset and Qualified tools
6	Quick change tooling system and automatic head changer	Automatic head changer	• Understanding the automatic tool changing phenomenon

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LECTURE 1

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TOPICS TO BE COVERED

- COMPUTER AIDED PROGRAMMING BASICS

LECTURE 1

- COMPUTER AIDED PROGRAMMING BASICS

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COMPUTER AIDED PROGRAMMING

Computer-aided design (**CAD**) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design.[1] CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing.[2] CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for *Computer Aided Design and Drafting*) is also used.[3]

Its use in designing electronic systems is known as electronic design automation (**EDA**). In mechanical design it is known as mechanical design automation (**MDA**) or **computer-aided drafting** (**CAD**), which includes the process of creating a technical drawing with the use of computer software.[4]

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

COMPUTER AIDED PROGRAMMING

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.[5]

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.[6]

COMPPUTER AIDED PROGRAMMING

Computer Aided Manufacturing (CAM) is the use of software and computer-controlled machinery to automate a manufacturing process.

Based on that definition, you need three components for a CAM system to function:

- **Software** that tells a machine how to make a product by generating toolpaths.
- **Machinery** that can turn raw material into a finished product.
- **Post Processing** that converts toolpaths into a language machines can understand.

These three components are glued together with tons of human labor and skill. As an industry we've spent years building and refining the best manufacturing machinery around. Today, there's no design too tough for any capable machinist shop to handle.

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LECTURE 2

TOPICS TO BE COVERED

- APT PROGRAMMING
- EXAMPLES

LECTURE 2

APT PROGRAMMING

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INTRODUCTION TO APT

- APT is a form of text code that was invented in the 1950s and is used to control CNC cutting tools.
- It programs the tools to cut complex parts, by creating the geometric points that create a path that the tool must follow in order to make the correct cuts.
- It utilizes a purpose-built language to program these points and to determine the specifics of the machine that will follow the path.

APT

- APT (automatically programmed tools) is a form of coding that is used for CNC (computer numerical control) tools.
- It was created in the 1950s at MIT by Douglas T. Ross and was partially funded by the U.S. Air Force.
- It was designed specifically for use in aeronautics, to be able to accurately cut the complex pieces needed for machinery.
- It creates the form that the tools must cut, by calculating all of the necessary geometric points. The code itself is non-proprietary, but the compilers that translate the code into the target language for the CNC tools are almost all proprietary.

APT

- APT was created in response to the swift developments in CNC technology.
- It was impossible for individuals to be able to calculate the movements needed to create complex parts – something that these new machines were capable of doing.
- The program helped to utilize these machines at their maximum potential, where human ability was limited.
- APT takes English statements and uses a process to convert them into instructions for CNC tools. These instructions are the code geometric points on a path for the tool to follow.
- These coordinates are also known as cutter location data (CLD).
- This information is then fed into a computer that controls the numerically controlled tool, which then follows the set paths to create the appropriate cuts.

APT

- When using APT, the programmer has two main tasks.
- Firstly, they must define the geometric points that will be used to create the tools' path and specify this path as well as the operational sequence (what order the cuts should be placed in). The rest is done by the computer.
- Apt is seen as the predecessor to more commonly used forms of CAM (computer-aided manufacturing). CAM is far more capable of using computer-assisted tools to accurately manufacture pieces of machinery but was also initially created to provide services in the aerospace industry.

FEATURES OF APT

- One of the main features of APT is that it is completely text-based.
- It was created before the advent of graphic interfaces, therefore required a method of creating complex toolpaths that was alternative to the one that is far more commonly used today.
- The text commands utilize English to specify the geometry and toolpaths needed to create the cuts to form the machine part.
- The code language is comprised of over 400 different words, to create all of the possible unique tool paths that are necessary.

APT is comprised of four different types of statements

- **Geometry statements/Definition statements –** Used to determine the geometric elements of the part, by defining the points and lines that the machine will follow. These statements are characterized by up to six alpha-numeric characters (always at least one alpha character), which is used to refer to a specific geometric feature. It can also be used to define the size and location of the feature, in relation to other parts.
- **Motion commands –** These specify the direction of the tools' movements that form the path. FROM is always the code for the starting point, and GOTO and GODLA are the commands used to continue on a tool path from point to point.

APT is comprised of four different types of statements

- **Postprocessor statements –** The aspects of the code that control the capabilities of the machine being used. This can include the speed of the tool (measured in revolutions per minute), sizing (whether things are measured in inches or millimeters), the tolerance value for circular interpolation (both inward and outward values), and the values pertaining to the cutter itself (such as the diameter and length, but these calculations can also be done in 3d). It also determines what tool, and what specific controller should be used for each cut, and this is the final postprocessor statement in a task. The tool can be defined by using up to 7 different variables and comes with its own language to denote the various tool shapes, including "bell end" and "chamfer".

- **Auxiliary statements –** The statements that are grouped together to accomplish a certain task. An ATP program begins with the code APTO, and ends with FINI – everything in between these two phrases is part of a single part program.

APT

APT for CNC tools are fully capable of utilizing 5-axis control, to create precise paths for the cutter to follow anywhere in 3d space, at any angle. It is also capable of creating instructions for 3d surfacing and 2.5d contouring.

It is very similar to other programming languages such as FORTRAN, which also converts statement text into instructions for a computer to then follow. In the case of APT, the computer then feeds the instructions specifically to CNC tools that perform cutting tasks.

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LECTURE 3

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TOPICS TO BE COVERED

- NC PROGRAMMING
- EXAMPLES

LECTURE 3

NC PROGRAMMING

Numerical Control(NC) Part Programming Using CAD/CAM

- A CAD/CAM system is a computer interactive graphics system equipped with software is accomplish certain tasks in design and manufacturing and to integrate the design and manufacturing functions.
- A *CAD/CAM system* is a computer interactive graphics system equipped with software is accomplish certain tasks in design and manufacturing and to integrate the design and manufacturing functions.
- In this method of part programming, portions of the procedure usually done by the part programmer are instead done by the computer.
- Recall that the two main tasks of the part programmer in computer assisted programming are (1) defining the part geometry and (2) specifying the tool path. Advanced CAD/CAM systems automate portions of both of these tasks.

Numerical Control(NC) Part Programming Using CAD/CAM

Geometry Definition Using CAD/CAM.

- A fundamental objective of CAD/CAM is to integrate the design engineering and manufacturing engineering functions.
- Certainly one of the important design functions is to design the individual components of the product.
- If a CAD/CAM system is used, a computer graphics model of each part is developed by the designer and stored in the CAD/CAM database.
- That model contains all of the geometric, dimensional, and material specifications for the part.

Numerical Control(NC) Part Programming Using CAD/CAM

- When the same CAD/CAM system, or a CAM system that has access to the same CAD data base in which the part model resides, is used to perform NC part programming, it makes little sense to recreate the geometry of the part during the programming procedure.
- Instead, the programmer has the capability to retrieve the part geometry model from storage and to use that model to construct the appropriate cutter path.
- The significant advantage of using CAD/CAM in this way is that it eliminates one of the tirneconsurning steps in computerassisted part programming: geometry definition.
- After the part geometry has been retrieved, the usual procedure is to lahel the geometric elements that will be used during part programming.
- These labels are the variable names (symbols) given to the lines, circJe~ and surfaces that comprise the part. Most systems have the capacity to automatically label the geometry clements of the part and to display tbe labels on the monitor. The programmer can then refer to those labeled elements during tool path construction.

G-Code: The CNC Programming Language

G-code was first established in the 1960s by the Electronics Industry Association (EIA). While the official language was documented as RS-274D, you'll hear everyone refer to it as G-code. Why? Many of the words, or individual pieces of code, that make up this machine-based language start with the letter G.

While G-code is supposed to be a universal standard, you'll find that many CNC machine companies have developed their own unique flavor. We're all be eating ice cream at the end of the day, but a Haas might be strawberry, and a Tormach chocolate. Because of this difference in G-code flavors, it's really important to understand how your own machine uses G-code

G-Code: The CNC Programming Language

Why the difference in G-code flavors? It really comes down to the capabilities of each machine. Take one machine that can process a coordinate system rotation based on probe inputs. You'll need a set of G-code commands that can enable or disable this rotation. Another machine without this adjustment capability won't require that G-code.

When in doubt, always refer to the documentation of your CNC machine as you work through the rest of this article. We'll be walking through the basics, but you never know if your machine might have taken a slightly different path to the same end destination.

G-Code Blocks

The G-code standard was published back in the days when machines had small amounts of memory. Because of this memory limitation, G-code is an extremely compact and concise language that might almost seem archaic at first glance. Take for example this line of code:

G01 X1 Y1 F20 T01 M03 S500

In this single line we're giving the machine a series of instructions:

- **G01** – Perform a linear feed move
- **X1/Y1** – Move to these X and Y coordinates
- **F20** – Move at a feed rate of 20
- **T01** – Use Tool 1 to get the job done
- **M03** – Turn the spindle on
- **S500** – Set a spindle speed of 500

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LECTURE 4

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TOPICS TO BE COVERED

- AUTOMATIC TOOL PATH GENERATION
- TOOLING FOR CNC

LECTURE 4

TOOL PATH GENERATION

AUTOMATED TOOL PATH GENERATION

- The first step in specifying the tool path is La select the cutting tool for the operation. Most *CADICAM* systems have tool libraries that can be called by the programmer to identify what tools arc available in the tool crib.
- The programmer must decide which of the available tools is must appropriate for the operation under consideration and specify it for the tool path.
- This permits the tool diameter and other dimensions to be entered automatically for tool offset calculations.
- If the desired cutting tool is not available in the library, an appropriate tool can be specified by rhc programmer. It then becomes part of the library for future use

AUTOMATED TOOL PATH GENERATION

- The next step is tool path definition.
- There are differences in capabilities of the various CAD/CAM systems, which result in different approaches for generating the tool path.
- The most basic approach involves the use of the interactive graphics system to enter the motion commands One by one.
- Simiilar to computer assisted part programming.
- Individual statements in APT or other part programming language are entered. and the CAD/CAM system provides an immediate graphic display of the action resulting from the command. thereby validating the statement.

