ME8451 – MANUFACTURIMG TECHNOLOGY - II

COURSE NOTES

UNIT-I

THEORY OF METAL CUTTING

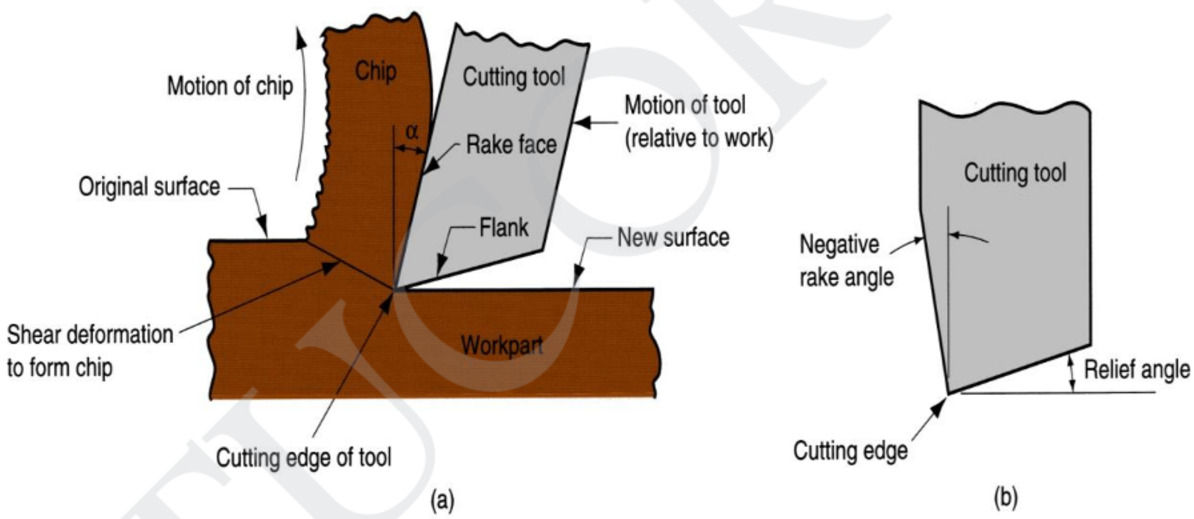
INTRODUCTION

- Components are made into various shapes and sizes by using metals.
- Depending the types of tools and operations.
- During the metal removal process, various forces act on the cutting tool and work piece.

METAL REMOVING PROCESS

- Non-cutting process (or) Chipless process
- Forging, Drawing, Spinning, Rolling, Extruding
- Cutting process (or) Chip process
- Turning, Drilling, Milling, Planer, Shaping

MECHANISM OF METAL CUTTING



MECHANISM OF CHIP FORMATION

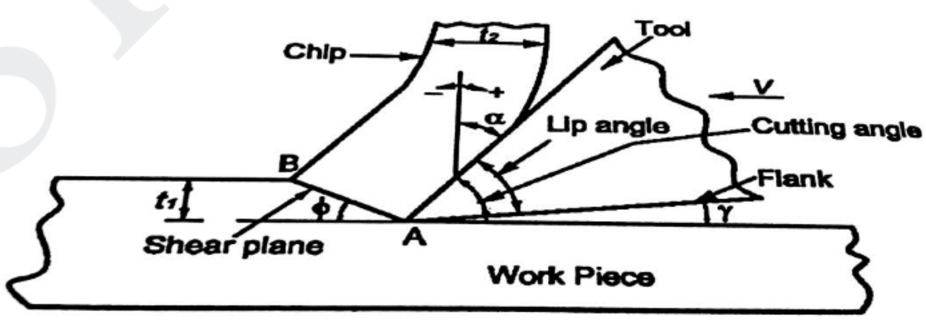
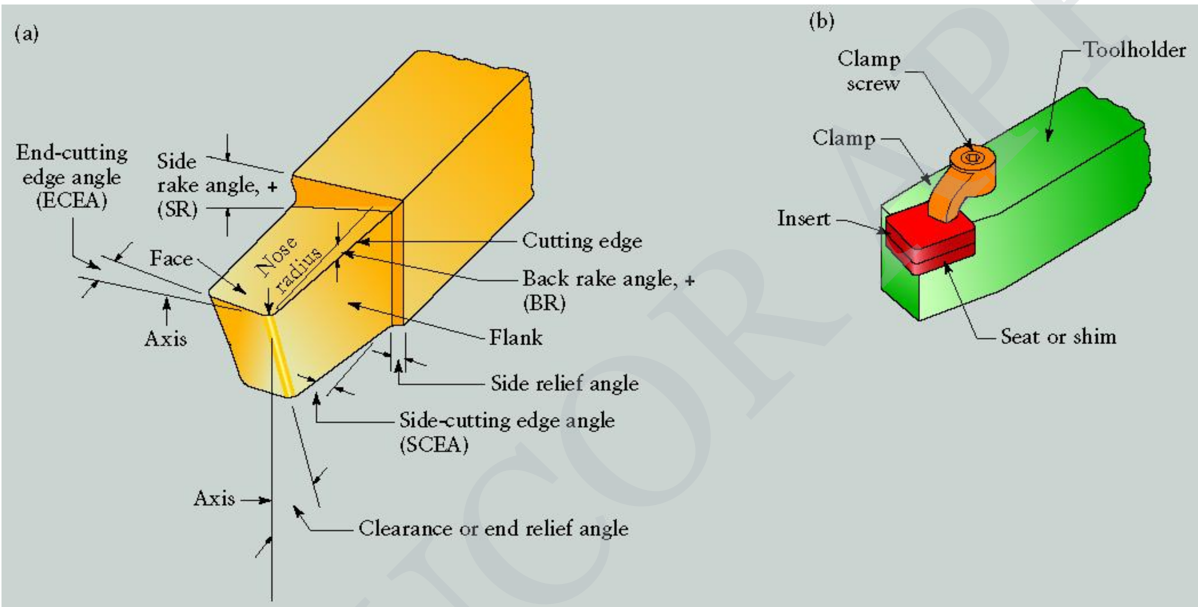


Figure 1.1 Mechanism of metal cutting

- The type of chip formed during metal cutting depends upon the machining condition and material to be cut.
- The following variables are influencing in producing the type of chip such as
- Mechanical properties of material to be cut in particular ductility and brittleness.

- Depth of cut
- Various angles of tool especially rake angle
- Cutting speed
- Feed rate
- Type of cutting fluid
- Surface finish required on work piece

SINGLE POINT CUTTING TOOL

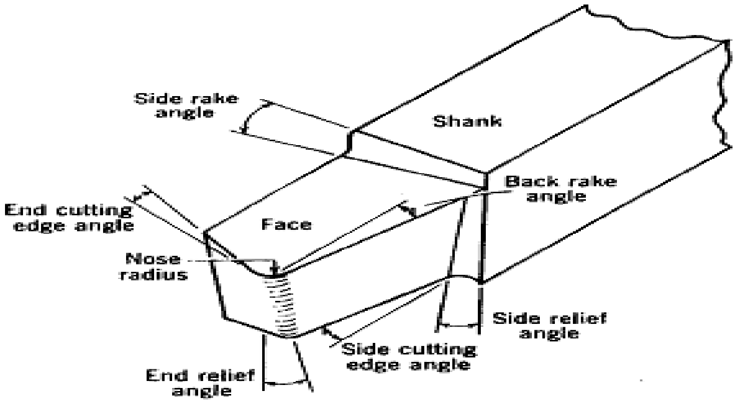


NOMENCLATURE OF SINGLE POINT CUTTING TOOL

- Parts of a single point cutting tool
- Angles of single point cutting tool
- Effects of Back rake angle
- Effects of Side rake angle

PARTS OF A SINGLE POINT CUTTING TOOL

- Shank
- Face
- Flank
- Base
- Nose



ANGLES OF SINGLE POINT CUTTING TOOL

- Rake angle
- Back rake angle
- Side rake angle
- Relief angle (or) clearance angle
- End relief angle
- Side relief angle
- Cutting edge angle
- End cutting edge
- Side cutting edge
- Nose radius

TOOL SIGNATURE

- Tool angles given in a definite pattern is called tool signature. The tool angle have been standardized by the American Standards Association (ASA).
- Back rake angle
- Side rake angle
- End relief angle
- Side relief angle
- End cutting edge angle

- Side cutting edge angle
- Nose radius

TYPES OF CHIP FORMATION

- Continuous chip
- Discontinuous chip
- Continuous chip with built-up edge

Continuous chip

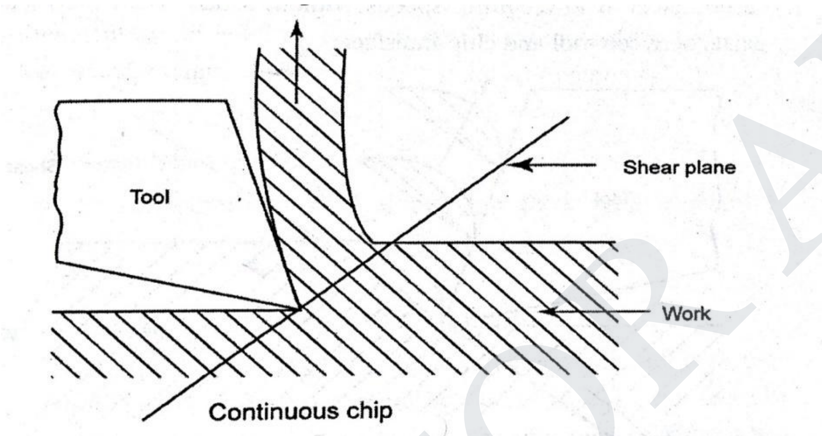


Figure 1.8 Continuous chip

Discontinuous chip

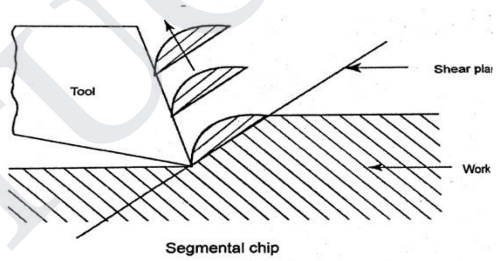


Figure 1.9 Discontinuous chip

Continuous chip with built-up edge

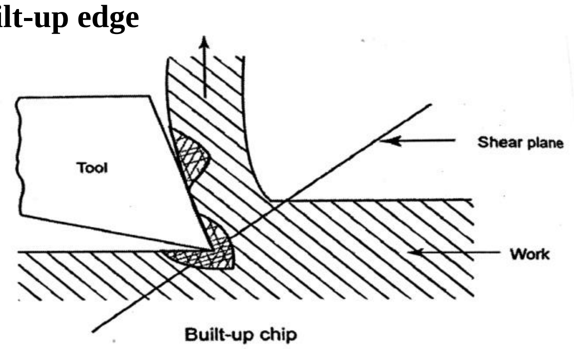


Figure 1.10 Continuous chip with built-up edge

TYPES OF METAL CUTTING PROCESS

- Orthogonal cutting process (Two – dimensional cutting)
- Cutting edge of the tool is perpendicular to the cutting velocity vector.
- Oblique cutting process (Three dimensional cutting)
- Cutting edge is inclined at an acute angle with the normal to the cutting velocity vector.

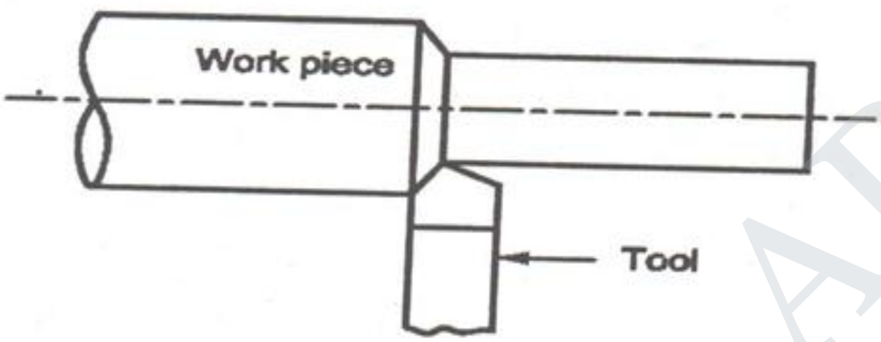


Figure 1.14 Oblique cutting

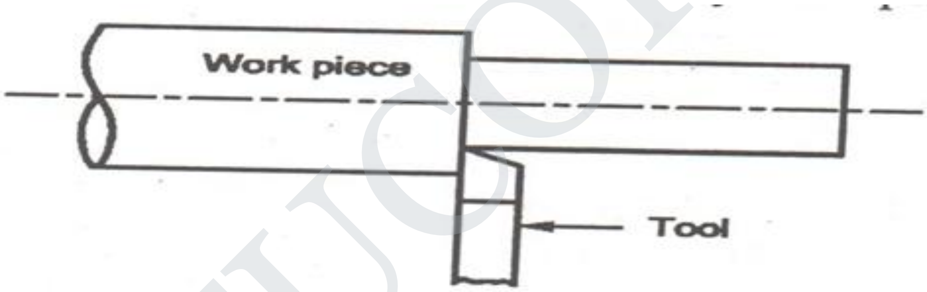


Figure 1.13 Orthogonal cutting

TOOL WEAR

- **Attrition**

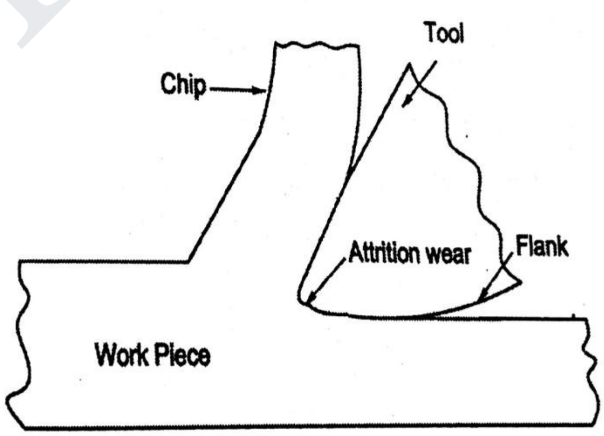


Figure 1.41 Attrition wear

- **Diffusion**

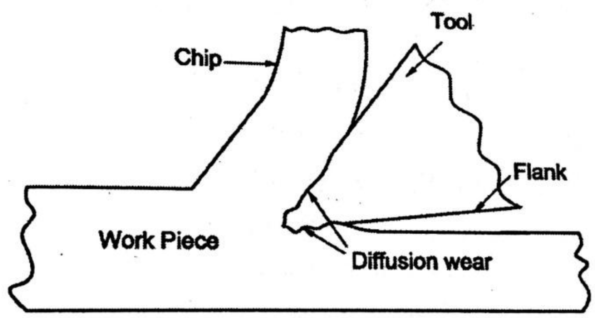


Figure 1.42 Diffusion wear

CLASSIFICATION OF TOOL WEAR

- Flank wear
- Feed < 0.15 mm/revolution
- Crater wear
- Nose wear

TOOL LIFE

- Tool life is defined as the cutting time required for reaching a tool life criterion or time elapsed between two consecutive tool resharpening.
- The following are some of ways of expressing tool life.
  - Volume of metal removed per grind
  - Number of work pieces machined per grind
  - Time unit

FACTORS AFFECTING TOOL LIFE

- Cutting speed
- Feed and depth of cut
- Tool geometry
- Tool material
- Cutting fluid
- Work material
- Rigidity of work, tool and machine

FUNCTIONS OF CUTTING FLUIDS

- It prevents the work piece from excessive thermal distortion
- It improves the surface finish
- It causes the chips to break up into small parts. It protects the finished surface from corrosion.
- It washes away the chip from the tool.
- It prevents the corrosion of work and machine.

Types of cutting fluids

- Basically two main type of cutting fluids
    - Water based cutting fluids
    - Straight (or) heat oil based cutting fluids

Methods of applying cutting fluids

- Cutting fluids are used in many ways such as
- Drop by drop under gravity
- Flood under gravity
- Form of liquid jet
- Atomised form with compressed air
- Through centrifugal action

MACHINABILITY

- Machinability is defined as the ease with which a material can be satisfactorily machined. It can also be defined as follows
    - The life of tool before tool failure
    - The quantity of the machined surface
    - The power consumption per unit volume of material removed.