AUTOMATED TOOL PATH GENERATION

- A moreadvanced approach for generating tool path commands is to use one of the automatic software modules available on the CAD/CAM system.
- These modules have been developed to accomplish a number of common machining cycles for milling, drilling, and turning. They are subroutines in the NC programming package that can be called and the required parameters given to execute the machining cycle.
- When the complete part program has been prepared, the CAD/CAM system can provide an animated simulation of the program for validation purposes.
- Computer Automated Part Programming. In the CAD/CAM approach to NC part programming, several aspects of the procedure are automated.
- In the future, it should be possible to automate the complete NC part programming procedure. We are referring to this fully automated procedure as computer automated part programming.
- Given the geometric model of a part that has been defined during product design, the computer automated system would possess sufficient logic and decision making capability to accomplish NC part programming for the entire part without human assistance.

Tool path generation

- This can most readily be done for certain NC processes that involve well defined, relatively simple part geometries. Examples are point to point operations such as NC drilling and electronic component assembly machines.
- In these processes, the program consists basically of a series of locations in an *xy* coordinate system where work is to be performed [e.g .. holes arc to be drilled or components are to be inserted).
- These locations are determined by data that are generated during product design. Special algorithms can be developed to process the design data and generate the NC program for the particular system. *"fe* contounag systems will eventually be capable at a similar level of automation. Automatic programming of this type is closely related to computer-automated process planning (CAPP), discussed in later pages.

Nc modules

TABLE 6.13 Some Common NC Modules for Automatic Programming of Machining Cycles

Module Type	*Brief Description*
Profile milling	Generates cutter path around the periphery of a part, usually a 2-D contour where depth remains constant, as in Example 6.8 and Figure 6.17.
Pocket milling	Generates the tool path to machine a cavity, as in Figure 6.25(a). A series of cuts is usually required to complete the bottom of the cavity to the desired depth.
Lettering (engraving, milling)	Generates tool path to engrave (mill) alphanumeric characters and other symbols to specified font and size.
Contour turning	Generates tool path for a series of turning cuts to provide a defined contour on a rotational part, as in Figure 6.25(b).
Facing (turning)	Generates tool path for a series of facing cuts to remove excess stock from the part face or to create a shoulder on the part by a series of facing operations, as in Figure 6.25(c).
Threading (turning)	Generates tool path for a series of threading cuts to cut external, internal, or tapered threads on a rotational part, as in Figure 6.25(d) for external threads.

Machining in nc

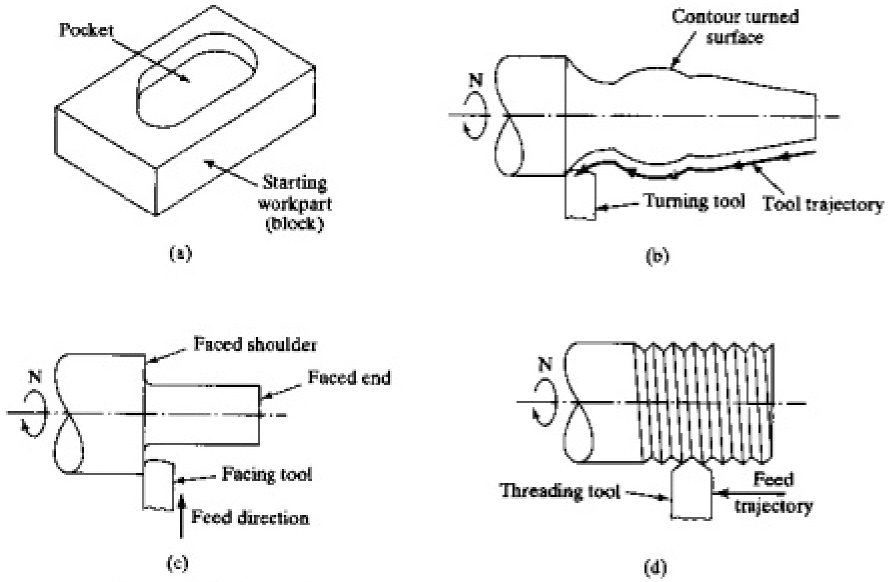

Figure 6.25 Examples of machining cycles available in automatic programming modules. (a) pocket milling, (b) contour turning (c) facing and shoulder facing, and (d) threading (external).

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TOPICS TO BE COVERED

- Preset tools and qualified tools
- Coolant fed systems

LECTURE-5

Preset and qualified tools

Preset and qualified tools

- Ideally, tooling should attach to a machine like the bayonet on the end of a rifle -- quick, sure, and precise. Preset, quick-change, and adjustable tooling can achieve this ideal to a greater or lesserextent, depending on the specific application. Use of this tooling can result in cost savings through such things as:
  - Reduced labor hours
  - Increased machine hours available for production
  - Reduced skill and training requirements for shop people
  - Improved quality
  - Reduced operator error
  - Reduced scrap

Preset Tooling

- The key attribute of preset tooling is that its location in the machine is known with a high degree of precision. Once such a tool has been attached to a machine, it will produce the desired predetermined dimension without adjustment.
- Presetting is done off the machine, and requires that tools have a means of adjustment. In addition, the method of attaching them to the machine must be repeatable and highly accurate.
- Presetting is often employed on end-working tools, but can also be used for cross-working applications.
- Preset tooling saves time during setup, as well as when tools are changed during the job's run, by reducing or eliminating test cuts, measurements, and adjustments.
- On screw machines in particular, where the "brass hammer method" is often used, these adjustments require either substantial skill or substantial time.
- The amount of time saved through the use of this tooling has to be balanced against the time required for presetting

Preset tooling

- However, even if there is no apparent reduction in labor hours, there will be an increase in the number of hours available for production on the machine.
- This is because presetting is part of “external” setup or operating time. That is, it can be done while the machine continues to make pieces.
- Whether the benefits of this type of tooling come in the form of reduced labor or increased uptime, they may be most significant on newer, more expensive, advanced technology machines which carry a higher machine hour rate.
- In this report, preset tooling has been handled separately from “quick-change,” which has been handled separately from “adjustable,” etc.
- The purpose of this is to be clear about exactly which benefits are inherent in each type of tooling. However, in actual practice these types are commonly combined, with examples such as “preset, quick-change tooling,” or “quick-change, adjustable tooling” coming to mind.

Preset tooling

- There is a question regarding the feasibility of this tooling on some cam machines, since the end points of tool slides are not necessarily predictable on a given job, or repeatable from one run to the next.
- In some cases this is due to small differences between “identical” cams which are used interchangeably. In addition, on single spindle machines the high and low points on the lead cam may not be exact, although some presetting systems can correct for this.
- These problems can be overcome by purchasing new cams to closer tolerances; but for the shop with a large inventory of existing cams, this may not be cost effective.
- Another option is to provide a means of making a graduated fine adjustment on the machine, either with an adjustable tool holder or with an integral adjustable slide, although this will reduce the benefits of this tooling somewhat.

Pre gaged tooling

- Pre-gaged tooling is a variation of preset tooling, but lacks its ability to be adjusted off the machine. It is made to close tolerances with only small differences between “identical” tools.
- Prior to being set up, this type of tool is gaged and variations from its nominal dimensions are noted.
- Generally it is used on CNC machines, and adjustments for these variations are handled by the tool compensation offsets, in many cases without the need for trial cuts and subsequent adjustments.
- While not common, this concept can be applied on cam machines as long as there is a way to make graduated fine adjustments, either within the tool holder system, or on the machine itself.

Qualified tooling

- Qualified tooling is another variation of preset tooling.
- All of the components that comprise a qualified tool are made to close tolerances; and because of this, it will cut very near to the desired dimension.
- One of the most common types is the carbide insert/insert tool holder combination. Installed in the machine, any combination of “identical” inserts and tool holders will generally be located within ?.005” of their nominal dimension.
- Like the pre-gaged type above, this tooling is not adjustable; and there must be a way on the machine to compensate for these small variations, following a trial cut and measurement.

QUICK CHANGING TOOLS

- The primary characteristic of quick-change tooling is the ease, speed, and convenience it provides in terms of removal and replacement.
- In addition, it generally fastens to the machine in a repeatable fashion. The very fact that it is quick acting allows this tooling to save time both during setup, and when it needs to be changed during a run.
- Unlike quick-change collets, most quick-change tooling can also be preset, pre-gaged, adjusted, etc. With this combination of qualities it is possible to exchange a new or “renewed” tool with one that needs sharpening, and have the machine producing again in a moment or two.
- In some instances it may even make sense to replace a slightly worn tool in this way, rather than taking time from production for a trial-and-error, on-machine adjustment.