Variables affecting machinability

- Work variables
- Tool variables
- Machine variables
- Cutting conditions

Evaluation of machinability

- Tool life per grind
- Rate of metal removal per tool grind
- Surface finish
- Dimensional stability of the finished work
- Chip hardness
- Shape and size of chips

SHEAR STRAIN

$$\text{Shear strain, } e = \frac{\Delta s}{\Delta t} = \frac{AB}{CD}$$

$$= \frac{BD}{CD} + \frac{DA}{CD} \qquad (\because AB = BD + DA)$$

$$e = \cot\beta + \tan(\beta - \alpha)$$

$$e = \cot\beta + \frac{\tan\beta - \tan\alpha}{1 + \tan\beta \tan\alpha} \qquad \text{..........(1.1)}$$

UNIT-II

TURNING MACHINES

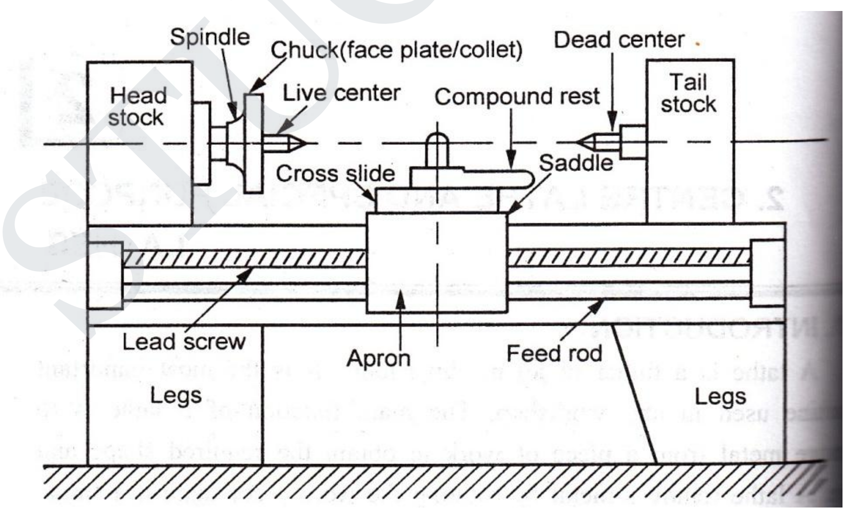
INTRODUCTION

A lathe is a father of all machine tools. It is the most important machine used in any workshop. The main function of a lathe is to remove metal from a piece of work to obtain the required shape and size. A lathe removes metal by rotating the work piece against a single point cutting tool. Generally, lathe is used to machine cylindrical shapes. The Parts to be machined can be held between two rigid supports called live and dead centers. The tool is moved perpendicular to the work piece axis to produce a flat surface. The tool is moved at an angle to the axis of work piece to produce tapered surface. The following operations can be done by using lathe: Turning, Taper turning, Eccentric turning, Chamfering, Facing, Drilling, Boring, Reaming, Tapping, Knurling, Forming, Grooving, Polishing, Spinning and Thread cutting.

CONSTRUCTIONAL FEATURES OF A CENTRELATHE

The principal parts of an engine lathe are labeled and shown in fig. Following are the principal parts of the lathe.

- ✓ Head stock
- ✓ Tailstock
- ✓ Carriage
- ✓ Feed Mechanism



SPECIFICATION OF A LATHE

- The length of bed.
- Maximum distance between dead and live centers.
- Type of bed i.e. straight, semi gap or gap type.
- The height of centers from the bed.
- Swing over the bed.
- Swing over the cross slide.
- Width of the bed.
- Spindle bore.
- Spindle speed.
- H.P. of main motor and rpm.
- Number of spindle speeds.
- Spindle nose diameter.
- Feeds.

FEED MECHANISM

Feed is defined as the movement of the tool relative to the work. There are three types of feed longitudinal, cross and angular feed.

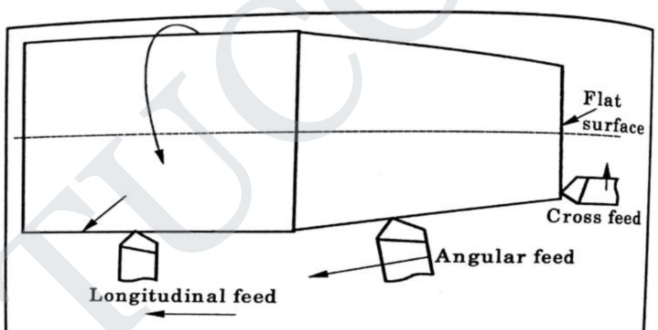


Fig. 2.13. Cross, Angular & Longitudinal Feeds

The following feed mechanisms are used

- Tumbler gear reversing mechanism
- Quick change gearbox
- Tumbler gear quick change gearbox
- Apron mechanism

TUMBLER GEAR REVERSING MECHANISM

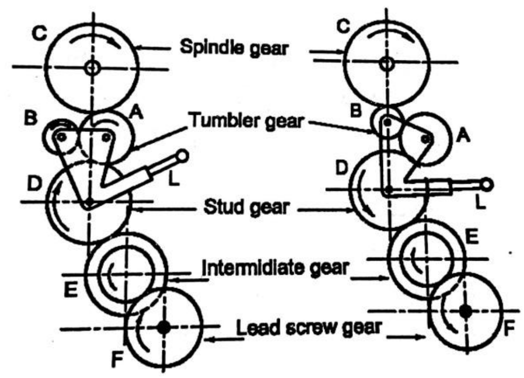


Figure 2.12 Tumbler gear reversing mechanism

QUICK CHANGE GEARBOX

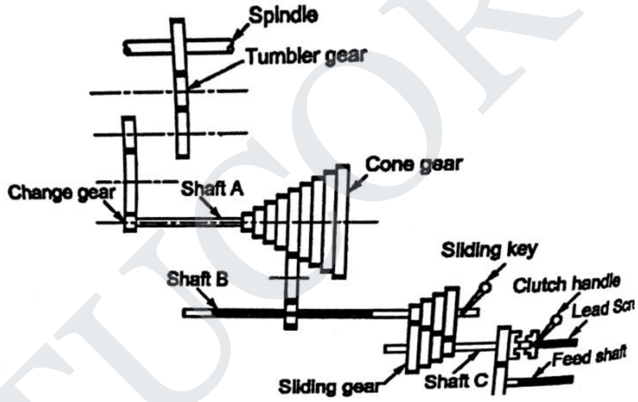


Figure 2.13 Quick change gear box

TUMBLER GEAR QUICK CHANGE GEARBOX

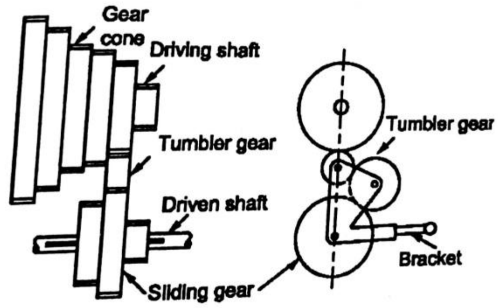


Figure 2.14 Tumbler gear-Quick change gearbox

APRON MECHANISM

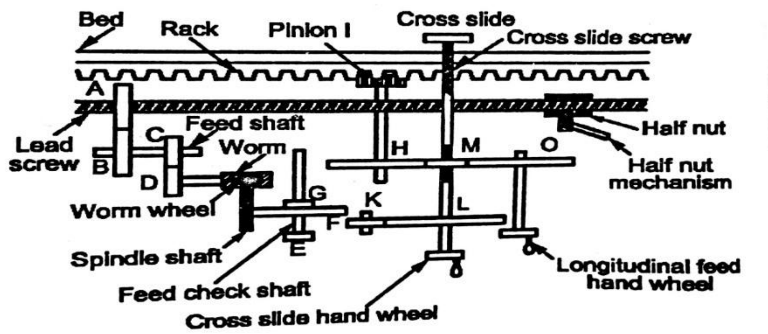
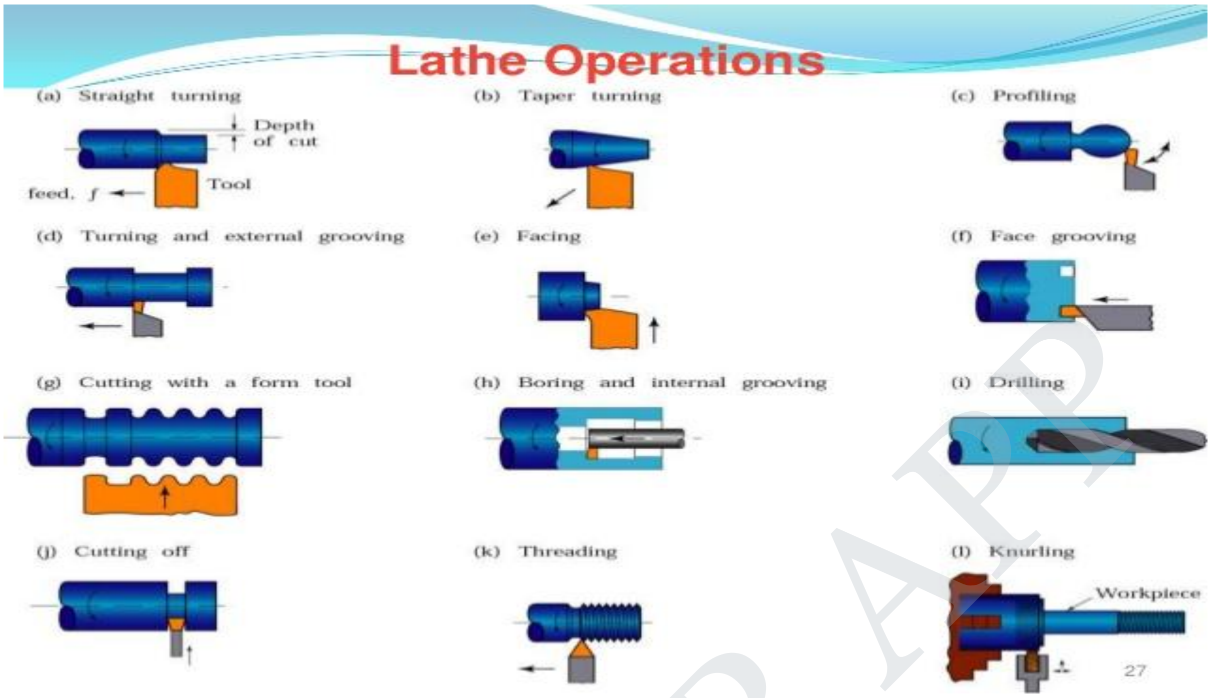


Figure 2.15 Apron mechanism

Types of lathe

- Lathes are classified in many ways with respect to size, design, method of drive and purposes.
- <u>Speed lathe</u>
  - Wood working lathe
  - Metal spinning lathe
  - Metal turning lathe
  - Polishing lathe
- <u>Engine lathe</u>
  - Step cone pulley drive lathe
  - Geared lathe
  - Variable speed lathe
- Bench lathe
- Tool room lathe
- <u>Semi automatic lathe</u>
  - Capstan lathe
  - Turret lathe
- Automatic lathe
- Special purpose lathe

LATHE OPERATIONS



TAPER TURNING METHODS

- Form tool method
- Tailstock set over method
- Compound rest method
- Taper turning attachment method

FORM TOOL METHOD

- It is one of the simplest methods to produce short taper.
- Taper length should be less than the tool cutting edge length.

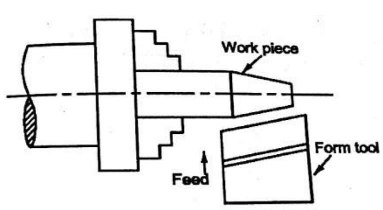


Figure 2.48 Form tool method

TAILSTOCK SET OVER METHOD

The tailstock set over is calculated by using the formula.

Set over, $h = \frac{D-d}{2l} \times L = L \tan\alpha$ [$\because$ angle is small $\sin\alpha = \tan\alpha$]

where D - Maximum diameter of the work piece

d - Minimum diameter of the work piece

l - Required length on which taper being made

L - Full length of the work piece.

If the taper is turned on entire length of the work piece, then $l = L$

$$h = \frac{D-d}{2}$$

COMPOUND REST METHOD

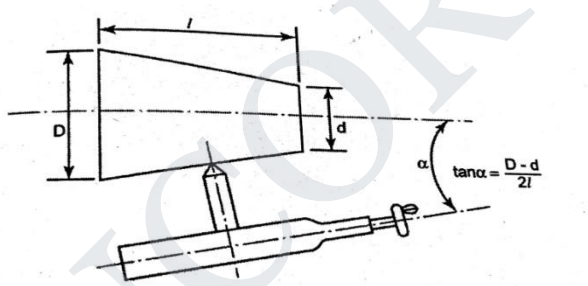


Figure 2.50 Compound rest method

TAPER TURNING ATTACHMENT METHOD

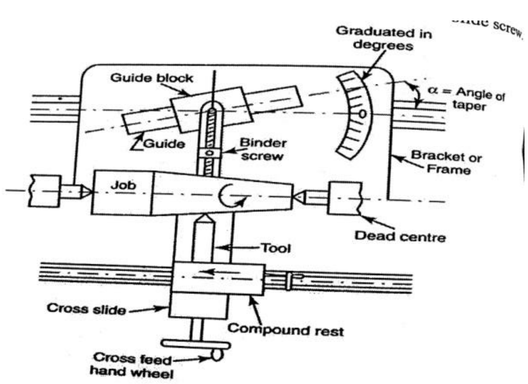


Figure 2.51 Taper turning attachment method

THREAD CUTTING METHODS

- Thread cutting is done in different methods
  - Reversing the machine
  - Marketing the lathe parts
  - Using a chasing dial or thread indicator
  - Using thread chaser

WORK HOLDING DEVICES

- Some of the standard work holding devices used to hold the work in a lathe are given below.
  - Chucks
  - Centres
  - Face plate
  - Angle plate
  - Mandrels
  - Steady and follower rest

CHUCKS

- Three jaw chuck or self centering chuck
- Four jaw chuck or independent chuck
- Magnetic chuck

Three jaw chuck or self centering chuck

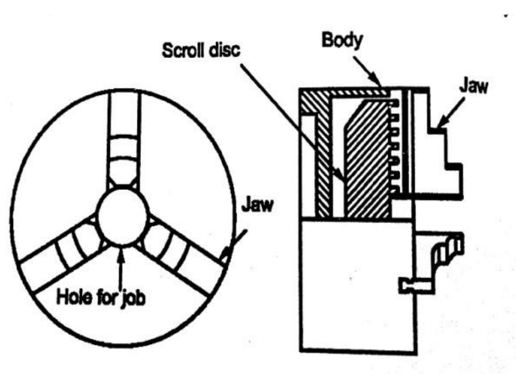


Figure 2.16 Three jaw chuck

Four jaw chuck or independent chuck

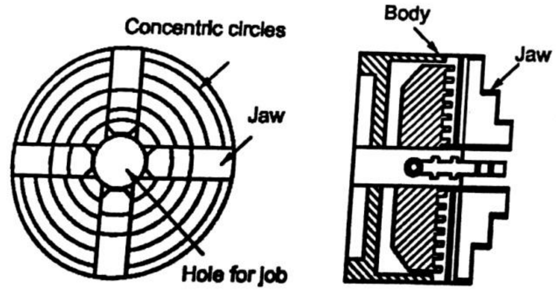


Figure 2.17 Four jaw chuck

Magnetic chuck

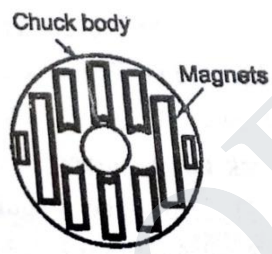


Figure 2.18 Magnetic chuck

AUTOMATIC LATHES AND SEMI AUTOMATIC LATHES

Capstan and Turret lathe

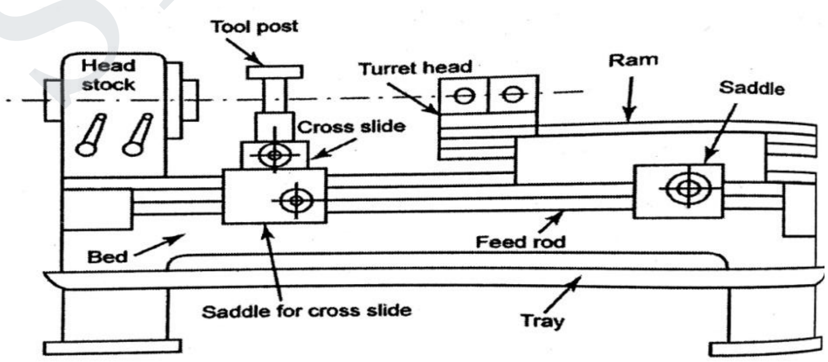


Figure 2.57 Capstan and Turret lathe

Geneva Mechanism (Or) Indexing Mechanism

The turret is provided with automatic indexing mechanism. To index the turret by 1/6 of a revolution, the ram is returned to the starting position. Then, the next tool comes into position to perform the machining operation.