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UNIT 4

DNC SYSTEMS AND ADAPTIVE CONTROL

CO4: **To understand APT & CNC Programming Concepts**

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PROBLEMS WITH CONVENTIONAL NC

- Part programming mistakes
- Nonoptimal speeds and feeds
- Punched tape
- Tape reader
- Controller
- Management information

COMPUTER NUMERICAL CONTROL

- Conventional hard- wired NC controller unit replaced by computer.
- NC system that utilizes stored programs in a dedicated computer to perform some or all NC functions
- Soft-wired
- Flexibility

CNC

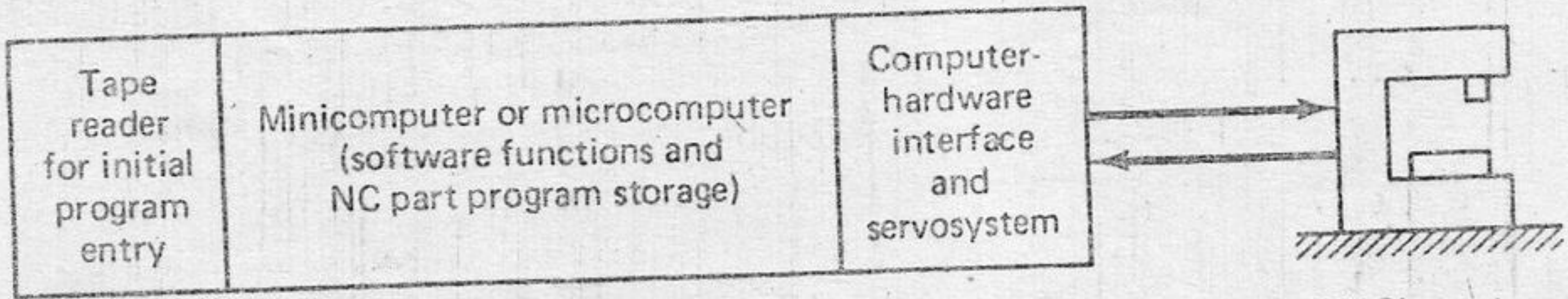


FIGURE 9.1 General configuration of computer numerical control (CNC) system.

FUNCTIONS OF CNC

Machine tool control

- Hybrid CNC –Hard-wired logic circuits for functions like feed rate generation , circular interpolation etc. in addition to computer mass production of circuits and less expensive computer
- Straight CNC – Computer to perform all NC functions

HYBRID CNC

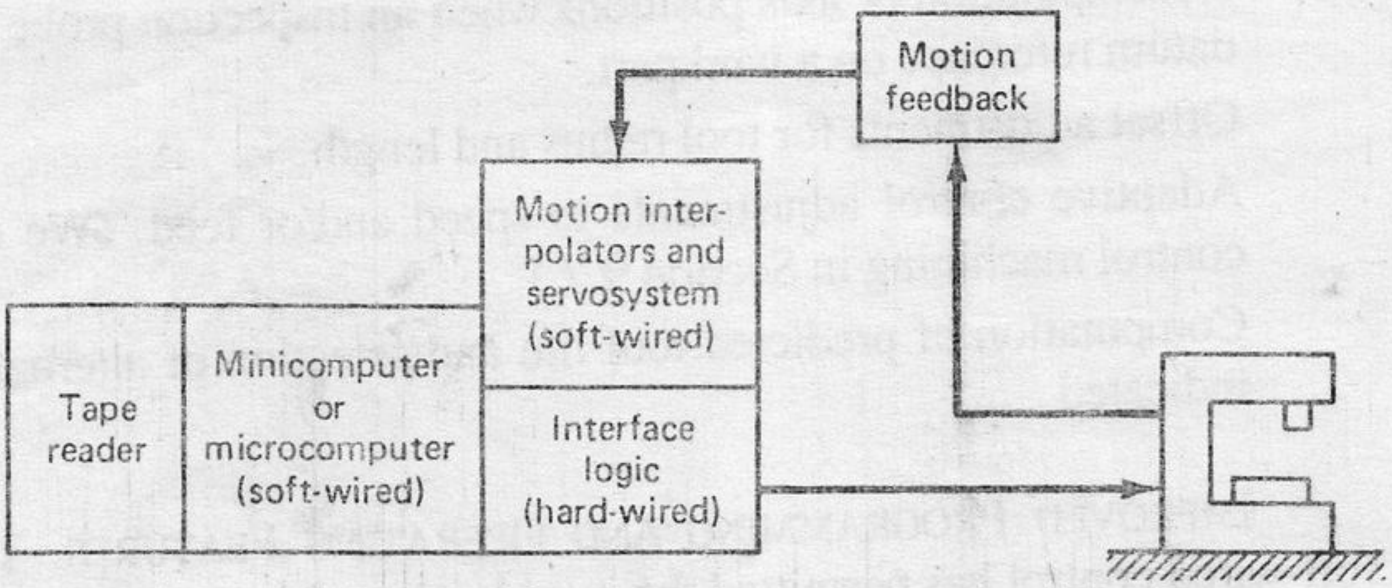


FIGURE 9.2 Hybrid CNC.

STRAIGHT CNC

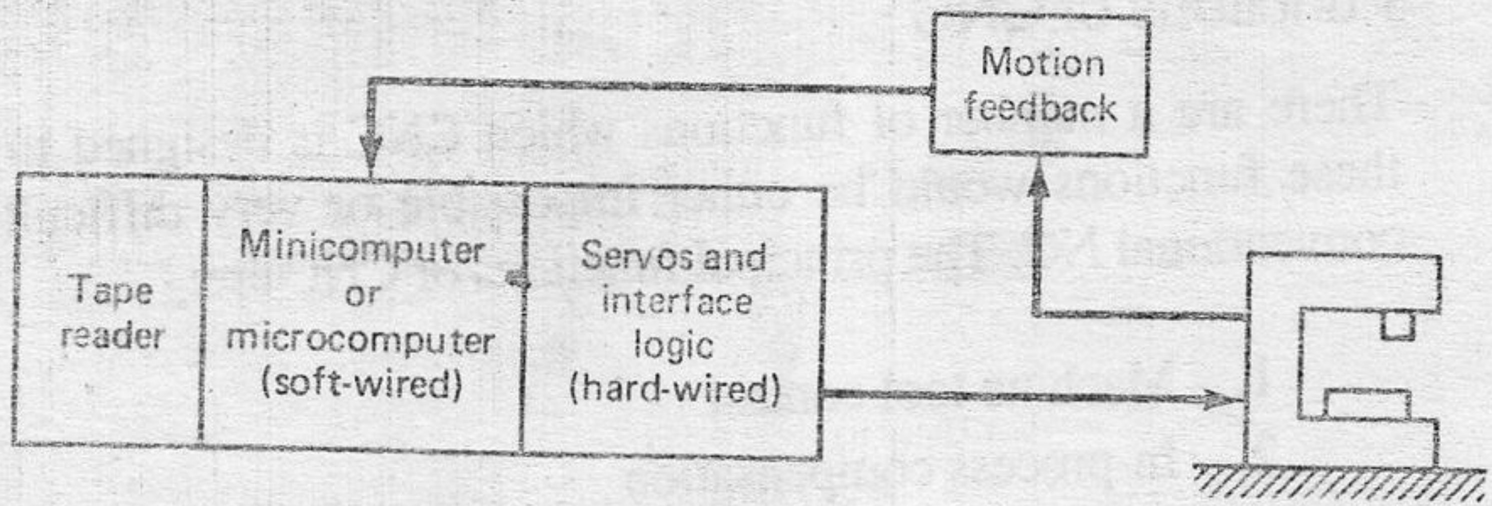


FIGURE 9.3 Straight CNC.

FUNCTIONS OF CNC

In-process compensation –

Dynamic correction of machine tool motion for changes or errors that occur during processing

- Adjustment of errors sensed by in-process inspection
  - probes and gauges
- Recomputation of axis positions when an inspection probe is used to locate a datum reference on the work part
- Offset adjustments for tool radius and length
- Adaptive control adjustments to sped and feed
- Computation of predicted tool life and selection of alternate tooling when indicated.

FUNCTIONS OF CNC

Improved programming and operating features

- Use of tape and tape reader only once
- On-line editing of part programs at the machine
- Special canned cycles.
- Graphic display of tool path to verify the tape
- Various types of interpolation: circular, parabolic, cubic
- Support of various units. Conversion from one unit to another unit.
- Use of specially written subroutines or macros
- Manual data input (MDI)
- Several part programs in bulk can be stored.

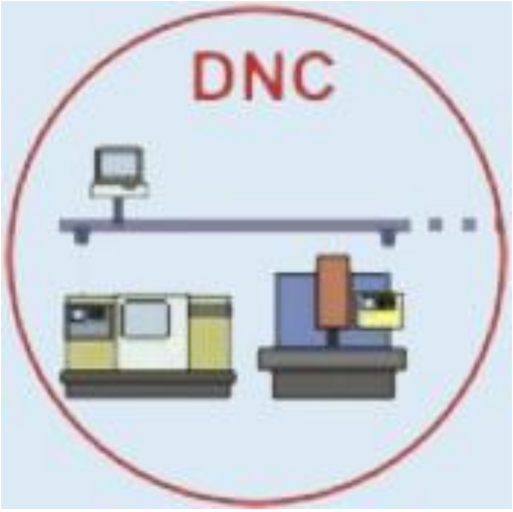
FUNCTIONS OF CNC

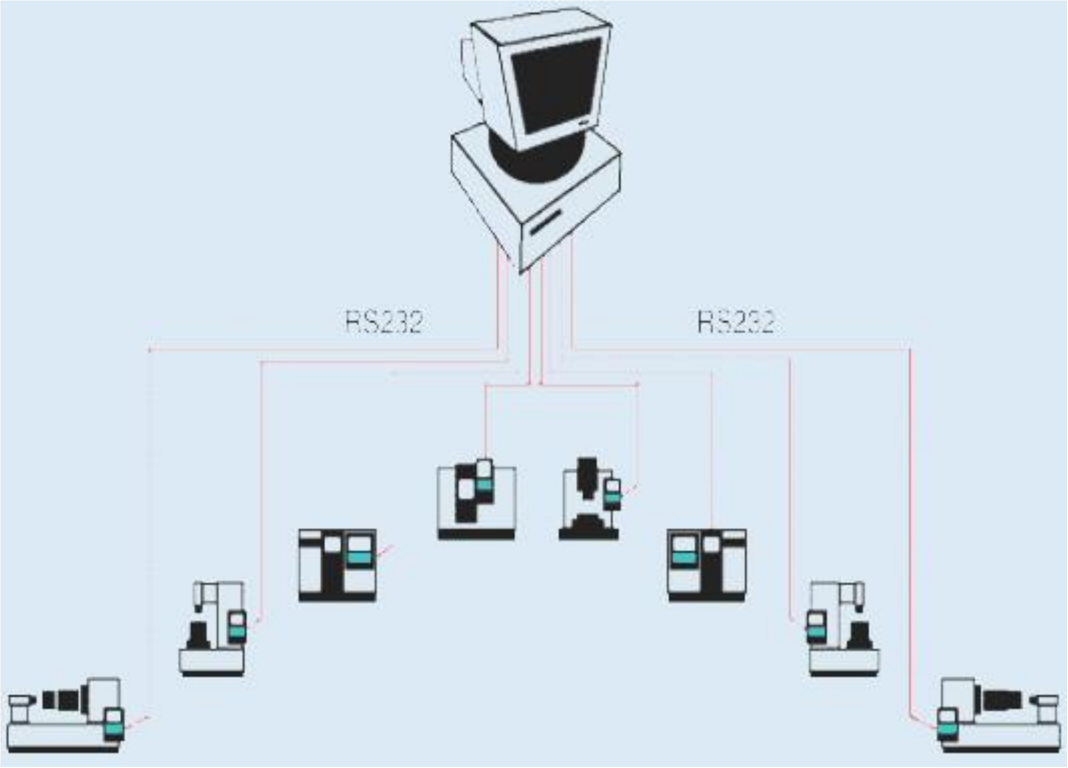
Diagnostics – Equipped with diagnostic capability to assist in maintaining and repairing the system