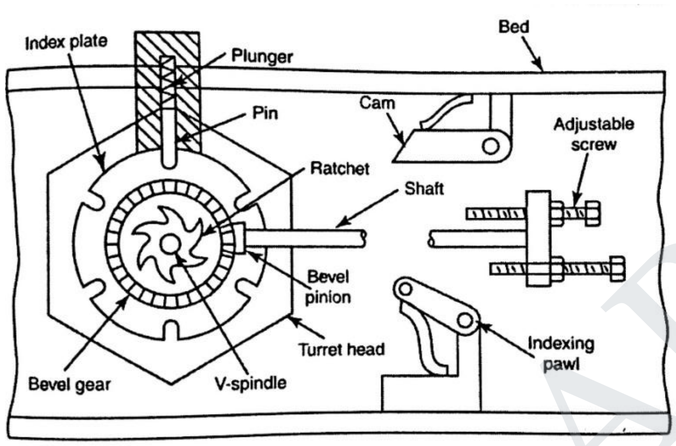


Figure 2.60 Geneva mechanism or Indexing mechanism

DIFFERENCE BETWEEN CAPSTAN LATHE AND TURRET LATHE

Sl No.	CAPSTAN LATHE	TURRET LATHE
1	Turret head is mounted on a ram which slides over the saddle	Turret head is directly mounted on saddle. But it slides on the bed
2	The turret movement is limited	The turret moves on the entire length of the bed without any restrictions
3	Hence, shorter workpiece can be machined	Longer workpiece can be machined
4	It does not provide rigidity	It provide rigidity and strong
5	It is very much useful for light duty application	It is useful for heavy duty application

6	**Turret head moved manually**	**Turret head cannot moved manually**
7	**The maximum size of 60 mm diameter work can be accommodated**	**It can accommodate only 125 mm to 220mm**

WORK HOLDING DEVICES

- The work holding devices used on capstan and turret lathes are mostly automatic types. It reduces the setting time.
    - Collets
        - Draw back collet
        - Push out collet
        - Dead length collet
    - Chucks
    - Fixture

BAR FEEDING MECHANISM

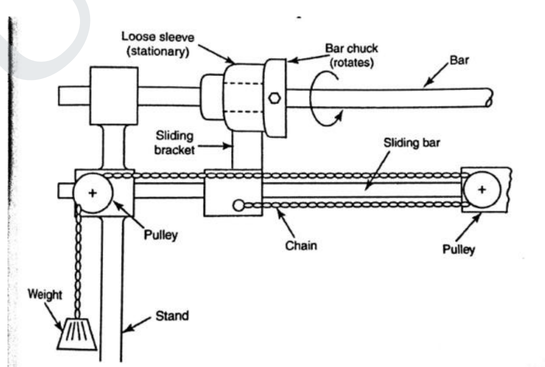


Figure 2.66 Bar feeding mechanism

TOOL HOLDING DEVICES

- To hold these tools in the respective positions, the various types of tool holders are fitted in a hexagonal turret or front tool post of the square turret or in the rear tool post.

- The following are the various types of tool holders
  - Straight cutter tool holder
  - Adjustable angle cutter tool holder
  - Multiple cutter holder
  - Offset cutter holder
  - Sliding tool holder
  - Knee tool holder
  - Flange tool holder
  - Roller steady box tool holder
  - Self opening type die holder
  - Knurling tool holder
  - Collapsible taps

TOOL LAYOUTS

- Turret and capstan lathe are mainly used for machining workpieces in rapid speed. Before starting the production, the following works are carried out.
  - Selection of tools
  - Designing of special tools
  - Selection of speeds
  - Selection of feeds
  - Setting the required length of work piece.

AUTOMATIC LATHES

- In automatic lathes, all operations required to finish off the work piece are automatically done without the attention of an operator.
- These machines are meant for producing identical parts without participation of an operator.
- All operations including loading and unloading are automatically done. By using the control system, all working and idle operations are performed in a definite sequence.

Classification of automatic lathes

- Classification according to the type of work material used

Bar stock machine

Chucking machine

- Classification according to the number of spindles

  Single spindle automats

  Multi spindle automats

- Classification according to the arrangements of spindles

  Horizontal spindle type

  Vertical spindle type

- Classification according to the feed control

  Single cam shaft rotating at constant speed

  Single cam shaft with two speeds

  Two cam shaft

- Classification according to the use

  Single purpose machine

SINGLE SPINDLE AUTOMATIC LATHES

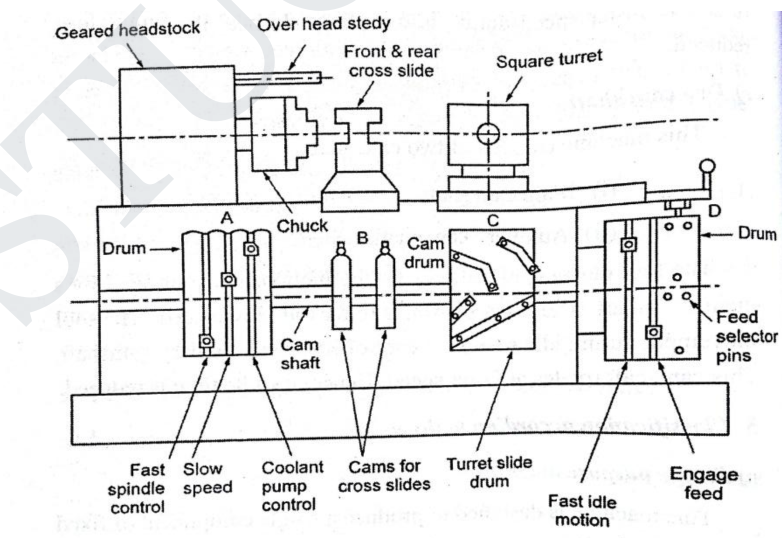


Figure 2.83 A single spindle automatic lathe

AUTOMATIC CUTTING OFF MACHINE

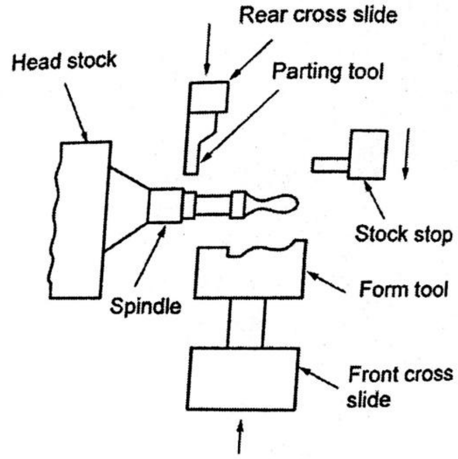


Figure 2.84 Automatic cutting off machine

Multi spindle automatic lathes

- Multiple spindle automatic lathes are machines which can produce larger work pieces than single spindle automats.
- The principle advantage of the multi spindle automat is that it has a tool slide working simultaneously on the jobs on all spindles and hence, the time for producing a piece is the time for the longest cut

General Description:

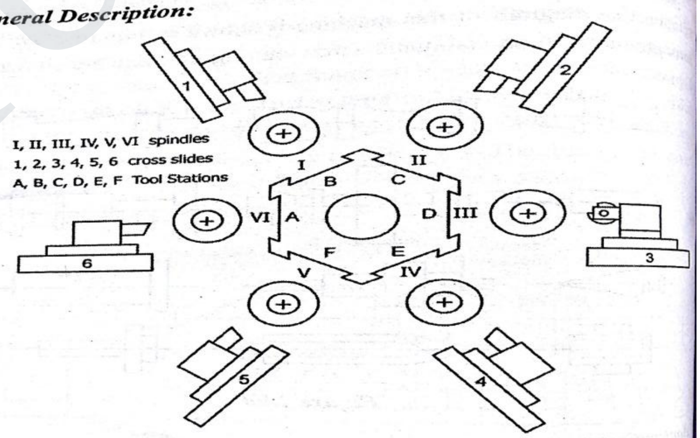


Figure 2.91 View of a six – spindle automatic lathe

Classification of multi spindle automatic lathes

- According to the type of work piece used
    - Bar type machine
    - Chucking type machine
- According to the arrangement of spindle
    - Horizontal spindle type
    - Vertical spindle type
- According to the principle of operation
    - Parallel action type
    - Progressive action type

UNIT – III

SHAPER, MILLING AND GEAR CUTTING MACHINES

SHAPER

- Shaper, planner and slotter are used for machining flat surface which may be horizontal, vertical or inclined surfaces. Single point cutting tools are mainly used in these machines.
- Drilling, grinding, boring, milling and broaching machines are not used for machining flat surfaces but they are performing specific operations by using a multi point cutting tool.

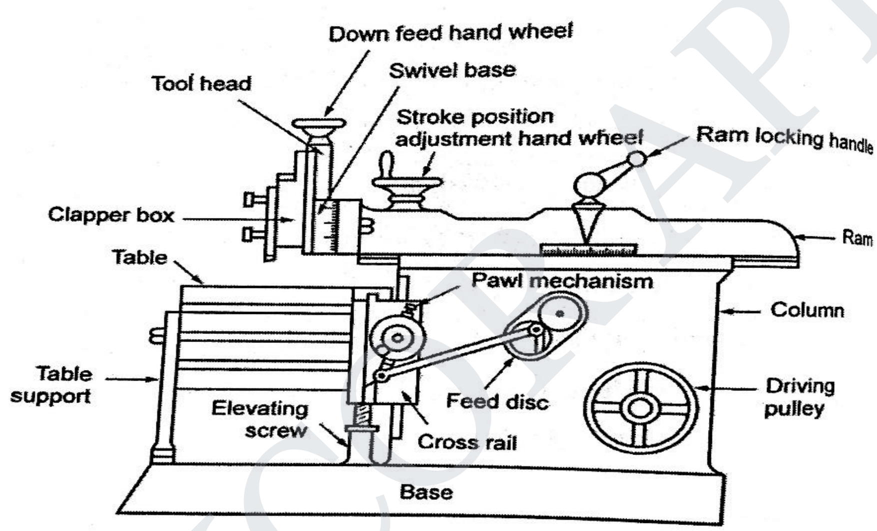


Figure 3.1 A standard shaper

Principle Of Operation

- The shaper having a reciprocating type of machine tool with single point cutting tool is used to produce flat surfaces.
- It has the three important parts such as
  - Table
  - Tool head
  - Ram

Classification Of Shaper

- According to the type of driving mechanism

  Crank drive type

  Whit worth driving mechanism

  Hydraulic drive type

- According to the position of ram
  - Horizontal shaper
  - Vertical shaper
  - Travelling head shaper
- According to the table design
  - Plain shaper
  - Universal shaper

SHAPER SPECIFICATION

- Maximum length of stroke
- Maximum crosswise movement of the table
- Maximum vertical adjustment of the table
- Type of driving mechanism
- Power of the motor
- Available speed and feed
- Type of shaper-plain or universal
- Floor space required
- Total weight of the shaper
- Ratio of cutting stroke time and return stroke time

TYPE OF QUICK RETURN MECHANISM

- The following are three types of quick return mechanism
  - Hydraulic drive
  - Crank and slotted link mechanism
  - Whit worth quick return mechanism

Hydraulic drive

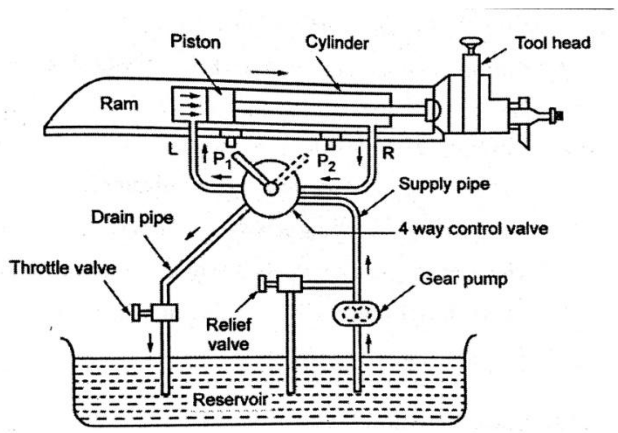


Figure 3.3 Hydraulic drive

Crank and slotted link mechanism

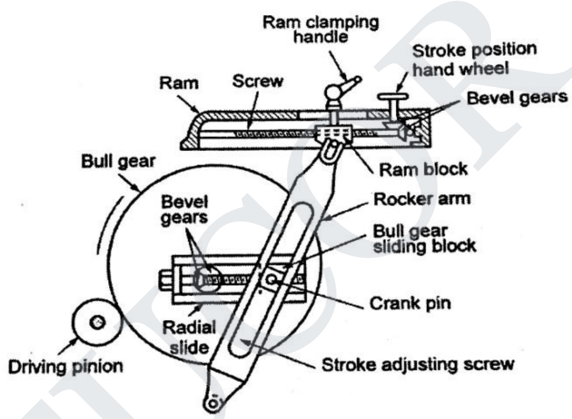


Figure 3.4 Crank and slotted lever mechanism

Whit worth quick return mechanism

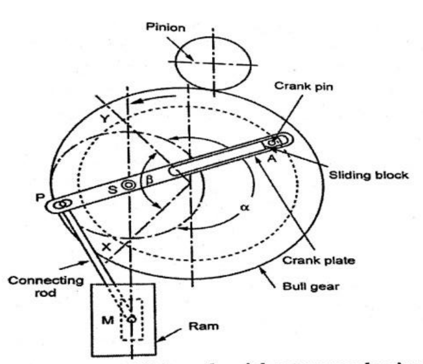


Figure 3.6. Whitworth quick return mechanism

UNIT-IV

ABRASIVE PROCESS AND BROACHING

INTRODUCTION

Grinding is a metal removing process in which the metal is removed with the help of rotating grinding wheel. Such wheels are made of fine grains of abrasive materials heldtogether by a bonding material, called a bond. These abrasive materials are having high hardness and high heat resistance. Grinding provides a very good surface finish with high accuracy. Therefore, it is used for finishing operation. This process removes comparatively little material usually from 0.25 mm to 0.5 mm.

While grinding, the wheel is rotated and the work is fed against the wheel. The abrasive grains which project on the surface of the grinding wheel moving with high velocity and shear off small metal Particle from the work piece. During machining, the blunt abrasive grains will be released from the wheel surface. In their place, new abrasive grains project from the surfaceof the wheel. This process is called self sharpening of the grindingwheel.

Grinding is mainly used for the followingpurposes:

To remove small amount of metal from work pieces and finish them to close tolerances. To obtain a better surfacefinish.

To machine hard surfaces that cannot be machined by high-speed steels.

Sharpening of cutting tools.

Grinding of threads.

Sometimes, it is used for removing bigger stocks of metals.

GRINDINGWHHELS

Grinding wheels are made up of small abrasive particles held together by bonding material. Thus, it forms a multi-edge cutter. Abrasive is a hard material. It can be used to cut or wear away other materials. Small abrasive particles are used in grinding wheels. They are called abrasive grains. Abrasives may be classified into two types.

(i) Naturalabrasives

(ii) Artificialabrasives.

Naturalabrasives

These are produced by uncontrolled forces of nature. These are obtained from mines. The following are the natural abrasives.

a) Sandstone or solidquartz.

b) Emery (50 to 60% crystalline Al203+ Ironoxide).

c) Corundum (75 to 90% crystalline *Al203* + Iron oxide) d)Diamond.

Artificialabrasives

These are manufactured under controlled conditions in closed electric furnace in order to avoid the introduction of impurities and to achieve necessary temperature for the chemical reaction to take place. These abrasives have better cutting properties and higher efficiency than natural abrasives. The various manufactured abrasives are

a) Aluminum oxide.