- Identification of reason for downtime
- Indication of imminent failure of certain component
- Redundancy of components

DIRECT NUMERICAL CONTROL

- A manufacturing system in which no. of machines are controlled by a computer through direct connection and in real time.





DNC WITH SATELLITE COMPUTER

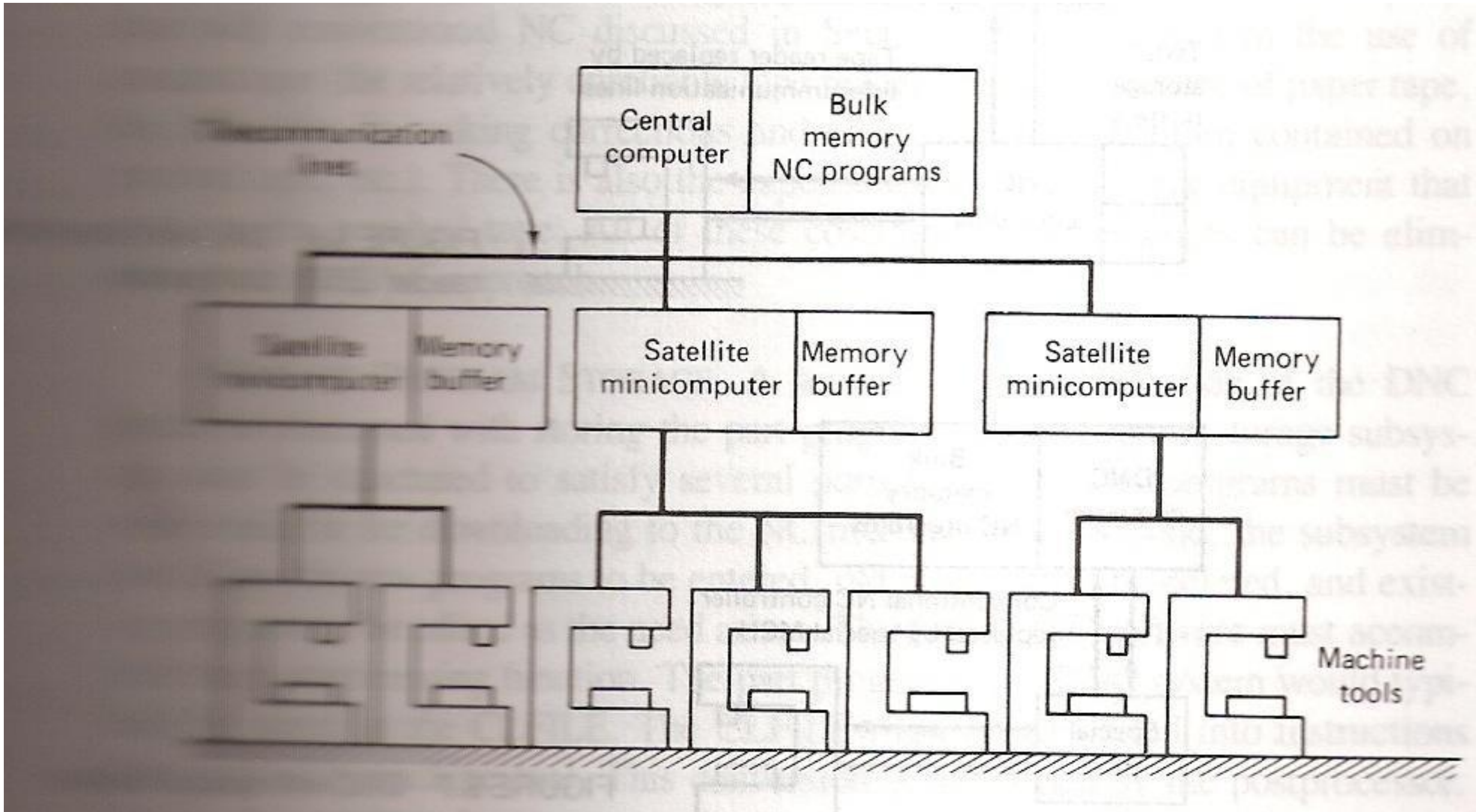
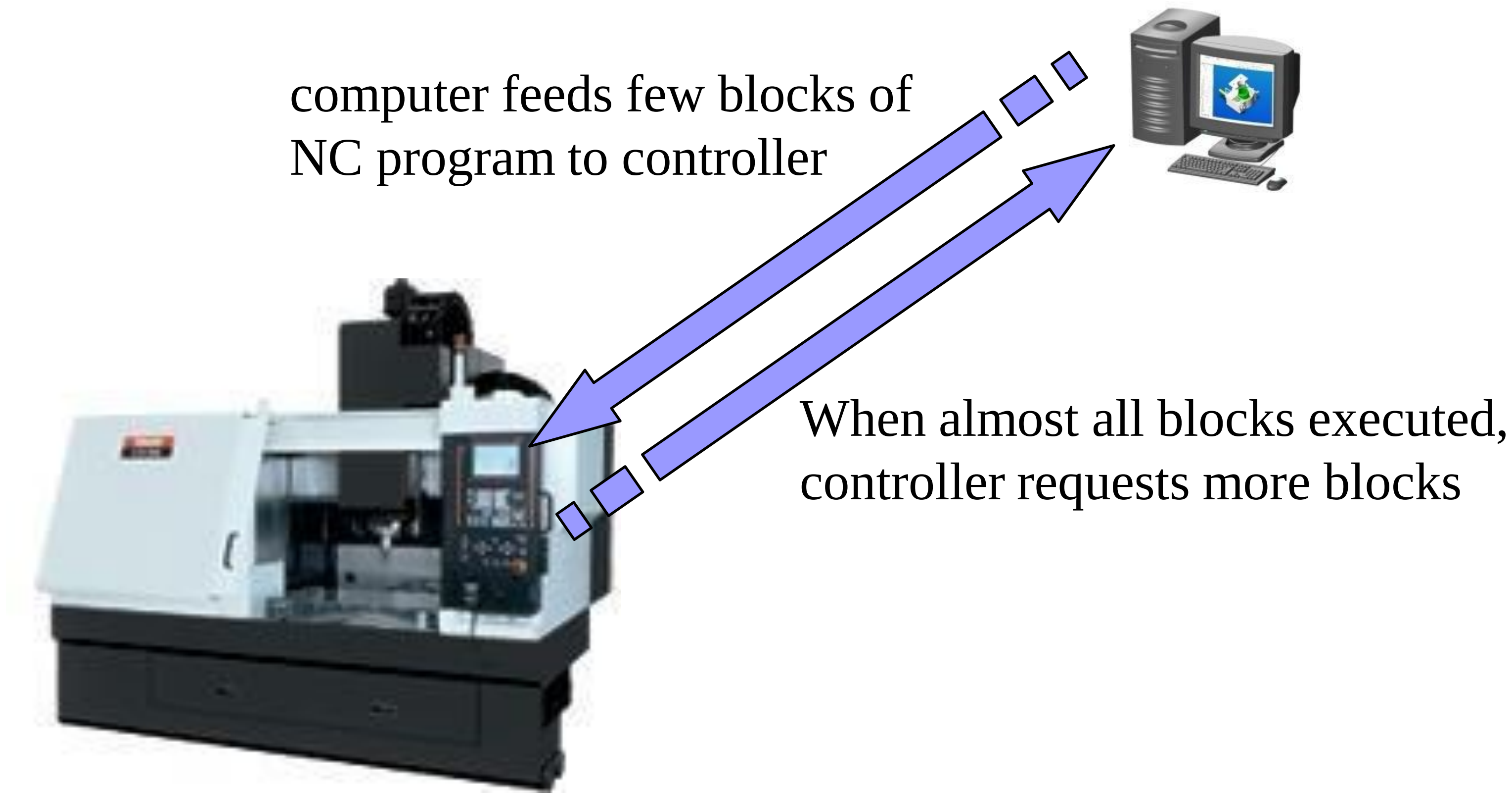


FIGURE 9.5 DNC with satellite minicomputers.