It is the crystalline form of aluminum oxide. This abrasive carries very hard and tough grains having sharp cutting edges. It is manufactured by fusing mineral Bauxite in an electric arc furnace mixed with coke and iron scrap. Here, iron scrap acts as a flux. After Using, it is crushed, washed and treated with alkalis. Again, it is washed and finally, ground.

(b) Siliconcarbide:

It is made from Silicon dioxide, coke, sawdust and salt. The ingredients are thoroughly mixed and heated in an electric furnace about 2000° C for 34 hrs. The mass under the action of intense heat fuses and the following chemical reaction takes place. Si

O2 + 3C = Si C + 2CO

(c) ArtificialDiamond:

Artificial diamond is a form of pure carbon which is mainly used for truing and dressing other grinding wheels for sharpening carbide tools, and for processing glass, ceramics and stone.

(d) Boron carbide(B4C):

It is harder than silicon carbide but not as hard as diamond. It is produced from coke and boric acid at tremendously high temperatures in an electric furnace. Boron carbide is mainly used for grinding and lapping very hard metals, hard alloys, glass and Jewells.

(e) Cubic boronnitride:

It is a never synthetic abrasive that is harder than either aluminum oxide or silicon oxide. It is a combination of boron and nitrogen. Boron nitride is the second hardest substance even developed by man or nature. It is used for grinding H.S.S. Cutters, grinding tool-steel, punch-press dies grinding some hard enable stainless steels and for internal grinding of all ferrous metals.

TYPES OFBONDS

Bond is an adhesive substance which holds the abrasive grains together to form the grinding wheel. The bonds must be sufficiently strong to withstand the stresses of high speed rotating grinding wheel. There are various types of bonds used and their choice depends on operating conditions of the abrasive tool such as grinding speed, pressure on the tool, heat formation in the grinding zone etc. Bonds are classified into two types.

(i) Organic

(ii) Non-organic.

Metallic, vitrified and silicate bonds are non-organic. Resinoid, rubber, shellac and oxychloride bonds are organic. The various bonding procedures are discussed below.

Vitrifiedbond

Vitrified bond is made of clay and water. The abrasive grains and Fusible clay (also called as 'felspar') are thoroughly mixed together With sufficient water to make the mixture uniform. This mixture is placed in moulds to get the shape of grinding wheel and air dried at roomtemperature.

These wheels are then fed into a kiln and allowed to remain there for few days at a temperature of about 1260°C. This process is known as fusing an d it provides for uniform distribution of the bond throughout the wheel. Then these wheels are trimmed to the required size. Vitrified bonds are used mostextensively.

Silicate bond

Silicate wheels are made by mixing abrasive grains with silicate of soda. The mixture is moulded in a mould and dried for several hours after drying; the moulded material is kept in a furnace at about 260°C for 20 to 80 hours. Silicate bonded wheels are light grey in colour

Resinoidbond

Resinoid bonding is produced by mixing abrasive grains with synthetic resins. The mixture is rolled to the desired shape and baked at a temperature of 210°C to 250°C for few hours. At this temperature, the resin sets to hold the abrasive grains in wheel form. Resinoid bonded Wheels are strong, elastic and permit high peripheral speeds but are destroyed by alkaline cooling fluids. This can be avoided by impregnating the wheel with paraffin. These wheels normally operate at surface speeds in the region of 300m/ min. They are particularly suitable for the use in grinding steel, cast iron and malleable ironcastings.

Rubberbond

The abrasive grains are mixed with liquid rubber and sulphur. The mixture is rolled into sheets of required thickness. The wheels are then cut and placed in preheated moulds and vulcanized under pressure these wheels are quite strong, close-grained and can be made in very thin sections. They are mainly used where a very high-class surface finish is primary requirement. The rubber-bonded wheels are also used as regulating wheels in centre less grinding. During the operation, Water can be safely used as a coolant but caustic soda and oil should not beused.

Shellacbond

Shellac bonded wheels are made by mixing the abrasive grains with shellac in a mixture. Then, the mixture has been rolled or pressed into desired wheel shape. They are hardened by baking for several hours at about 160°C. Shellac bo nd wheels are strong but posses some elasticity as rubber wheels. These wheels produce high surface finish and are used form grinding parts like camshafts and mill rolls. Very thin wheels are used for cutting offoperations.

Oxy chloridebond

This bond is produced by mixing abrasive grains with oxide and chloride of magnesium. This mixture is pressed into moulds and dried. It is heated in a furnace. These wheels are less brittle and less sensitive to side loads as compared to vitrified bond wheels. The type of wheel ensures a cool cutting action. So, grinding is done dry condition. These wheels are affected by acidic solutions, dampness and sudden changes in temperature. This bond is used for making disc shaped wheels. Different types of bonds used in grinding are represented by different symbol as shownbelow:

Vitrified bond	-	V
Silicatebond	-	S
Resinoidbond	-	B
Rubber bond	-	R
Shellacbond	-	E
Oxychloridebond	-	O

GRIT OR GRAINSIZE

It refers to the actual size of the abrasive particles. The grain size is denoted by the number. This number is equal to the number of meshes in *254cm* of a sieve through which the grains can pass through. Larger is the grit number, smaller will be the grain size (fine grit) and vice-versa. For rough grinding, coarse grained wheels (smaller grit number) are used. For finish grinding, fine-grained wheels (large grit number) are used. The table 4.1.shows the grain size used for course to very fine grindingoperations.

4.5 GRADE

Grade or hardness indicates the strength with which the bonding material holds the abrasive grains in the grinding wheel. It does not refer to the hardness of abrasive grains. So, the grade of the wheel has nothing to do with the hardness of the abrasive particles. The degrees of hardness are specified by the use of letters of the alphabet. 'A' indicates the softest grade where as 'Z' indicates the hardest grade. A soft graded wheel will release the abrasive particles readily. When grinding the hard metal, the abrasive grains will blunt quickly. When soft grade wheels are used here, the blunt grains are released readily. New sharp grains will project from the wheel surface. There grains will effectively cut the hard material.

Therefore, for grinding hard material, soft wheels are used. For grinding hard material, soft grade wheels are used. Different grades of grinding wheels are shown in table.

STURCTURE OFWHEELS

This term denotes the spacing between the abrasive grains or in other words thedensity of the wheel. The structure of grinding wheel is designated by a number. The higheris the number, wider will be the spacing. When the spacing is small, the structure is called dense structure. When the spacing is wide, the structure is called open structure. The numbers aregiven in ascending order from dense to wider structure. Table 4.3 indicates the two types of structure with their numbers

The Indian standards Institution (IS: 551-1954) have specified a standard system of marking the grinding wheels. According to this system, the following elements are represented in a definite order.

1. Types ofabrasives.
2. Grain size or gritnumber.
3. Grade of thewheel.
4. Structure
5. Type ofbond.
6. Manufacturer'scode.

SELECTION OF GRINDINGWHEEL

Selection of a proper grinding wheel is very important for getting the best results in grinding work. A wheel may be required to perform various functions like quick removal of stock material, give a high-class surface finish and maintain close dimensional tolerances.

A single wheel will fai1to meet all requirements. It is necessary. Therefore, that proper gram Size, bond, grade, strength, shape and size of the wheel should be selected to meet the specific requirements. The factors upon which the above selection will depend the following factors:

(i) Constantfactors.

(ii) Variablefactors.

These are described below:

ConstantFactors

Physical properties of material to beground

Materials of high tensile strength such as steel, tough varieties of bronze and other materials are the best ground with aluminum oxide wheels. Materials of low tensile strength such as soft bronze, case hardened and chilled cast iron and aluminum are ground with silicon carbide wheels. Hard wheel is used for soft materials and soft wheel is used for hard materials. Close spacing is required for hard and brittle materials and wide for soft and ductile materials.

Amount and rate of stock to beremoved

This involves accuracy and surface finish. Coarse grain and wide spacing are used for fast cutting. Fine grain and close spacing are used for the finish.

Area ofcontact

The area of contact between the wheel and work affects the pressure over the number of cutting points and therefore, it influences the selection of wheel. When contact area is small, fine grain and close spacing will be useful. When the contact area is larger, coarse grain and wide spacing will be useful.

Type of grindingmachine

Heavy rigidly constructed machines take softer wheels than the lighter and more flexible types. The combination of feeds and speeds on precision machines may affect the grade of the wheel desirable for the best results.

Variable Factors

Workspeed

The speed at which the work piece traversed across the wheel face is called work speed. When the work speed is higher, the greater will be the wear and tear of the wheel. So, hard wheels should be selected. If the Work speed is low, the wheel wear will also be lowandtherefore, soft Wheel should be selected. However, low speed resulted by local over heating produces deformation and lowers the hardness of the work pieces. Most of the grinding machines are provided with variable speed mechanisms. As the diameter of the wheel decreases, the work speed needs to be increased accordingly to provide optimum working Conditions.

Wheelspeed

The speed of grinding wheel is influenced by the grade and bond If the wheel speed is higher, soft wheel should be selected. If the work speed is lower, soft wheel should be selected. When the wheel speed is up to 2000m/min, vitrified bonded wheels are used. When the speed is more than 2000m/min, rubber, shellac and resinoid bonded wheels are used.

Condition of the grindingmachine

Heavy, rigid and well-maintained machine can use soft grade wheels. Light and poorly maintained machine should use hard wheels. When the grinding is done in dry condition, soft wheel should be selected. When the grinding is done in wet condition, hard wheel should be selected.

Personalfactor

The skill of the workman is another variable factor which should be considered in selecting the wheel. An unskilled worker cannot handle soft wheels. Thus, unskilled worker should be allowed to work on hardwheels.

RECONDITIONING OF GRINDINGWHEEL

During grinding operation, the grains of the wheel are subjected to wear and the wheel losses its cutting capacity. Grinding wheels are dressed to restore their cutting capacity which is lost by the phenomenon of loading and glazing. During the operation, the chips formed get entrapped in the inner granular space of abrasive particles. This is called loading and it results an inefficient cutting operation.

When the bond of the abrasive is very hard, it does not dislodge an abrasive particle. Therefore, the surface of the wheel becomes smooth and gets a glassy like appearance. This is known as glazing of the wheel.

DRESSING

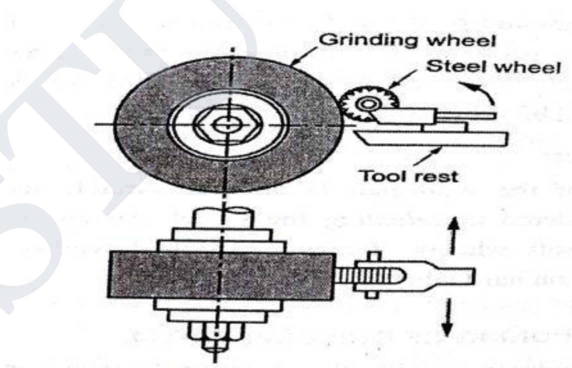


Fig 4.2 a) Star wheel dresser b) Abrasive stick dresser c) Diamond tip dresser

There are various types of dressing tools available.

a) Star dressing tool

b) Round abrasivestick

c) Diamond dressingtool.

Fig. 4.2 (a) shows dressing grinding wheel using a star wheel dresser. Star Wheel is a steel wheel having hardened teeth on the periphery. The dresser is guided by the tool rest. The grinding wheel runs at a slow speed. The dresser is pressed against the face of the revolving wheel and moved across the face to dress the surface. This type of wheel dresser is used for grinding coarse grain abrasive wheels. Round abrasive stick type of dressing tool consists of steel filled with a bonded abrasive. The end of the tube is held against the wheel and moves across the face. The grinding wheel used for precision and high finish grinding is dressed by a dresser having diamond tip. The diamond tip is hold in 8 holders and moved across the width of

Only the pointed up of the diamond does the dressing. The holder is inclined at an angle shown in fig 4.2 (c) Very light material is taken in diamonddressing.

TRUING

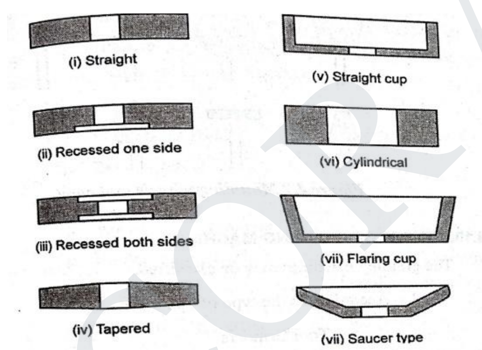


Figure 4.5 Standard grinding wheel shapes

4.11 MOUNTING WHEELS AND POINTS

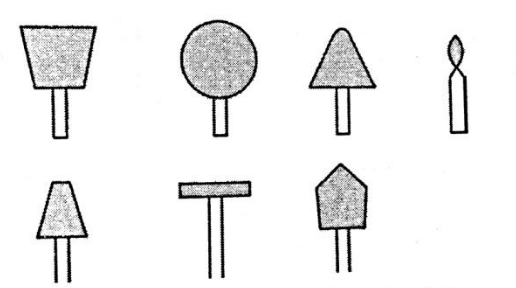


Figure 4.7 Mounting wheels and points

Fig 4.5 Mounting Wheel and Points

They are small grinding wheels of different shapes. They are attached to metal shanks that can be inserted in the chucks of portable high speed electric motors. Fig. 4.5 shows some mounted wheels andpoints.

TYPES OF GRINDINGMACHINES

The grinding machines may be classified according to the

I. Type ofoperation.

a. ToolGrinders

b. Cut offgrinders.

2. Quality of surfacefinish.

a. Precisiongrinders.

b. Roughgrinders.

3. Type of surface generated.

a. Cylindricalgrinders.

b. Internalgrinders.

c. Surfacegrinders.

d. Toolgrinders.

e. Special purpose grindingmachines

f. Surface finishinggrinders.

Grinding machines can probably be best classified according to the type of surfaces they are used to produce. i.e. Rough and precision grinders. They are further classified as follows.Roughgrinders.

a. Floor stand grinders.

b. Benchgrinders.

c. Portable grinders.

d. Abrasive beltgrinders.

e. Swing framegrinders.

2. Precisiongrinders.

a. Cylindricalgrinders.

(i) Centre type plaingrinders.

(ii) Centre type universalgrinders.

(iii) Centrelessgrinders.

b. Internalgrinders.

(i) Chucking typegrinders.

(ii) Planetary typegrinders.

(iii) Centrelessgrinders.

c. Surface grinders.

(i) Reciprocating table-horizontalspindle.

(ii) Rotary table-horizontalspindle.

(iii) Reciprocating table-vertical"spindle.

(iv) Rotary table-verticalspindle.

d. Tool and Cuttergrinders.

e. Specialgrinders.

ROUGHGRINDERS

Rough grinders are mainly used for removing large amount of metal from the work piece. Therefore, the surface finish and the accuracy in dimension are not high. Rough grinding is used for removing projections like sprue pins from castings, grinding the projections in the forgings, finishing the weldments, sharpening of hand tool etc. The various types of grinder used for rough grinding are given below.

Floor StandGrinder

It is mounted on a base and consists of a horizontal spindle with grinding wheels mounted at each end of the motor shaft extensions. It is also known as pedestal grinder. The work is normally held by the operator in hand and pressed against the wheel to remove the material. The driving motor is placed inside the pedestal. The motor is connected to the spindle by belts. It has a guard with an eye shield for safety purpose. A work rest is provided for supporting the work piece while grinding. This type of grinder is used for rough grinding of tools and other smallparts.

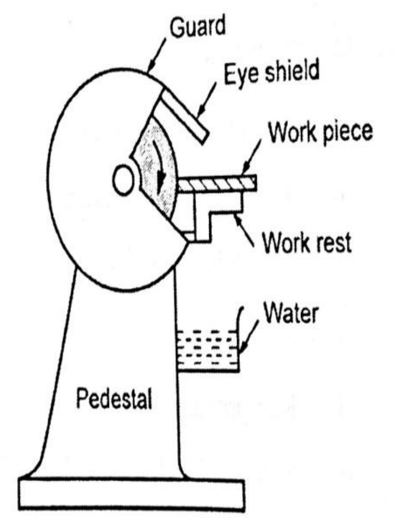
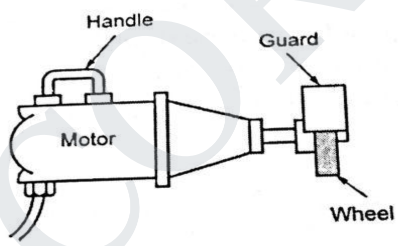


Figure 4.8 Floor stand grinder

It is similar to a floor grinder except for the size. It is mounted on a bench. It has two wheels and guards similar to pedestal grinder. A Work rest is provided for supporting the work piece while grinding. Bench grinders are mainly used for grinding of hand tools and small parts.