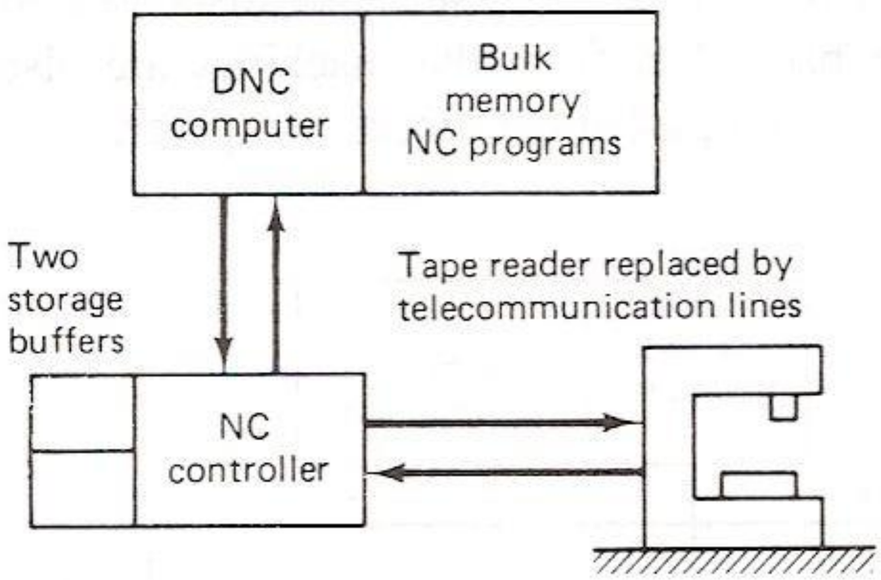
DNC – DRIP FEEDING

Very complex part shapes very large NC program

NC controller memory may not handle HUGE part program

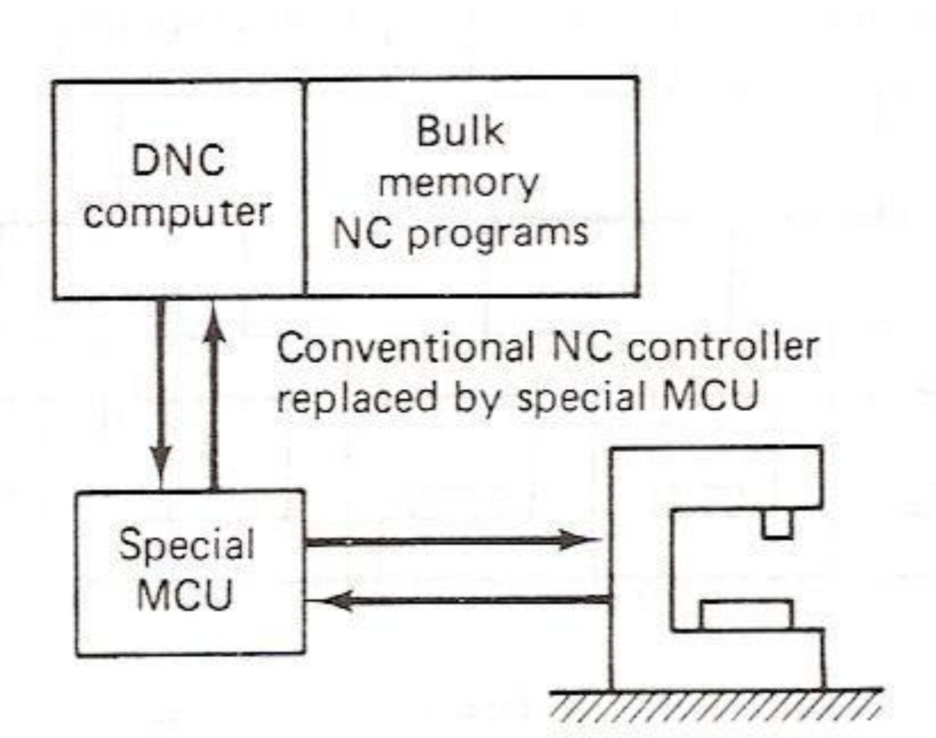


BEHIND THE TAPE READER (BTR)



- Computer is linked directly to regular NC controller unit
- The connection is made behind the tape reader
- Two temporary storage buffers
- Less cost

SPECIAL MACHINE CONTROL UNIT



- Regular NC controller is
  - replaced by special MCU
- More accuracy in circular interpolation and fast material removal rates than BTR systems
- Most CNC machines are sold with computer

NC, CNC AND DNC

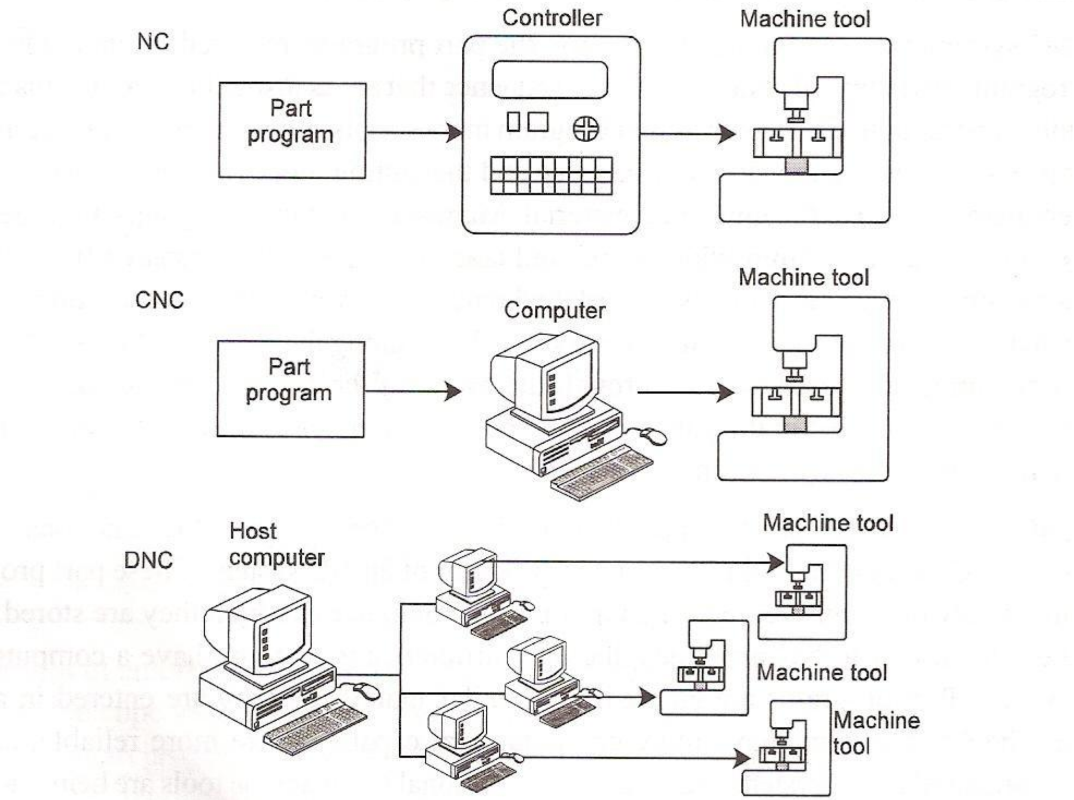


Figure 1.7: NC, CNC, and DNC Systems

FUNCTIONS OF DNC

  - NC without punched tape
  - NC part program storage
- Programs must be made available for downloading to CNC machine tools
- Part program can be uploaded after editing from CNC machine
- Entry of new programs. Editing of programs , deletion of programs
- Tool management
- Tool offsets can be downloaded in to MCU
- Postprocessor
- Data processing and management functions
- Primary storage and secondary storage
- Syntax checking and graphic proving of programs on CNC computer
- CNC can be operated directly from DNC computer
- Flexibility in shop floor scheduling
- Part program preparation
- Machinability database for calculating speed/feed

FUNCTIONS OF DNC

- Data collection, Processing and reporting
- Monitor production in the factory
- Data processing and report generation by DNC computer
- Getting the data about health of the machine in the form of sensor signals or diagnostic messages which can be used for preventive/predictive maintenance
- Metrological data in the form of dimensional acceptance
- Communications
- Central computer and machine tools
- Central computer and NC part programmer terminals
- Central computer and bulk memory, which stores the NC
- programs
- CAD system
- Shop floor control system
- Corporate data processing
- Remote maintenance diagnostics system

JUSTIFICATION OF DNC

- Interconnected CNC machines are large in number
- Very large program size. Can not be accommodated in the part program memory of MCU
- Large variety of part programs and small batch sizes
- Frequent changes in program designs

ADVANTAGES OF DNC

- Elimination of punched tape and tape reader
- Greater computational capability and flexibility
- Convenient storage of NC part programs in computer files
- Programs stored as CLFILE
- Reporting of shop performance
- Establishes the framework for evolution of future computer automated factory (CIM)
- 2-5 % increase in operational efficiency of CNC machine tools. Cost of DNC installation can be recovered quickly.

COMBINED CNC/DNC SYSTEMS

- Development of hierarchical computer systems in
  - manufacturing
- Flexibility
- Ability to gradually build the system
- More versatile and economic approach
- Distributed Numerical System
- Part program downloaded only once
- Redundancy
- Improved communication between central computer and shop floor

ADAPTIVE CONTROL

- A control system that measures certain output process variables like spindle deflection, force, torgue, cutting temperature, vibration amplitude, horse power and uses them to control speed or feed
- NC reduces non productive time in a machining operation
- AC determines proper speeds and feeds during machining as a function of variation in work piece hardness, width or depth of cut, air gaps in part geometry etc.
- Increased metal removal rate and reduced cost per volume of metal removed

WHERE TO USE ADAPTIVE CONTROL?