Portable Grinder



This type of grinding machine is very handy for cleaning castings, welded works, sheet metal works, rough works etc. It can be carried from place to place. It has a small electric motor.

A small grinding wheel is attached to the end of motor. The motor is connected by a long wire to the main supply using aplug.

Abrasive Belt Grinder

The line diagram of this grinder is shown in fig. 4.8. Belt has an endless abrasive belt running over two drums. The abrasive belt has small abrasive grains pasted to one of its side. The bottom drum is connected to a driving motor. Work pieces may feed against the abrasive cloth by hand. There is a platen supporting the belt at its backside. This grinder is used for rough grinding the work piece. We cannot expect the accuracy in this grinder. Accuracy depends upon the skill of the operator. Small and irregular shaped work piece can be ground safely on this grinder.

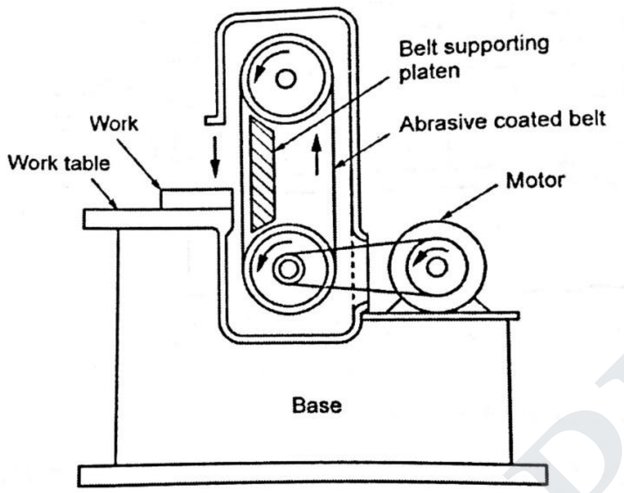


Figure 4.11 Abrasive belt grinder

PRECISIONGRINDERS

Precision grinders are used to manufacture parts of accurate dimensions and good surfacefinish. The work piece and the grinding wheel are mounted rigidly but they are adjustable according to the requirement of the machining methods. Precision grinding is applied for grindingcylinder

There are four movements in a cylindrical centre type grinding.

Rotation of cylindrical work piece about its axis.

Rotation of the grinding wheel about its axis.

Longitudinal feed movement of the work past the wheel face.

Movement of wheel into the work perpendicular to the axis of the work piece to give depth ofcut.

1. Types of operations in cylindricalgrinding

   Two types of grinding operations are carried out.

   (i) Traverse grinding.

   (ii) Plunge grinding.

2. Types of cylindricalgrinding

   (i) Plain centre type cylindrical grindingmachine:

Plain centre type cylindrical grinding machine

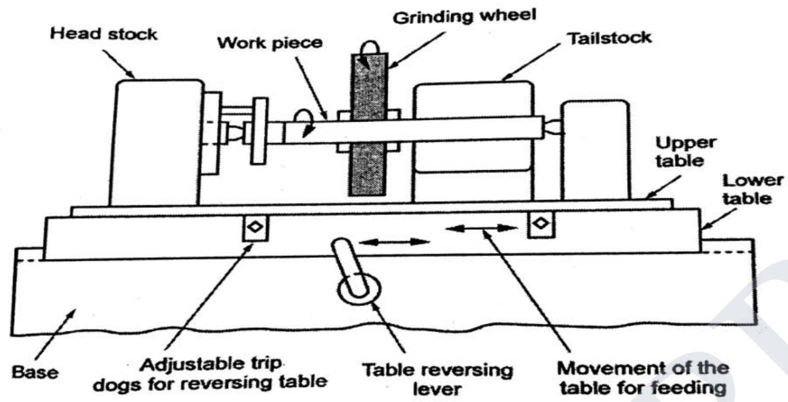


Figure 4.16 Plain centre type cylindrical grinding machine

Base

The base is the main casting that rests on the floor and supports the parts mounted on it.

Table

There are two tables such as upper table and lower table. The lower table slides on the guide ways of the bed and provides traverse feed or longitudinal feed of the work past the grinding wheel. It can be moved by hand or power within the limits. Adjustable dogs are provided at the side of the lower table. These dogs can be set up in proper place to reverse the table of the end stroke. The upper table is mounted on the lower table and it carries headstock and tailstock. The headstock and tailstock can be adjusted according to the length of the work piece. The upper table can be swiveled and clamped in position over the power table. The maximum angle of swivel is 10° on either side. The swiveling is used for grindingtapers.

Headstock

The headstock supports the work piece by means of a dead centre. The work piece is driven by headstock through dog and driving pin. A separate motor is housed in the headstock to rotate the work piece.

Tailstock

The tailstock can be adjusted and clamped to accommodate different length of work pieces. The work piece is held in between the centre of headstock andtailstock.

Wheelhead

The wheel head carries a grinding wheel and rotated by a motor housed in the headstock. The wheel head is placed over the bed at its backside. The wheel head can be moved perpendicular to the table ways by hand or power. This movement is the cross feed.

Working principle

The work piece is held between centres. It is rotated by a dog or faceplate. The grinding wheel also rotates about its own axis in the opposite direction of work. The grinding wheel is fed by hand or automatically towards the work piece for successive cuts. In most of the cases, the work speed is selected between 20 and 30 surface speed meters per minute (s.m.p.m.). Wheel speed is usually selected between 1500 and 2000 s.m. p.m. The depth of cut at each reversal isfrom 0.025mm to 0.125mm for rough grinding. For finishing, it should be from 0.0125mm to 0.0625mm.

(ii) Centre type universalgrinder

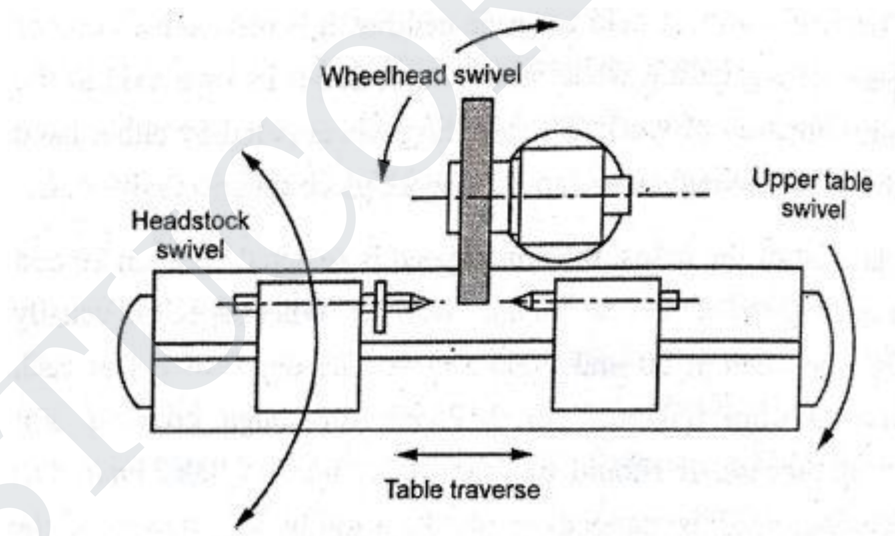


Fig. 4.12. Universal grinder

Center type universal grinders are widely used in tool room for grinding tools. The features of this machine are similar to those of plain grinders but in addition, it is provided with the following features.

1. The centre of the head stock spindle can be used as alive or dead. The work can be held and revolved by a chuck. It can also be held between centres andrevolved.
2. The wheel head can be swiveled in a horizontal plane in any angle. The wheel head can be fed in the inclined directionalso.
3. The headstock can be swiveled to any angle in the horizontalplane.
4. The wheel head can also be arranged for internalgrinding.

SURFACEGRINDERS

Surface grinding machines are used to produce and finish flat and plane surfaces. By using special fixtures and form dressing devices angular and formed surfaces can also be ground. 'The various machine parts such as machine guide ways, piston rings, valves, dies, surface plates etc are finished by surface grinding.

Horizontal Spindle Reciprocating Table SurfaceGrinder

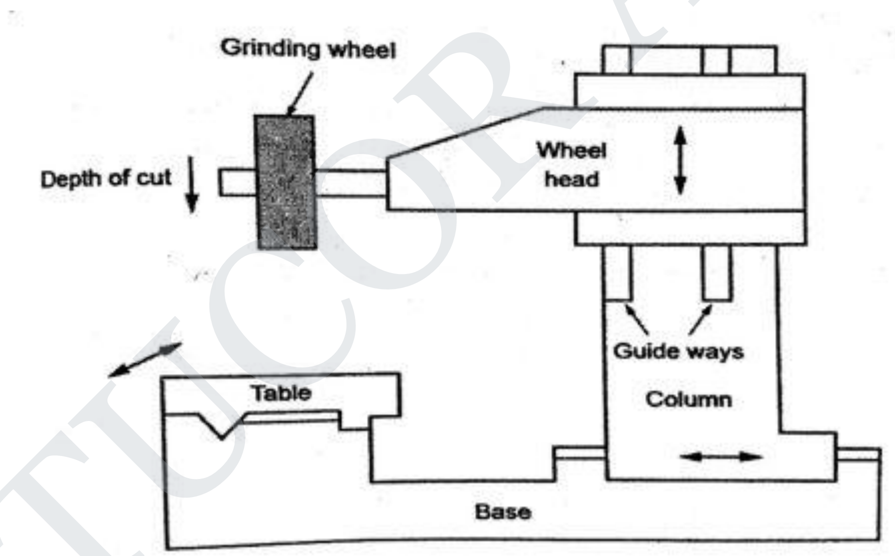


Fig 4.13 Horizontal spindle reciprocating table surface grinder

Working

The work piece is clamped on the table. The trip dogs are adjusted suitably to get the correct stroke length of the table. The work piece reciprocates under the table. The periphery of the grinding wheel does the grinding. Cross feed is given to the work piece after every stroke. Depth of cut is given by lowering the wheel head. For rough grinding of work piece, the depth of cut may be from 0.02mm to 0.06mm. For finishing operation, the depth of cut may be From0.005mm to 0.0lmm.

Horizontal Spindle Rotary Table SurfaceGrinder

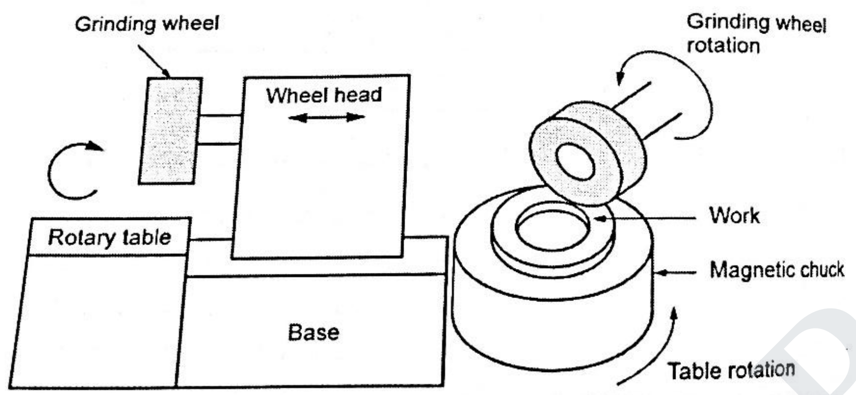


Figure 4.19 Horizontal spindle rotary table surface grinder

In horizontal spindle rotary table surface grinders, the work pieces are mounted on magnetic chucks or on fixtures rotating slowly under the rotating grinding wheel in its horizontal axis. The circular table rotates at specific speed and the wheel can feed axially (cross-feed). The wheel head is lowered to give the required depth of cut. The periphery of the grinding wheel takes the cut. This machine is used for small and medium sizeworks

Vertical Spindle Reciprocating Table SurfaceGrinder

The work piece is clamped on the reciprocating worktable using a magnetic chuck or fixture. The grinding wheel rotates about a vertical axis. It may be of cup or cylindrical type for faster stock removal. It is used where accuracy is not stringent. The longitudinal and cross feed are given through the table. The face or side of the grinding wheel cuts the metal. The wheel head is lowered down for giving the depth of cut. This grinding machine is used for grinding flat surfaces on medium sizeworks.

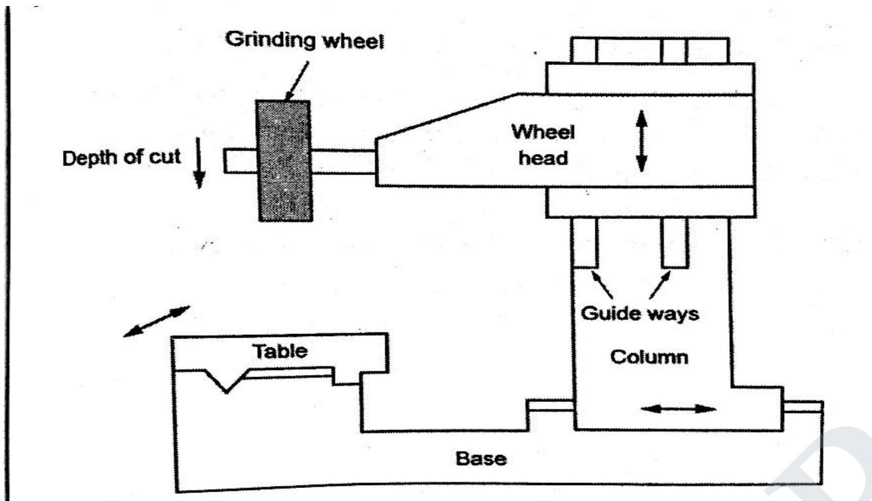


Figure 4.18 Horizontal spindle reciprocating table surface grinder

Fig 4.15 Vertical spindle reciprocating table surface

Vertical Spindle Rotary Table Surface Grinder

This machine has all parts similar to a horizontal type machine except that the grinding wheel rotates about a vertical axis as shown in fig. 4.16. The grinding spindle is mounted vertically on the face of a column and rotates in fixed position. Vertical spindle carries a cup type grinding wheel. The grinding wheel is lowered for giving depth of thecut.

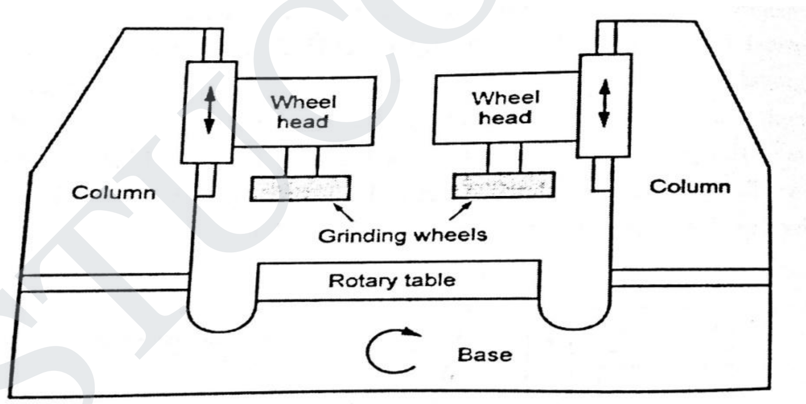


Figure 4.21 Vertical spindle rotary table surface grinder

Fig 4.16 Vertical spindle rotary table surface grinder

CENTRELESSGRINDERS

Centreless grinding is performed on work pieces which do not have centres, such as pistons, valves, rings, tubes, balls, wrist pins, drills, bushings, shafts etc. Centreless grindingcan be done on both external and internal cylindrical surfaces. The principle of external Centreless

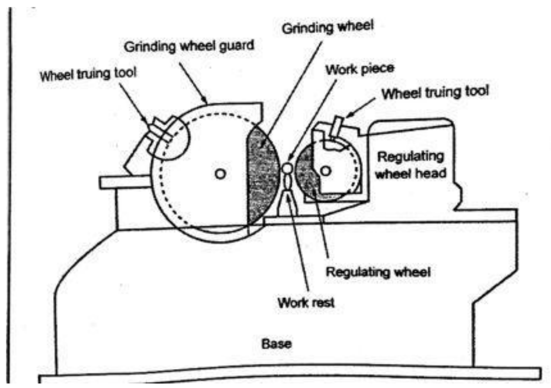


Fig 4.17 Centreless grinders

The work is placed on the Work rest. The regulating wheel is fed forward forcing the work against grinding wheel. So, the work on work rest is pressed against the grinding wheel surface. By friction, the regulating wheel makes the work piece to rotate. The rotating work piece is pressed between two wheels. Work piece is placed in a floating condition between the grinding wheel and regulating wheel. So, it is called as Centrelessgrinding.

METHODS OF CENTRELESSGRINDING

Basically, there are three different methods by which centreless grinding can be done. They are

(i) Throughfeed.

(ii) Infeed.

(iii) Endfeed.

1. Throughfeed

It is used for straight cylindrical work piece like long shafts or bars, roller pins etc. In this method, the regulating wheel is tilted at a small angle. This makes the work to move axially through the space between the grinding wheel and regulating wheel. The guides are provided at both the ends of wheel and guide the movement of workpiece.

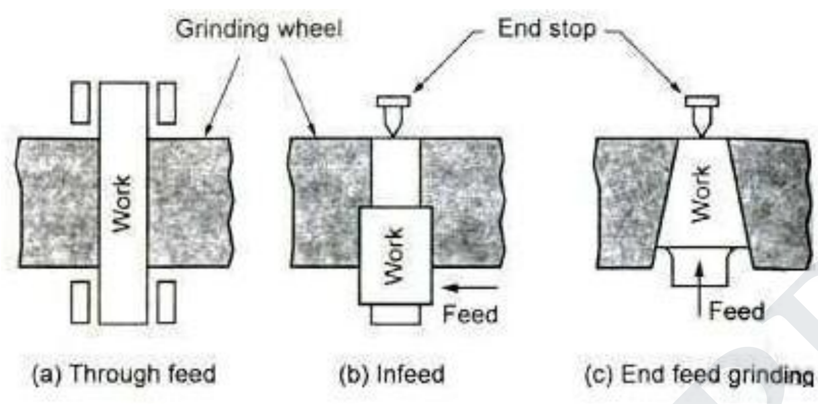


Fig 4.18 Methods of centreless grinding

2. In-feedgrinding

It is similar to plunge grinding. The work is placed on the work rest against an end stop. This prevents the axial movement of work piece. The regulating wheel and the work rest with the work pieces are moved towards the grinding wheel by hand feed shown in fig. 4.18. (b). this method is useful to grind shoulders and formed surfaces.

3. End feedgrinding

In this method, both the grinding and the regulating wheels are tapered and thus, it produces tapered work pieces. The work piece is fed lengthwise between wheels and is ground as it advances until it reaches the end stop shown in fig. 4.18.(c).

INTERNALGRINDERS

Internal grinders are used to finish straight, tapered or formed holes to the correct size, shape and finish. There are three types of internal grinders:

(a) Chuckingtype.

(b) Planetarytype.

(c) Centrelesstype.

Chucking Type InternalGrinders

In this, the work piece is chucked and rotated about its axis. The Work head is mounted at the left side of the machine. The wheel head is mounted at the right end of the machine. The grinding wheel is rotated.

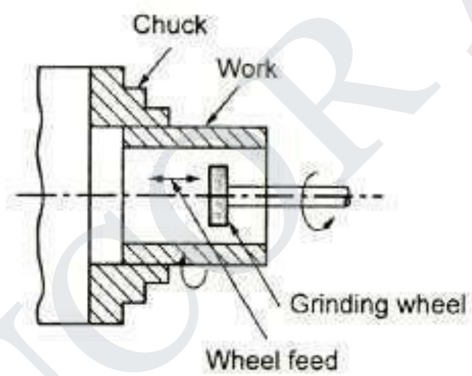


Fig 4.19 Chucking type internal grinder

At the same time, it reciprocates back and forth through the length of the hole as shown in fig. 4.19. These machines are used for grinding work piece which can be easily held in a chuck.

Planetary Type InternalGrinders

The work remains stationary and the rotation of wheel spindle gives an eccentric motion according to the diameter of the hole to be ground. Such type of operation is used where the work is difficult to be rotated. Therefore, in this operation, the motion of the grinding wheel is in

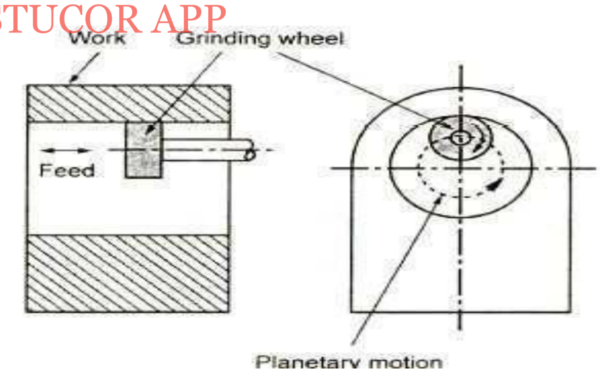


Fig 4.20 Planetary type internal grinders

4.18.3. Centreless Grinding

The external centreless grinding principle is also applied to internal grinding. In internal centreless grinding, the work is supported by three rolls.

one is a supporting roll and the last one is pressure roll to hold the work piece against the support and regulating rolls. The regularity roll is a rubber bonded wheel. This roll makes the work piece to rotate.

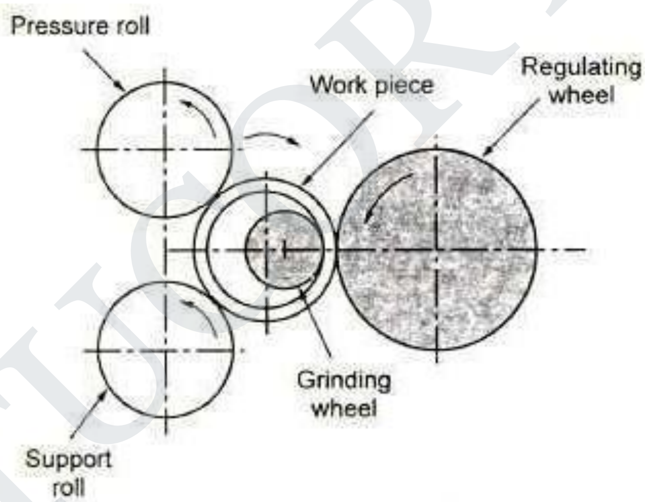


Fig 4.21 Centreless grinding

The grinding wheel contact inside diameter of the work piece directly and reciprocates about its axis for giving the feed. The depth of cut is given by moving the grinding wheel in a crosswise direction. The pressure roll is mounted to swing aside to permit loading and unloading

SPECIAL PURPOSE GRINDINGMACHINES

Some grinding machines are designed for highly specialized Works such as forming, gear teeth grinding, thread grinding, earn grinding, tool and cutter grinding etc. These grinders are called as special purpose grinders. Some of these types are explainedbelow.

FormGrinders

The grinding wheel for form grinding is so shaped such that the form of the surface to be obtained. Fig.4.28 shows the grinding operation of dovetail guide ways and machining of complex cross section.

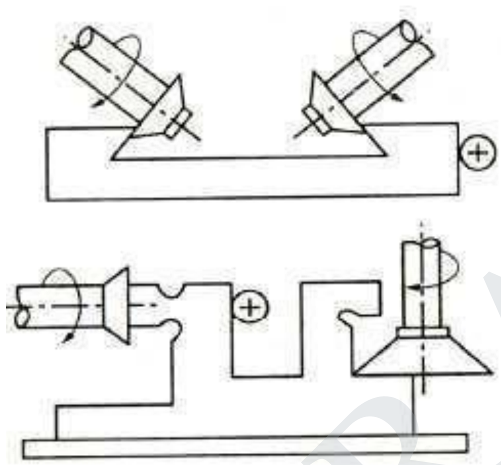


Fig 4.22 Form Grinding

Gear TeethGrinding

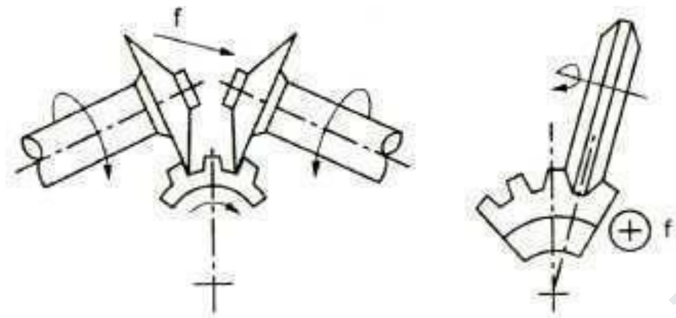
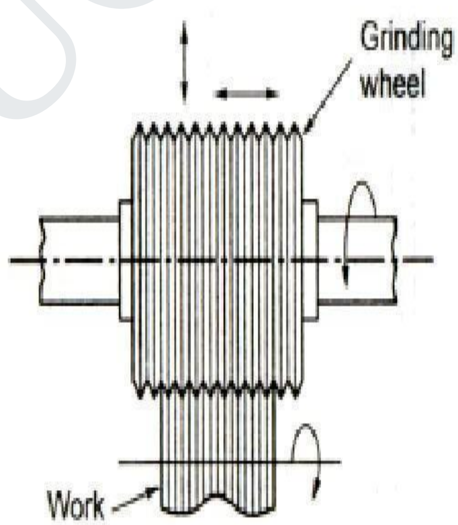


Fig 4.23 Gear teeth grinding

The generating grinding method uses two saucers shaped grinding wheels as shown in fig: 4.23. These grinding wheels are set so that their active faces are in planes tangent to the involutes curvatures of two teeth on the gear. This is accomplished by turning the wheels to an angle equal to the pressure angle of the gear being ground.

ThreadGrinding

Fig 4.24 Thread grinding



This is also one type of forming method by which the thread is ground on a cylindrical surface. These machines differ from conventional cylindrical machines only in that the grinding wheel is either single or multiple rib wheels. The work is mounted between centres and is rotated at a definite speed. The ribbed grinding wheel is mounted on the wheel head spindle and is rotated by separate drive. The Wheel also has a longitudinal movement which is equal to one pitch of the thread per revolution of thework.

CamGrinders

These machines are basically cylindrical grinding machines with additional feeding and withdrawal mechanisms for the work piece. An arrangement for grinding cams of a camshaft is shown in fig. 4.31. The grinding wheel is arranged so that it can be moved radially towards or away from the work piece in co-ordination with the rotation' of the work piece.

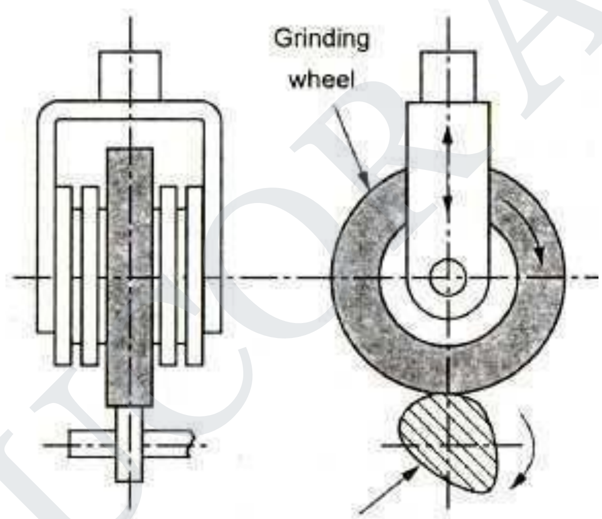


Fig 4.25 Cam grinding

Before carrying out the operation, a small template is mounted on the headstock. A hardened steel roller in conjunction with a template actuates the movement of the whole unit to produce the desired shape· the grinding wheel is continuously in contact with the cam surface during operation. The camshaft has simultaneous rotary and oscillating motion as well as an axial motion to obtain a fine surfacefinish.

CUTTING FLUIDS INGRINDING

(i) It cools the work piece Water solutions are liquids that consist of water with synthetic additives in order to increase its wetting performance and prevent corrosion. Such fluids contain no oil and provide good cooling performance but poorer lubricationperformance.

(ii) It acts as a lubricant and reduce friction between the chips, work piece and grinding wheel Emulsions consist of water with an admixture of 2- 5% of oil in an extremely finely distributed form. Sulphur or chlorine additives may also be used as EP additives. Cutting oils are composed of a mineral oil base with EP-type additives. Cutting oils provide effective lubrication but poorer cooling. Water solutions are most suitable when grinding with diamond wheels. Emulsions are used nowadays for the majority of grinding operations because they are ecologically beneficial and performadequately.

(iii) It removes chips from the contactarea.

SUPER FINISHING

Super finishing is suitable for obtaining a surface of the highest class of finish. It is similar to honing with small allowances but it differs in the large number of different abrasive stones and wheels and also the types of motions. In addition to high surface finish, super finishing also removes chatter marks, feed spirals, grinding commas and other imperfections left by the previous grinding operations. In super finishing, the pressure exerted is very low and stock removal is up to 0.025mm. The contact area of the stone and the work piece are large. The stone is given oscillating motion while the work piece is given a rotarymotion.

Working

Super finishing can be used to external and internal cylindrical, tapered, flat surfaces. External cylindrical surfaces can be super-finished by oscillating the abrasive stones at amplitude of 1.5mm to 3mm and frequencies of 500 to 1500 cycles per min., reciprocating axially along the rotating work piece. External cylindrical surfaces can also be super finished by oscillating and rotating the abrasive stones about the stationary work piece. Internal cylindrical surfaces can be super finished by axially oscillating and reciprocating abrasive stones applied to the rotating work piece.

Flat surfaces can be machined by rotating cup-shaped abrasive stone with the work resting on a circular rotating table. (Abrasive stone and the circular table are rotating in opposite directions). An additional oscillating movement and hydraulic pressure given are to the abrasive stone for traverse feeding and superfinishing.

Cutting Conditions for SuperFinishing

Cutting speed 10 to 40m/min

Oscillating frequencies 500 to 2000 cycles/min. Working pressure 1 to 4kg/cm2

Allowance range 0.002 to 0.02mm

1. Fluids

Light mineral oil or kerosene mixed with heavier cutting oil is used as coolant to keep the stone clean and sharp.

2. Abrasive Stones

This process is suitable to external or internal cylindrical, tapered, flat, curved, spiral surfaces, or where high class of finish is required.

3. Difference between honing and superfinishing

I. It is possible to create dimensions. i.e., the desired size through honing while super finishing is employed only for obtaining a high quality surface finish with no appreciable amount of stockremoval.

2. The honing process needs only two motions whereas super finishing may involve many. With the result, the path of an abrasive grain is neverrepeated.

3. The honing process is mostly employed for finishing internal surfaces, whereas super finishing is largely used for outsidesurfaces.

4. Super finishing is done at much lower operating speeds thanhoning.

5. The total pressure on the work is too low in super finishing as compared to honing enabling finishing of even the very delicateparts.

6. The length of stroke in super finishing is very short usually 1.5mm to 6mm as compared to honing. With the result, there is no appreciable accumulation of chips and therefore, no scratches are produced on the jobsurface.

POLISHING

Polishing is also a surface finishing process. It is performed by a Polishing wheel to remove appreciable quantity of metal, tool marks, Points and other defects from any rough surfaces on the metal. It is mainly used for obtaining good surface finish. Sometimes a tolerance less than 0.02mm can be obtained by this process. Generally a wheel made of leather, papers, canvas, felt or wool is used in the process. Rarely, abrasive grains with glue or thermosetting resins are applied on the face of the polishing wheel to remove the metal from surface. Similar to grinding process, here also work is held against the rotating polishing wheel. This may anyone of the process of honing, lapping or super finishing. To remove the metal from the surface, either wheel may be pressed towards the work or work may be pressed towards the wheel. The polishing methods are divided into two types such as endless belt machines and coated abrasive wheels.

BUFFING

Buffing is the process of making higher, lustrous, reflective finish to be made on the surfaces of work piece which cannot be obtained by polishing process. In this process, a very fine abrasive is applied with a rotating wheel. Before applying the abrasive, first it should be mixed with binder. The binder may be wax mixed with grease parafine and kerosene or turpentine and other liquids. Abrasive may consist of iron oxide, chromium oxide, emeryetc,

BROACHINGMACHINES

Broaching is a proce ss of machining a surface with a specified multipoint cutting tool called 'broach' which h as successively cutting edges in a fixed path . Each tooth removes a predetermined amount of material. The job is completed in one st roke of the The last tooth of the cutting tool is conforming to the desired the finished surface. It is a faster and cheaper method of macho. The depth of removed material is limited to 6mm or less. External and internal surface can be machined bybroaching.