- In-process time consumes significant portion of the machining cycle time. (>40%)
- Significant sources of variability in the job
- Higher cost of operation of machine tool
- Work material – steel, titanium, high strengh alloys

SOURCES OF VARIABILITY IN MACHINING

- Variable depth/width of cut
- Variable workpiece hardness and variable machinability
- Variable workpiece rigidity
- Toolwear
- Air gaps during cutting

ADAPTIVE CONTROL OPTIMIZATION (ACO)

- Index of performance is a measure of overall process performance such as production rate or cost per volume of metal removed.
- Objective is to optimize the index of performance by manipulating speed or feed in the operation
- IP = MRR/TWR

  MRR – Material removal rate

  TWR – Tool wear rate
- Sensors for measuring IP not available

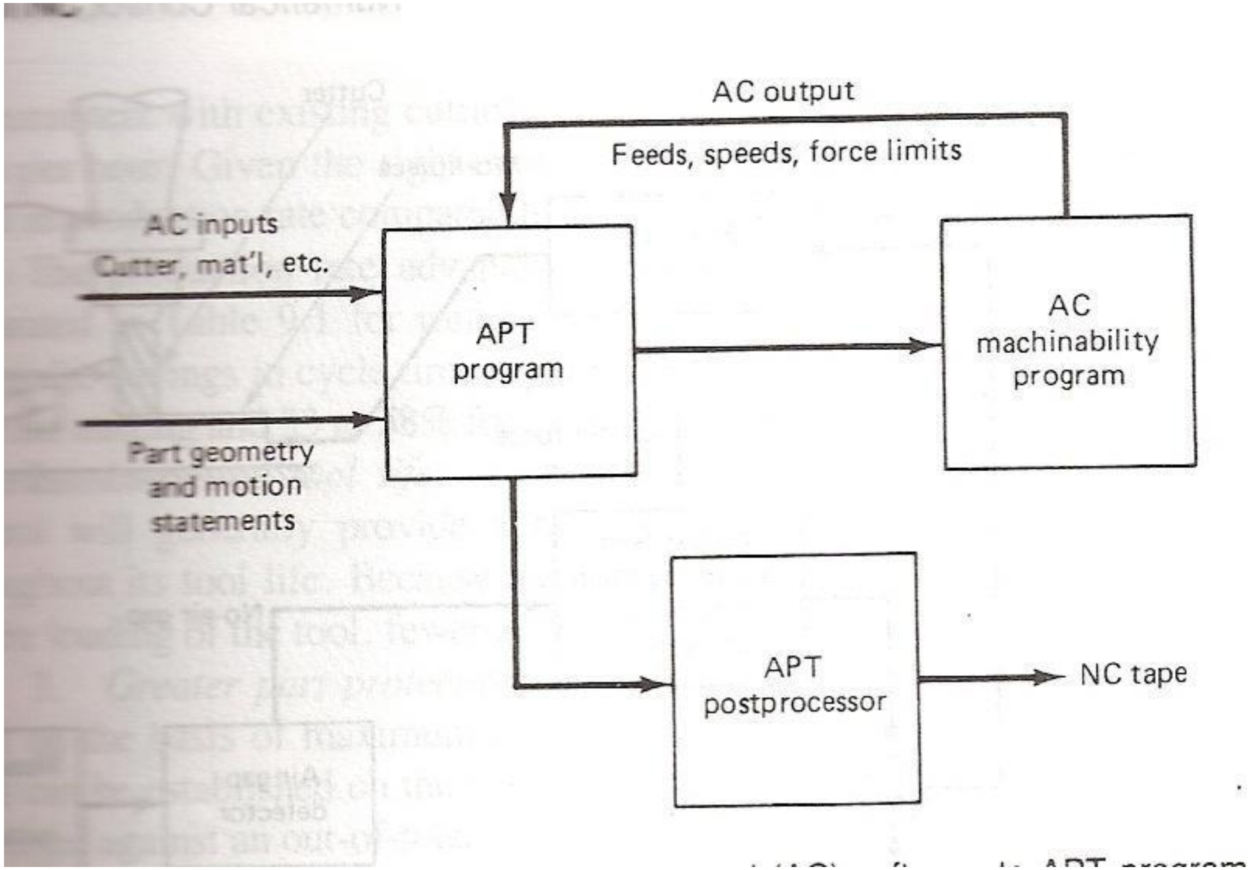
ADAPTIVE CONTROL CONSTRAINT (ACC)

- Nearly all AC systems is of this type
- Less sophisticated and less expensive than research ACO systems
- Objective is to manipulate speed or feel so that measured process variables are maintained at or below their constraint limit values.

OPERATION OF ACC SYSTEM

- Profile or contour milling on NC machine tool
- Feed is controlled variable
- Cutter force and horsepower are used as measured variables
- Hardware components
- Sensors mounted on the spindle to measure cutter force
- Sensors to measure spindle motor current
- Control unit and display panel to operate the system
- Interface hardware to connect the AC system to existing NC/CNC system

RELATIONSHIP OF AC SOFTWARE TO APT PROGRAM



OPERATION OF ACC SYSTEM DURING MACHINING PROCESS

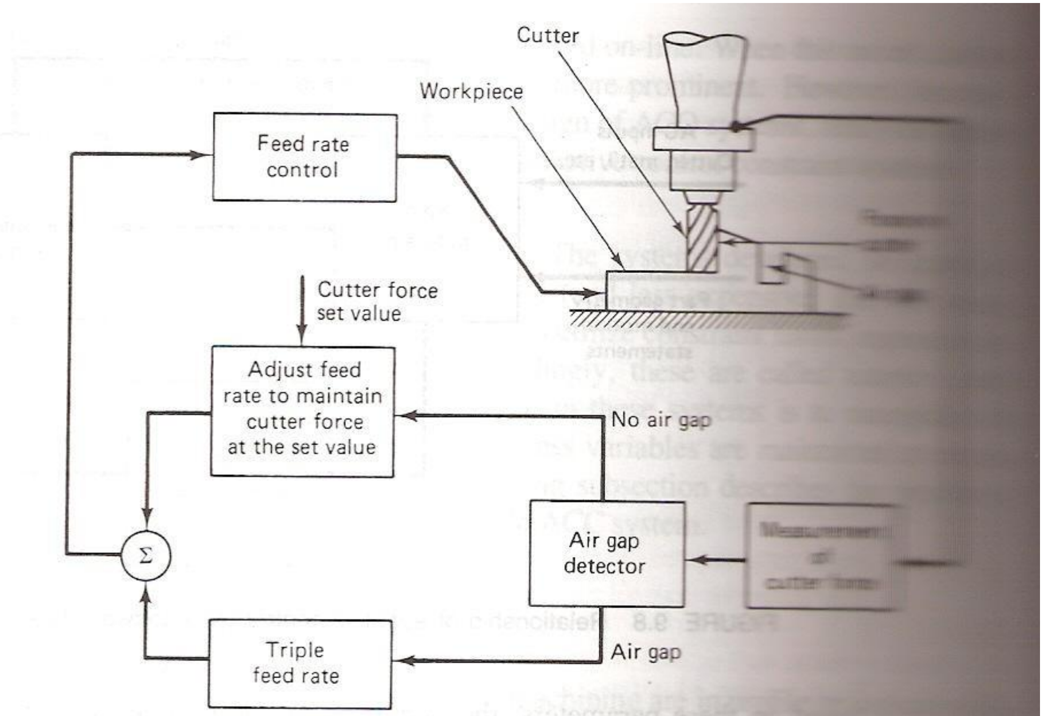


FIGURE 9.9 Configuration of typical adaptive control machining system [illegible] as the measured process variable.

BENEFITS OF AC

- Increased production rate
- Increased tool life
- Greater part protection
- Increases machine life
- Less operator intervention
- Easier part programming

WHAT IS A CNC POST PROCESSOR?

- Say you are going to manufacture a part on a mill, lathe or multi-axis machining center. To do this, you create the tool paths in your CAM system, and then you “post it.” That means you send the instructions for making your part to the post processor, an intermediary piece of software that translates the tool motions calculated by your CAM software into NC code that can be executed by your particular machine.

CONT…

- A good post is also capable of "flavoring" this information in ways that best suit your shop's workflow, data handling procedures, and most importantly, the requirements of your machine tool and control. For example, your control will expect information such as work offsets, tool offsets and canned cycles to be formatted and presented in a specific way. Examples of machine shop-specific customization might include your standards for safety blocks or required comments. The post can also generate additional outputs such as alarms or signals to equipment performing secondary operations. Some posts can be programmed to deliver functionality beyond what is currently available in your CAD system.

OPEN VS. CLOSED POST PROCESSORS

- CAM vendors offer post processors that are either open or closed. Closed post processors allow no one but authorized parties (that is, the post vendor) to customize the post. Open post processors have an architecture that allows anyone—vendors, resellers and customers—to make modifications to customize the post processor's behavior.
- The benefit of the closed approach lies in its simplicity and safety. Users get what they pay for, and ideally, the CAM software will give them everything they need in functionality and performance. If not, the vendor will create customizations for a fee.

CONT…

- Open post processors give their users more options to make this software fit their preferences and requirements. Today, there is a large community of experts who know how to develop post customizations, and they share their knowledge with each other. Open post processors provide their own layer of safety, too. Because extensive modifications can be made entirely outside the main CAM program routines, it is less likely that a user's CAM software code might be corrupted by poorly developed customizations.
- The ready availability of customization expertise means that resellers and users can be more involved in flavoring the post so that the user's preferences are realized sooner. In addition, users with the right expertise can continue to make modifications as needed so that the post's contribution to quality and productivity may increase substantially over the years.
- As a software engineer deeply involved in the development of open post processors, I will keep my observations mainly to that arena.

VARIETY OF POST PROCESSOR USERS

- The first customers for new posts are the machine tool builders. When a new machine tool is being developed, leading CAM software developers work closely with the machine builder and controller suppliers to develop an initial "generic" post that satisfies a majority of output requirements for the new machine tool. The typical CAM software developer is likely to have relationships with many machine tool vendors. These relationships enable the software developer to create and test posts on new machine tools. Mastercam, for example, works with nearly a hundred machine tool companies.
- These generic posts can be used as written, with little (if any) customization, to put the new machine tools through initial testing by shops that are early adopters. There has to be enough functionality in the generic post so that the new users can operate the equipment productively. However, flavoring of the post should be kept to a minimum at this point. Otherwise, some customers may be satisfied, while others may find the post totally contrary to the way they structure their CNC manufacturing workflow. This approach enables the final configuration to be tailored closely to the specific needs of each end user.