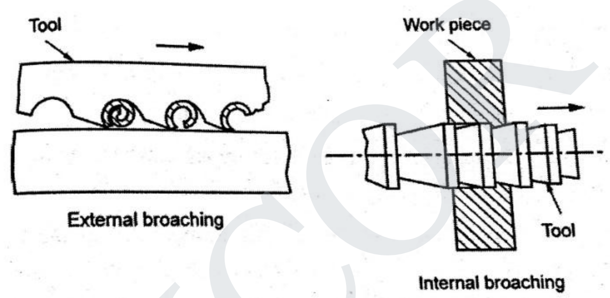


Figure 4.32

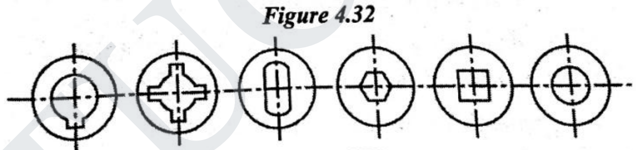


Figure 4.33

SPECIFICATION OF A BROACHINGMACHINE

Main specifications of a broa ching machine are:

1. Maximum length o f stroke inmm.
2. Maximum force de veloped by the slide in Tonnes. The

subsidiary specificationsare

1. Type of drive for straight-line motion i.e. Electro-Mechanical or H ydraulicetc.
2. Power rating of ele ctrical motor inH.P.
3. Speed and feed range.
4. Weight of the mac hine inTonnes.
5. Floor space require d in squaremetre.

ADVANTAGES ANDD LIMITATIONS OF BROACHING

Advantages

1. Rapid loading and unloading arrangement of the work pieces by using fixture and machining the surface in one pass gives high rate ofproduction.

2. High accuracy and surface finish of about 0.001mm suitable to int erchangeable manufacture.

3. Semi-skilled work er can perform a broachingoperation.

4. Any form that can be reproduced on a broach can bemachined.

Limitations

Broaching is not sui table for removal of large amount of stock. A lmost all the work pieces will need fixture for rigid support. Tool grinding is difficult and expensive because it needs special type grinding machine. Broach is a single purpose tool because it requires different broaches with different shapes andsizes.

TYPES OF BROACHINGMACHINE

The broaching machine may be classified as follows:

(a) According to the nature and direction of primary cuttingmotion

(i) Horizontal broachingmachine

(ii) Vertical broachingmachine

(iii) Continuous broachingmachine

(b) According to thepurpose

(i) Internal broachingmachine

(ii) External Surface broachingmachine

(c) According to methodoperation

(i) Pull broachingmachine

(ii) Push broachingmachine

(d) According to the construction of the broachtool

(i) Solid broachingmachine

(ii) Inserted toot broachingmachine

(iii) Progressive cut broachingmachine

(iv) Built-up broachingmachine

(e) According to thefunction

(i) Keyway broachingmachine

(ii) Burnishing broachingmachine

(iii) Spline broachingmachine

(iv) Round-hole broachingmachine

(v) Surface broachingmachine

(f) According to the number of main slides orstations

(i) Single broachingmachine

(ii) Double broachingmachine

(iii) Multiple Slides broachingmachine

(g) According to the motion of the broach tool relative to thework

(ii) Straight-line motion broaching machine
(iii)Stationary broac h tool broaching machine

HORIZONTAL BRO ACHINGMACHINE

Mostly, all horizonta l broaching machines are of pull type. They are generally used for internal broaching. External or surface broaching can also be done by this machine. Fig. 3.102 shows th e horizontal internal broaching machine. This machine has a box type bed. The length of bed is twice the length of stroke. Most o f the modem horizontal broaching machines are provided with hydraulic or electric drive . It is housed in the bed. The job is located in the adopter as shown in fig 3.102. The adopter is fitted in the front vertical face of the machine. The small end of the broach is inserted through the hole of the job and connect ed to the pullinghead. The pulling head is mo unted on the front end of the ram. The ra m is connected to the hydraulic drive mechan ism. The rear end of the broach is support ed by a guide. The broach is moved along the guide ways. Broaching machines are ge nerally operated at low speed of 2 to 15m per min. These machines are provided with automatic stops to control the length of the stroke of ram. These machines may be fully automatic or semiautomatic.

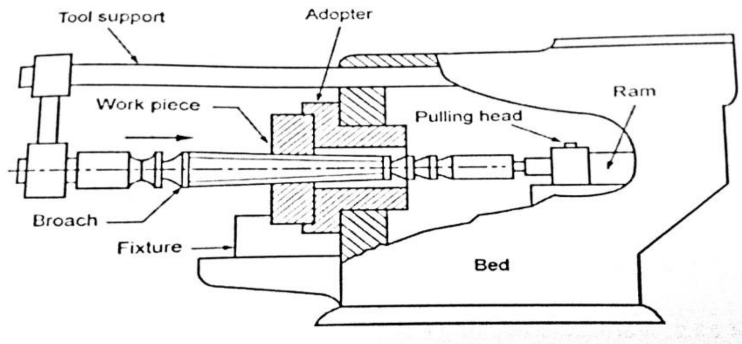


Figure 4.34 Horizontal type internal broaching machine

Fig. 4.34 Horizontal type internal broaching machine

VERTICAL BROAC HINGMACHINE

Broaching tools are mounted on slide which is hydraulically operated and accurately guided on the column ways. Slide with the broaches travels at various speeds which are controlled by the hydraulic drive. Its stroke is adjusted to suit t he broaching operation to be performed. The slide is provided with quick return mecha nism. In this type, most of the machines are provided with receding table so that the fixture may be loaded and unloaded during its return stroke. The worktable is mounted on the base in front of the column. The fix ture is clamped to the table. The work piece is held in the fixture. After advancing the table to the broaching position, it is clamped and the slide with the broach travels dow nwards for machining the work piece Then the table recedes to load a new work piece a nd the slide returns to its upper position. The cycle is thenrepeated.

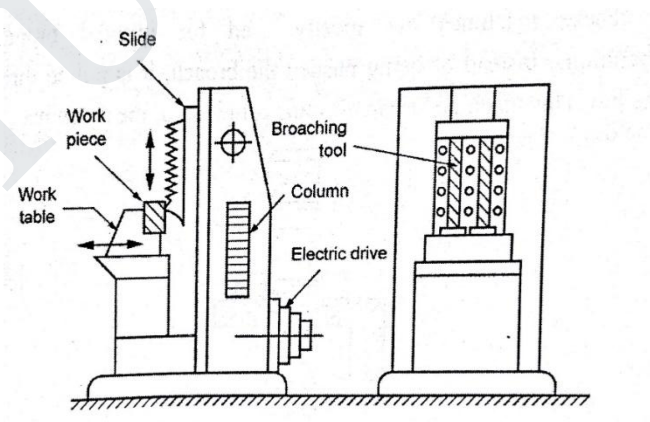


Figure 4.36 Push down type vertical broaching machine

CONTINUOUS BRO ACHING MACHINE

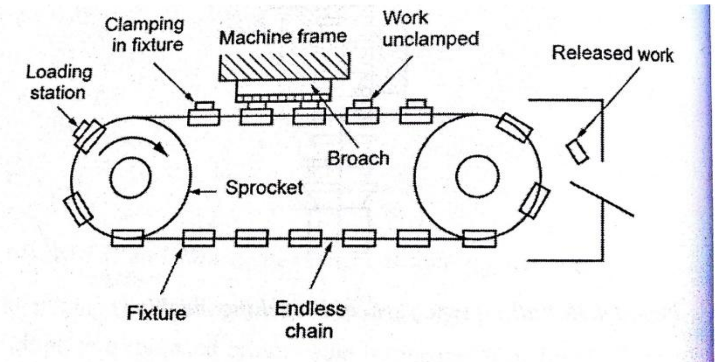


Figure 4.39 Horizontal type Continuous Broaching Machine

Continuous Broaching Machine

This is one type of surface broaching machine. The broaching m achine has a driving unit which consists of two sprockets. They are connected by an e ndless chain. Fixtures are mounted at inte rvals on the chain for locating and holding work pieces. The broach tool is fixed horizontally in the frame of the machine. The rigid guiding member is arranged under the chain in the zone where the work pieces pass under the broach. When the fixture passes the loading station, the operator will drop the part in the fixture. The work is automatically clamped before it reaches the tunnel. The bro aching lakes place when work pieces will move under the broach. The work pieces are then automatically released by a cam. At the Unloading point, the work piece falls out the fixture. Continuous Broachi ng machine increases the productivity and hen ce, it is used for Massproduction.

UNIT – V

CNC MACHINING

CONTENT

Technical Terms

NC System

A system in which actions are controlled by the direct insertion of numerical data at some point is known as *NC system.*

Point to Point NC system

It is also called *positioning system.* The objective of the machine tool control is to move the cutting tool to a predefined location. The speed or path is not important in this system.

Computer Numerical Control system (CNC)

Computer Numerical Control is an NC system that utilizes stored program to perform basic numerical control functions. Mini or micro computer based controller unit isused.

Coordinate Measuring Machine

In modern automated inspection procedure, sensors are having important role to control and communicate data.

Part Program

The part program is a set of instructions proposed to .get the machined part starting with the desired blank and the NC machine tool. Each line of instruction is capable of specifying dimensional and non dimensional data and. is written in a specific format. This format is known as *NCblock.*

RAM-EDM

In this machine, the electrode has to get the similar size and shape of its counter part of the work piece which is to be machined. Servo control is used to maintain the gap between the electrode and the workpiece.

APT programming

APT program is used to command the cutting tool through its sequence of machining process. APT is also used to calculate the cutter positions. APT is a three dimensional system controlling up to live axes including rotational co-ordinates.

Motion Statements

These statements are used to control the cutter path to generate the part and include start-up procedures, point-to-point programming.

INTRODUCTION

In the late 1940's T.Parsons formulate a method of using punched cards containing coordinate position data to control a machine tool. The machine was directed to move in small increments to generate the desired surface of an airfoil. In 1948, Parsons demonstrated his concept to the U.S. Air-force. Then it was taken as a series of research projects at the Servo mechanisms laboratory of the Massachutts Institute of Technology (MIT).

The initial stage involved in the development of a prototype milling machine by retrofitting (back fit) a conventional tracer mill ith position. Servo mechanisms have for three machine tool axes. The First demo of the NC prototype was held in 1952. By 1953, the usefulness of NC concept had been proven.

Shortly thereafter, the machine tool builders began initiation of their development projects to introduce commercial NC units. Also certain user industries, airframe builders worked to device numerical control machines to satisfy their needs. Additional researches were going on at MIT.

They developed part programming language which could be used for NC machines which resulted in the Automatically Programmed Tools (APT) language. APT is utilized in many industries and most other languages are based on APT language.

There are numbers of problems in conventional NC machines which have motivated the machine tool builders to seek improvements in basic NC system.

Some of the problems are

(i) Part Programmingmistakes.

(ii) Non optimal speeds andfeeds.

(iii) Punched tape wear andtear.

(iv) Least reliable tapereader.

(v) Less managementinformation.

To rectify the above said problems, the use of the digital computer has also permitted substantial improvements made in the controls for NC.

Direct Numerical Control (DNC) was the first of the computer control systemsto be introduced around 1968. In this evolution, the computer of that era was quit large and expensive, and the only feasible approach was to use large computer to control a number of machine tools on a time-shared basis. The advantage of DNC was that a direct control link between the computer and the machine tool which eliminates the punched tapeinput.

The next stage after getting less expensive computers was introducing single small computer to one machine tool. This concept is then called Computer Numerical Control (CNC). The CNC systems were first commercially introduced around 1970, and they applied the soft-wired controller approach to good advantage. One standard computer control could be adapted to various machine tools by programming control functions into the computer memory for particular machine. Being less expensive, the machine tool builders design the CNC control panel as an integral part of the machine tool rather than as a separate stand-alone cabinet. This reduces the floor space requirements for the machine. The very large scale integrated (VLSI) circuits used in these controllers are advantageous to the machine tool designer and to the machineuser.

NUMERICAL CONTROLSYSTEM

Controlling a machine tool by means of a prepared program is knownas *Numerical Control or NC.*

5.2.1 Definition of NC System

A system in which actions are controlled by the direct insertion of numerical data at some point is known as *NC system.* The system must automatically interpret at least some portion of this data. A general configuration of NC system is shown in fig 5.1.

In NC system the numerical data which is required for producing a part is maintained on a punched tape called as *part program.*

The part program is arranged in the form of blocks of information. The block contains the numerical data required to produce one segment of workpiece. The punched tape is moved forward by one block each time the cutting of a segment is completed. Dimensional information is taken from the engineering drawing.
Dimensions are given separately for each axis of motion (x, y).

Types of NCSystems

There are three types ofNC used for motion control. They are

1. Point to point NCsystem.
2. Straight cut NCsystem.
3. Contouring NC system

1.point to Point NCsystem

It is also called *positioning system.* The objective of the machine tool control is to ;nove the cutting tool to a predefined location. The speed or path is not important in this system.

2. Straight cut method NCsystem

This system is capable of moving cutting tool parallel to one of the major axes at a controlled rate for machining. It is preferred for milling operations. Here, it is not possible to combine more than a single axis direction. Angular cuts are notpossible.

3. Contouring NCsystem

It is a complex and flexible method of tool control. It is capable of performing

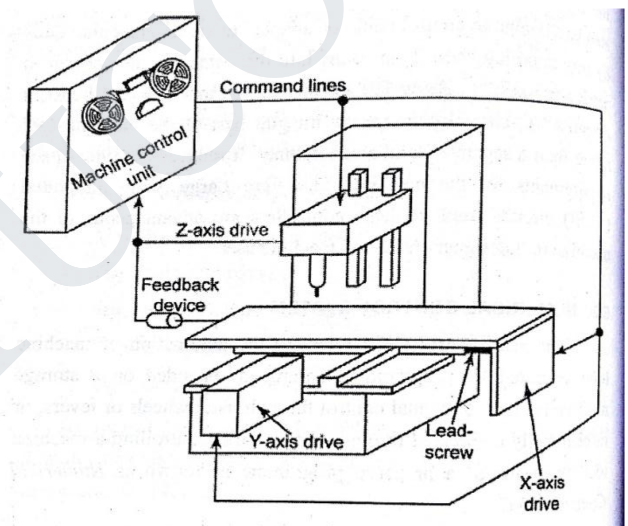


Figure 5.1 Numerical control system

both point to point and straight-cut operations. More than one axis movement of the machine tool is possible. The path of NC cutter is continuously controlled to generate the desired geometry of the work piece. This system is also called as *continuous path NC system.*

Comparing NC with ConventionalSystem

As compared to a conventional machine tool, the NC system replaces the manual actions of the operator. In conventional machining, a part is produced by moving a cutting tool along a workpiece by means of hand wheels guided by an operator. Contour cuttings are performed by an expert operator by sight. On the other hand, operators of NC machine tool need not be skilled machinists. They only need monitoring of operations of the machine, operate the tape reader and usually replace the workpiece. All thinking operations that were formerly done by the operator are now contained in the part program. Preparing the part program for a NC machine tool requires a partprogrammer. The part programmer must possess knowledge and experience in mechanical engineering fields.

He must be familiar with the function of NC machine tools and machining processes. He must decide on the optional sequence of operations.

Advantages and Disadvantages of NCMachines

Advantages

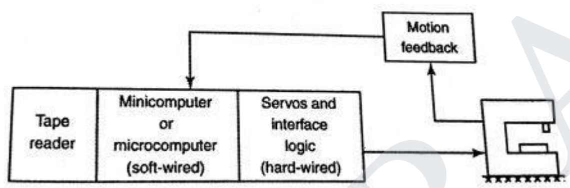
1. Greateraccuracy.
2. Lesser production cost per piece due to reduction in lead time and also setup time.
3. Improved product quality and provision of high order of repeatability.
4. High production rates as the machining conditions are optimized and thenon-machining times are reduced to aminimum.
5. Less scrap due to consistent accuracy and absence of humanerrors.
6. Reduced inventory in work-in-process(WIP).
7. Less operator skill is required.
8. Machine utilization isbetter.
9. Lower tooling cost.
10. Cycle time is reduced thereby increasing toollife.