CONT…

- End users generally fall into one of three categories. A great many will find that the generic post (with or without some minor modifications by the reseller) meets their needs. Others will need some specific customization, which could be minimal or extensive. In most cases, the cost of customization will only be a small fraction of what it would take to develop a completely custom post, because a generic version that already covers all or most of the end user's requirements is likely to be the starting point.
- The third type of end user includes CNC programmers and machine operators who have learned to go into the post and change lines of code to change its functionality. For example, most machinists who need to make a minor variation on a part that has already been programmed will simply modify the G and M code at the machine. However, if such part variations are made frequently, then it is far more efficient to edit the post processor to generate the code automatically by prompting for some dimensional variables.

FUNCTIONALITY OF POST PROCESSORS

- Additional functionality for their equipment even when the desired routines are not supported in the CAM system itself, as these two examples show:
- **Canned Pocket Cycles:** Many CAM packages have canned drilling cycles but few have canned pocketing. This is not a problem if you have an open post. You can customize the post to take data from a CAM drilling cycle and output a canned pocket routine instead.
- **Programming Robots:** Although Mastercam does not support robots, enough data is available in the CAD file to drive one. The developers of RobotMaster (Jabez Technologies Inc.) grasped this fact and used the Mastercam post processor to create a specialized module to drive a wide variety of six-axis robots. Robot trajectories are programmed graphically within the CAM package. Then the RobotMaster module uses the CAM software's machine definitions to define the outputs for particular robots.
- The lesson here is simple: If the requisite data is in the CAD file, you can use a good CAM system and an open post processor to program a CNC machine to its full capability.

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UNIT 5

COMPUTER – AIDED PROCESS PLANNING (CAPP)

CO3: To understand about tooling of CNC machines

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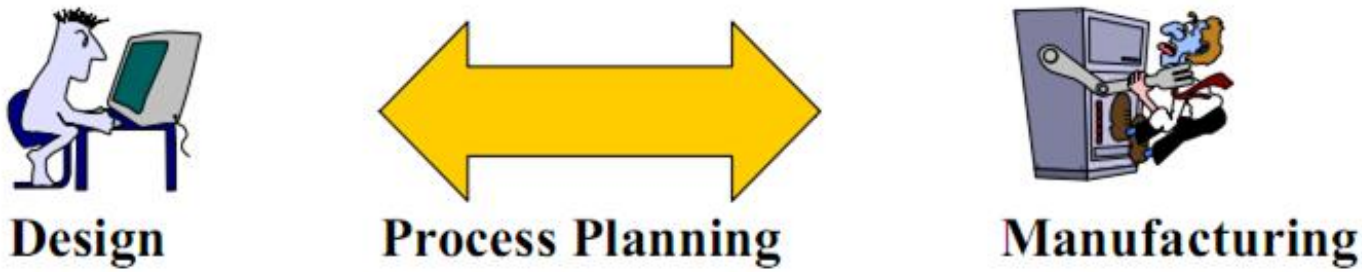
WHAT IS CAPP

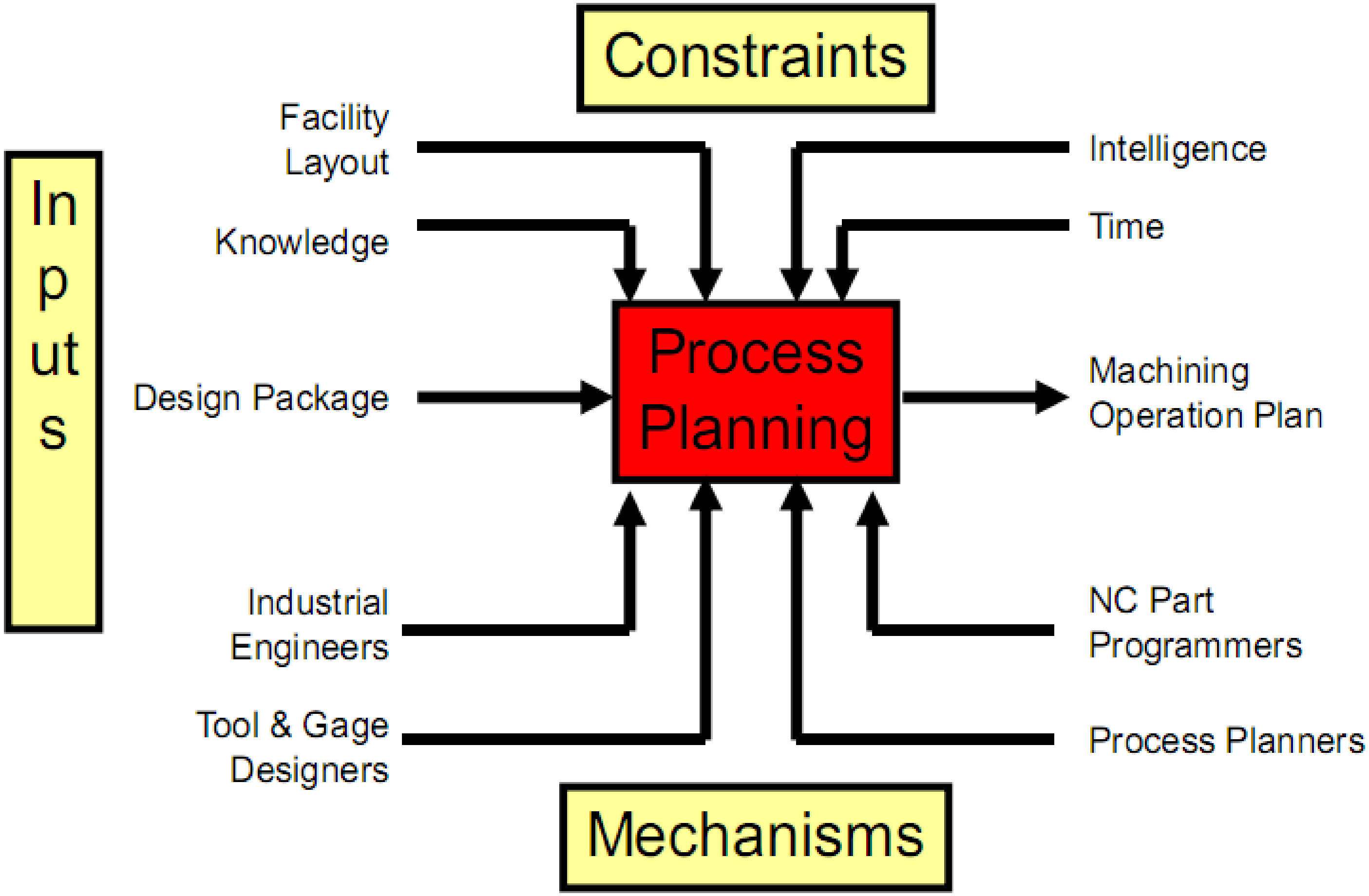


Process planning acts as a bridge between design and manufacturing by translating design specifications into manufacturing process details

PROCESS PLAN

- Refers to a set of instructions that are used to make a component or a part so that the design specifications are met
- Determines how a component will be manufactured
- Is a major determinant of manufacturing cost and profitability of products

PROCESS PLANNING



BASIC PROCESS IN DEVELOPING A PROCESS PLAN

1. Analysis of part requirements
2. Selection of raw workpiece
3. Determining manufacturing operations and their sequence
4. Selection of machine tools
5. Selection of tools, work-holding devices, and inspection equipment
6. Determining machining conditions (cutting speed, feed, depth of cut) and manufacturing times (setup time, processing time, and lead times)

PROCESS PLANNING APPROACHES

- Manual Systems
- Computer Aids
  - Variant System
  - Experimental Generative System

MANUALLY PREPARED PROCESS PLANS

- A skilled individual examines a part drawing to develop the necessary instructions for the process plan
- Requires knowledge of the manufacturing capabilities of the factory (many times undocumented)
  - Machine and process capabilities, tooling, materials, standard practices, and associated costs
- Widely used, time consuming, plans developed over a period of time may not be consistent nor objective
- Excessive time and cost may be required to develop necessary skills for successful planners

COMPUTER AIDS

- "Computer-aided" is a key factor in the integration of CAD and CAM
- The use of computers in process planning can:
  - Systematically produce accurate and consistent process plans
  - Reduce the cost and lead time of process planning
  - Reduce skill requirements of process planners
  - Increase productivity of process planners
  - Interface application programs such as work standards, cost estimation, and lead time estimation
  - Consistently optimize process routings
  - Reduce preproduction lead times
  - Increase responsiveness to engineering changes

VARIANT (RETRIEVAL) CAPP METHODOLOGY

- Recall, identify, and retrieve and existing plan for a similar part and make necessary modifications
- Interactive environment between the planner and the computer
- Process planning for a new part starts with coding and classifying the part into a similar family
- Requires the establishment and maintaining of a database of standard process plans that contains operations, tools, notes, etc.
- Requires recall and editing capability

VARIANT CAPP

New Part

Process Plans on File

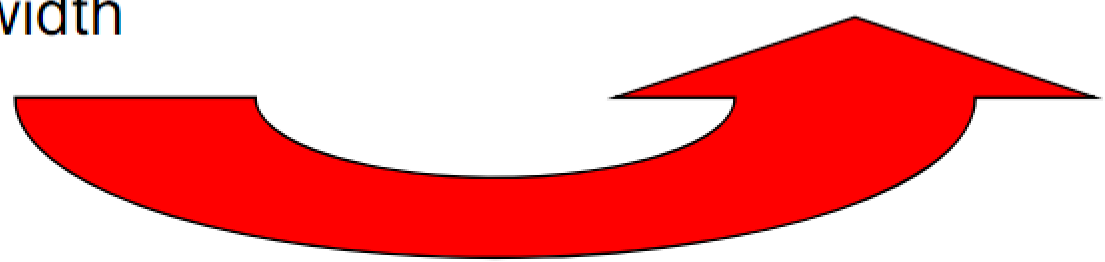
VARIANT CAPP

Modify:

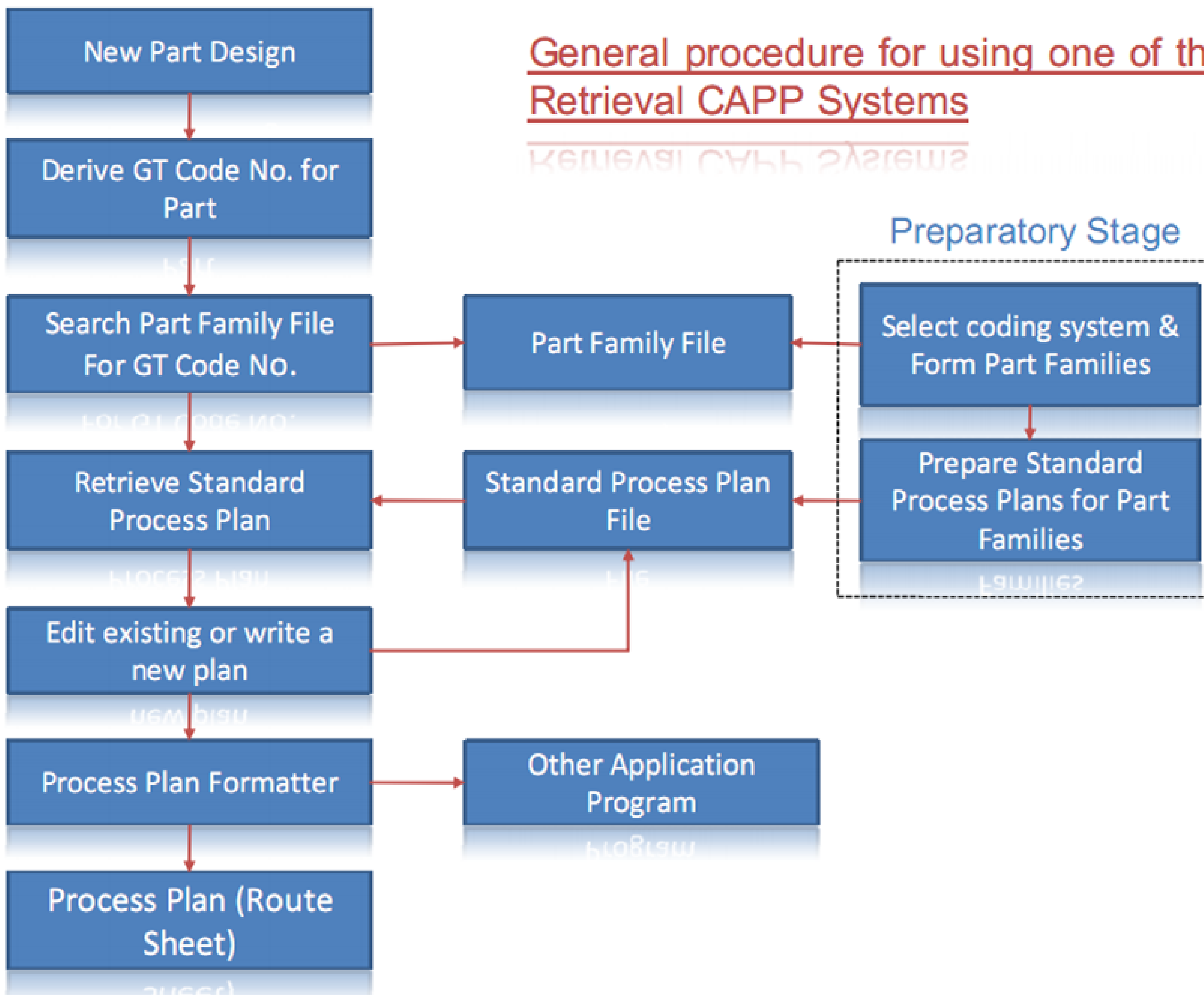
Remove slot operations

Change width

File:



General procedure for using one of the Retrieval CAPP Systems



VARIANT CAPP

- **Advantages:**
  - Efficient processing and evaluation of complicated activities and decisions
  - Standardized procedures
  - Lower development and hardware costs
  - Shorter development times
- **Disadvantages:**
  - Inconsistency in editing
  - Quality is dependent on knowledge and skill of planner
  - Optimization of variables such as material, geometry, size, precision, quality, alternative processing sequences, and machine loading is difficult

GENERATIVE CAPP METHODOLOGY

- Process plans are automatically generated by means of decision logic, formulae, technology algorithms, and textual and geometry-based data
- Truly universal system not yet developed
- There are essentially two major components
  - Geometry-based -- define all geometric features for all process related surfaces together with feature dimensions, locations, and tolerances and the surface finish desired on the features.
  - Knowledge-based -- the automatic matching of part geometry requirements with the manufacturing capabilities using process knowledge in the form of decision logic and data.

KNOWLEDGE BASED PROCESS PLANNING

- Knowledge-based; Artificial Intelligence; Expert System; Rule-based…
- “Mimic the decision-making process of a human expert”
- Experience ➔ Knowledge
- Human experts “learns” ➔ How about software?
- Knowledge Representation:

  IF <CONDITIONS> THEN <ACTION>

DECISION TABLES

- A table of rows and columns, separated into four quadrants
  - Conditions
  - Condition alternatives
  - Actions to be taken
  - Rules for executing the actions

FIGURE BELOW IS THE STANDARD FORMAT USED FOR PRESENTING A DECISION TABLE

Conditions and Actions	Rules
Conditions	Condition Alternatives
Actions	Action Entries

DEVELOPING DECISION TABLES

- Determine conditions that affect the decision
- Determine possible actions that can be taken
- Determine condition alternatives for each condition
- Calculate the maximum number of columns in the decision table
- Fill in the condition alternatives
- Complete table by inserting an X where rules suggest actions
- Combine rules where it is apparent
- Check for impossible situations
- Rearrange to make more understandable

FIGURE BELOW CONSTRUCTING A DECISION TABLE FOR DECIDING WHICH CATALOG TO SEND TO CUSTOMERS WHO ORDER ONLY FROM SELECTED CATALOGS

Conditions and Actions	Rules 1	2	3	4	5	6	7	8
Customer ordered from Fall catalog.	Y	Y	Y	Y	N	N	N	N
Customer ordered from Christmas catalog.	Y	Y	N	N	Y	Y	N	N
Customer ordered from specialty catalog.	Y	N	Y	N	Y	N	Y	N
Send out this years Christm as catalog.		X		X		X		X
Send out specialty catalog.			X				X	
Send out both catalogs.	X				X			

CHECKING FOR COMPLETENESS AND ACCURACY

- Four main problems
  - Incompleteness
  - Impossible situations
  - Contradictions
  - Redundancy

CHECKING THE DECISION TABLE FOR INADVERTENT CONTRADICTIONS AND REDUNDANCY IS IMPORTANT

Conditions and Actions	Rules 1	2	3	4	5	6	7
Condition 1	Y	Y	Y	Y	Y	N	N
Condition 2	Y	Y	Y	N	N	Y	N
Condition 3	—	N	—	—	—	N	Y
Action 1	X			X	X		
Action 2			X			X	
Action 3		X					X

Contradiction (rules 1, 2, 3)

Redundancy (rules 4, 5)

Example

- Construct a decision table for the weekend decision that can be described as following:
  - "If it is raining, I will go to the arcade and play video games"
  - "If it is not raining and hot, I will go to the beach"
  - "If it is not raining and cool, I will go on a picnic with a friend"

	Rule 1	Rule 2	Rule 3
Raining	T	F	F
Hot		T	F
Go to the arcade	X		
Go to beach		X	
Go to picnic			X

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TYPES OF DECISION TABLE

- Limited-entry decision tables:
  - The condition stub/tag specifies the conditions (the value of the input variable(s))
  - Condition entries can be only T, F, or do not care

	R 1	R 2
Temp $\geq$ 25	T	F
Go to beach	X	
Go to picnic		X

- Extended-entry decision tables:
  - The condition stub/tag specifies the identification of the condition, but not the value.
  - The values are specified in the condition entries

	R 1	R 2
Temp (c)	$\geq$ 25	< 25
Go to beach	X	
Go to picnic		X

- Mixed-entry decision tables:
  - Sequenced as well as unsequenced actions can be identified using mixed-entry decision tables

	R 1	R 2
Temp (c)	$\geq$ 25	< 25
Go to beach	1	
Go to picnic	2	X

Main Considerations in Decision Tables – Construction

- Size
  - If a decision table requires several pages of print, it is difficult to read and interpret
  - A "large" decision table in a computer not only requires excessive memory, but also reduces the efficiency of the decision-making process
- To reduce the size of the table:
  - Merge those rules with a common action and only one different condition. The merged rule has a "do not care" in that different condition entry

	A	B	C
Condition 1	T		F
Condition 2		F	
Condition 3	F	T	F
Condition 4	F	T	F
Action 1	X		X
Action 2		X	
Action 3		X	

Merge A, C →

	A'	B
Condition 1		
Condition 2		F
Condition 3	F	T
Condition 4	F	T
Action 1	X	
Action 2		X
Action 3		X

Main Considerations in Decision Tables Construction

- To reduce the size of the table:
  - If the table is still too large, it can be split; decision-table parsing can be used to connect the separate tables

	A	B	C	D	E
Condition 1	T	T	F	F	F
Condition 2	F	T			
Condition 3			T	F	F
Condition 4				T	F
Action 1	X		X		
Action 2		X	X		X
Action 3				X	X

Split
(A,B) (C,D,E)

Condition 1	T	F
Table 1	X	
Table 2		X

	A	B
Condition 2	F	T
Action 1	X	
Action 2		X

	C	D	E
Condition 3	T	F	F
Condition 4		T	F
Action 1	X		
Action 2	X		X
Action 3		X	X

THANK YOU

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