Disadvantages

The major disadvantages of NC machines are their costs and req uirements of highly knowledgeable perso n in this field. Long preparation time requi red for each production series. Flexibility is not there since machine is for only fixed cycle of operation.

COMPUTER NUMERIICAL CONTROL SYSTEM(CNC)

Computer Numerical Control is an NC system that utilizes store d program to perform basic numerical control functions. Mini or micro computer based c ontroller unit is used.



The external appear ance of CNC is very similar to that of N C. The part programmes are entered in similar manner. Punched tape readers are common device for both CNC and NC. In CNC , the program is entered once and then stored in computer memory whereas in conventional NC machines for every workpiece the punched tape is cycled through the tape reader. When compared to NC, CNC offers more flexibility and computational capability. Re programming is easy. Because of this facility, CNC is often termed as *softwired NC.*

Types ofCNC

There are two types o f CNC used according to the controller design. They are:

1. Hybrid CNC.
2. Straight CNC.

In *Hybrid CNC*, the controller consists of softwired and hardwired logic circuits. In *Straight CNC*, the hardwir e is used to interface the computer with the mac hine.

5.3.2. Major Elements of CNC Systems

The different element s of CNC systems are:

1. Hardware

It includes microprocessor, machine tools, actuators and other peripheral devices

2. Software

CNC software includes v arious instructions, programming languages, Input/output control and Graphics.

3. Information

Information is nothing but th e data required for cutter location, programmin g, machining process.

DNC

Direct Numerical C ontrol is termed as DNC. DNC can be defined as a manufacturing system in which a number of machines are controlled b a computer through direct connection an d in real time. Components of DNC are:

(i) Centralcomputer

(ii) Bulk memory wh ich stores the NC partprograms.

(iii) Telecommunicat ion lines

(iv). Machinetools.

Configuration of NCSystem

The computer calls the part program instructions from bulk storage and sends them to individual machines. It also receives data back from the machines. The two-way

Main Difference between CNC andDNC

CNC System can do operations on only one machine at a time. But Direct Numerical control involves that at a time a large central computer to direct the operations of a number of separate NC machines.

Advantages ofCNC

Computer Numerical Control possesses a number of existing advantages over conventional NC. These are

(i) An increase inflexibility.

(ii) An improvement in the possibilities for correcting errors in partprogramming.

(iii) The possibility of using the computer's peripheralequipment.

(iv) Tape and Tape reader are used only once for resulting improvedreliability.

(v) CNC is morecompatible.

(vi) CNC can accommodate conversion of tapes prepared in units of inches to the international unitsystem.

Comparison of NC andCNC

S.No	NC machines	CNC machines
1.	The NC system is produced in sixties and used electronic hardware based upon digitalcircuittechnology.	The CNC system produced in early seventies employ a mini or micro computer to control machine tool and eliminate, as far as possible, additional hardware circuits in the control cabinet.
2.	Less flexibility.	The trend from hardware is based on NC to software based equipment brings an increase in system flexibility and an improvement in the possibility forcorrectingpart programs using the CNCcomputer.

3.	The punched tape is moved forward by one block and read each time the cutting of a segment is completed. During the production of each part, the tape isreadagain.	The complete-tape is read one time only and stored in the computer memory before the cutting starts. During machining, the control program of the CNC uses thestored part program to command the machine. Bythis method, tape reading errors are eliminated in CNC.

5 Comparison of NC, CNC with ConventionalSystem

S.No	Conventional system	NC system	CNC system
1.	It requiresmore manual work.	It requires less manual work.	It requires less manual work.
2.	Skilled labour is needed.	Less skill is enough.	Less skill is enough.
3.	Less accuracy is obtained.	More accuracy is obtained.	More accuracy is obtained.
4.	The system has less flexible.	The system medium has flexible.	The system has more flexible.
5.	Part programming is not required.	Part programming is used.	Re – programming is easy.
6.	Machining is done every time.	Programming and punched tape are read each time.	Only one time, the tape is read and storing is possible.
7.	Simulation cannot be done.	Simulation is also possible.	Simulation is also possible.
8.	It is more suitableforless Production rate.	It is more suitable in medium production rate.	More suitable for mass production.

CNCMACHINES

Production equipment with Computer Numerical Control is a major component of CAD/CAM technology. For flexible automation on the shop floor, CNC machines plays major role. This technology is applied for large scale industries of material processing equipment. For manufacturing a component, the CAD/CAM process generates a Numerical Control program which can run on the CNC machine. The integration of CNC machines in the Computer IntegratedMachines.

Types of CNCMachines

I. CNC Machiningcentre.

2. CNC Turningcentre.

3. CNCLathes.

4. CNC milling/drillingmachines.

5. CNC special purposemachines.

Applications of CNCMachines

1. Metal cutting industry, for processes suchas:

Milling, Drilling, Boring, Turning, Grinding, Sawing etc.,

For production jobs where

(i) Part geometry iscomplex.

(ii) Parts and processed frequently and in small lotSize.

(iii) Many operations must be performed on the part in itsprocessing.

(iv) Design changes arelikely.

(v) Close tolerances arenecessary.

(vi) It is an expensive part and a mistake would becostly.

2. In addition to metal cutting machines, CNC has also been applied to the following:

(i) Weldingmachines.

(ii) Press working machinetools.

(iii) Inspectionmachines.

(iv) Wire - wrapmachines.

(v) Clothcutting.

(vi) Automate d knittingmachines.

(vii) Laser be amprocesses.

(viii) Flame a nd plasmacutting.

(ix) Assembly machinesetc.

NC Axis Conventions

In NC machine tool s, each axis of motion is equipped with a sep arate driving device which replaces the h and wheel of the conventional machine. The driving device may be a DC motor, hydraul ic actuator or a stepping motor. The type of motor selection mainly depends on power re quirements of the machine.

By axis of motion, we mean an axis in which the cutting tool moves relative to the workpiece. This movement is achieved by the motion of the machine tool slides. The main three axes of motion will be referred to as the x, y and z axis. The z axis is perpendicular to both x and y in order to create a right-hand coordinate system asshown in fig *5.4.* Positive motion in the z direction moves the cutting tool away from the workpiece.

The location of the origin x = y = z = 0 may be fixed or adjustable. In the drilling and milling machines, the *x* and *y* axis are horizontal. A positive motion command in the drill moves the *x* axis from the left to right, the *y* axis from front to back and the z axis toward the top. In the milling machine, the directions are reversed. In the lathe, two axes are only required to command the motions of the tool. Since the spindle is horizontal, the *z* axis is horizontal. The cross axis is denoted by *x.* A positive position command moves the z axis from left to right and the *x* axis from back to front in order to create right hand coordinate system. In addition to the primary slide motions, if secondary linear slide motions exist, they may be designated *u*, *v* and w. Rotary motions around the axes parallel to *x, y* and z are designated *a,* band *c* respectively. The above discussed NC conventional system for drilling, milling and Lathe is shown in fig 5.4 (a), (b) and (c) respectively.

CUTTINGSPINDLES

Spindle tooling provides an objective connection between the cutting tool and the spindle of the machine tool. The spindle is employed to perform variety of cutting operations.

Requirements of spindles for CNC machines

(i) High stiffness - both static anddynamic.

(ii) Runningaccuracy.

(iii) Axial load carrying capacity.

(iv) Thermalstability.

(v) Axis freedom for thermalexpansion.

(vi) High speeds

The following are typical spindle tooling for various machining requirements.

(i) Drill chuckadaptors.

(ii) Colletchucks.

(iii) Morse taperadaptors.

(iv) Shell milladaptors.

(v) Face milladaptors.

(vi) Screwed shank end milladaptors.

(vii) Boringbars.

(viii) Boringheads.

Spindle Heads

The following are the various types of spindle heads:

(i) Inclinablehead.

(ii) Robot-likehead.

(iii) Horizontal spindlehead.

(iv) Vertical spindlehead.

(v) Universalhead.

In Robot-like heads, nine axes are available in the machines and six axes are controlled simultaneously. In *Universal-head,* pitch and roll are also offered on large floor type machine. In *horizontal and vertical heads,* long beam is available to rotate the orientation of a spindle through 90°. It is similar to right angle spindleattachments.

DRIVESYSTEMS

Basically the NC and CNC components are divided into two groups. They are

1. Electromechanicaldevices
2. DigitalCircuits

Every system includes a drive which converts the electrical command signals to mechanical motions. These are known as *electromechanical devices.* Drives for NC and robot systems are hydraulic actuators, DC motors or stepping motors. The selection depends upon the power requirements of the machine tool and the power Sources available.

ACDrives

Nowadays, CNC manufacturers started to use Alternate current motors as drives to CNC machine tools. AC motors are sometimes referred to AC synchromotors which would operate without brushes and eliminates one of the main maintenance problems associated with demotors.

Principle of operation

The velocity of the AC synchromotor is controlled by manipulation of the voltage frequency supplied to the motor. The frequency manipulation requires the use of an electrical inverter. The inverter contains a DC power supply and the circuit inverts the DC voltage into AC voltage with a continuously controllable frequency.

Advantages of AC motor over DC motor

1. AC motors are more reliable than DCmotors
2. AC drive provides stable and smoothoperation
3. AC cooling system allows high-speed, high output with compactsize.
4. AC motors are free from brushes which avoidsmaintenance.

Disadvantages of AC drives

I. Inverters used/or converting DC into AC are verycostly.

3. Size of the inverters is big which occupies more space.

Direct CurrentMotors

Direct current (DC) motors allow precise control of the speed over a wide operating range by manipulation of the voltage applied to the motor. They are ideally suited for driving the axes of small-to medium sized NC machines and robots. DC motors are also used to drive the spindle in lathes and milling machines, when a continuous control of the spindle speed isdesired.

Principles of operation

The DC motor is actually a DC machine which can function either as a motor or as a generator. The principle of operation of a DC machine is based on the rotation of an armature winding within a magnetic field. The armature is the rotating member, or rotor, and the field winding is the stationary member, or stator. The armature winding is connected to a commutator which is a cylinder of insulated copper

SteppingMotor

The stepping motor I S an incremental digital drive which translates a n input pulse sequence into a proportiona l angular movement and rotates one angular i ncrement i.e., step for each inputpulse.

Principle of operation

The drive unit contains a steering circuit and a power amplifier. It translates the input pulses into the correct switching sequence required to step the motor. The steered pulses are then converted into power pulses with correct time, duration and amplitude for driving the motor. To revers e the motion, an additional input is provided. Th e shaft speed in steps per second is equal t o the input frequency in pulses persecond.

Advantages

I. Stepping motors can be used in open loop NCsystem.

2. The system is cheaper.

3. More accuracy is achievable.

Hydraulic Systems

Hydraulic systems are used extensively for driving high-power mach ine tools and industrial robots, since they elm deliver large power while being relatively small in size. They can develop much hig her maximum angular acceleration than DC motors of the same peak power. They hav e small time constants, and it results in smooth operation of the machine tool slides and t he robot axes.

Hydraulic systems, however, present some problems in terms of maintenance and leakage of oil from the transmission lines and the system components. The oil must be cleaned and protected against contamination. Other undesirable features are the dynamic lags caused by the transmission lines and viscosity variations with oil temperature.

1. A hydraulic powersupply.
2. A servo valve for e ach axis ofmotion.
3. Asump.
4. A hydraulic motor for each axis ofmotion.

1. Hydraulic PowerSupply

The hydraulic power supply is a source of high-pressure oil for the hydraulic motor and the servo valve. The main components of the hydraulic pow er supply are shown in fig 5.7 and are as follows:

1. A pump *P* for su pplying the high-pressure oil. The frequently used types are the gear pump, an d radial or axial displacementpumps.
2. An electric motor *M*, usually a three-phase induction motor for driving the pump.
3. A line filter, for pr otecting the servo system from any dirt Or chips.
4. A coarse filter, located at the input of the pump for protecting the latter against Contamination that h as entered the oilsupply.
5. A check valve, for eliminating a reverse flow from the accumulator into the pump.
6. A pressure-regula ting valve. for controlling the supply pressure to the servo system.
7. An accumulator, for storing hydraulic energy and for smoothing the pulsating now.

Accumulators can provide a large amount of energy over a short interval of time and are used where the load is characterized by an average demand which is far below the required peak. The accumulator supplies the peak requirements and is subsequently recharged by the pump. Another function of the accumulator is to smooth the pulsations caused by the pump, and the variations caused by the sudden motions of the valve. The accumulator functions like a capacitor in an electric circuit.

2. Servovalve

The electro-hydraulic servo valve controls the flow of the high pressure oil to the hydraulic motor. The servo valve receives a voltage actuating signal and it drives a solenoid device to move the valve spool. The magnitude of the input voltage *V* defines the flow rate of oil *q* through the valve. Assuming that the oil pressure drop across the valve is constant, the following relationship isvalid:

$$q=KV$$

Where *K* is the constant.

The flow rate of oil through the valve is proportional to the velocity of the hydraulic motor. The time constant of a servo valve in a high-power system is on the order of 5111sand is usually negligible compared with the other lags in the system.

3. Sump

The used oil is returned to a sump or tank through a special return line. The oil is fed back to the hydraulic power supply and forms the Source of fluid for the latter.

4. Hydraulicmotor

The hydraulic motor or actuator is either a hydraulic cylinder for linear motion or a rotary-type motor for angular motion. The hydraulic cylinder is due to the large limited to a relatively small motion. The rotary hydraulic motor is usually used in large power servo systems. It operates at higher speeds and is geared down to the lead screw which drives the table. The simplified equation commonly used for determining the steady-state speed of hydraulic motors is

$$V=k\,q$$

Where, *q* is the flow rate of oil through the value (Volume per time), *V* is the motor speed, *and k* is the constant.

Pneumatic Drives

Like hydraulic syst em, pneumatic drives also obey the same principle i.e., pressurizing a fluid and deli vering it under pressure to where it can do w ork as in the hydraulic components.

In pneumatic power, an air compressor is used in place of a hydrauli pump and is usually located in a remote position within the factory. This location is usually away from the shop floor. The compres sor will normally be of such a size as to be abl e to provide a compressed air supply to t he whole industry for various pneumatically operated and controlled equipments. High pressure air for power In CNC machines is aro und 5 *bar* and low pressure for various control functions is about 1*bar*. As a result of the air being compressed, heat, water and oil are introduced into the air supply. Coolers are used to remove heat and much of the water. The remar.ru.ng water will require draining at regular points in the system . The falling ring system as shown in fig 5.8 illustrates this function since water is heavi er thanair.

SLIDE MOVEMENTELEMENT

Precise positioning and repeatability of machine tool slides ar e the major functional requirements of C NC machines. The inaccuracies that are cause d are mainly due to the stick slip motion w hen plain (metal to metal contact) slide ways ar e used.

To fulfill the requirements of elimination of stick-slip, there are different slide way systems such as rolling friction slide ways and slide ways with low friction. These have low wear negligible stick-slip, good vibration damping easy machinability, low price and low coefficient of frictionproperties.

Combinations of Machine Tool SlidewaySystems

Plain	**Rolling friction**
(Metal to metal) CI-CI CI CI - Steel Steel-Steel Steel-Steel Plastic - Steel	Linear motionsystem with recirculatingbars recirculating rollers.

In addition to this, both hydrostatic and aerostatic slide way systems (as in coordinate measuring machines) can also be used.

The Requirement of a Good SlidewaySystem

A good slideway system must possess:

1. Low co-efficient of friction at varying slidevelocities.
2. Minimum difference between static and dynamic friction coefficient -positive slope for friction - velocitycharacteristics.
3. Low rate ofwear.
4. High stiffness at the slidingjoints.
5. Sufficientdamping.

Plain slideways have good damping property than antifriction and pressurized slide ways. But there is a tendency for stick-slip at low feed rates. If it is coated with some antifriction material, good damping and low friction can be obtained.

IN-PROCESS PROBING ORINSPECTION

Generally, inspections are carried out in three methods. They are

1. Off-lineinspection
2. On-line/in-processinspection
3. On-line/post-processinspection

An *Off-line inspectio n* is performed away from the manufacturing process and there is a delay between proc essing and inspection. Most manual inspection falls into thiscategory.

In *on-line/post-proce ss inspection,* the measurement or gauging procedure is done immediately following the production process.

In *On line/in-process inspection (in process probing),* inspection probemeansdevice or tool used fo r inspection. The process of inspection is calle d*probing.*In-processprobing is the pro cess of performing the inspection procedureduringthe manufacturing operation. In this process, inspections as well as manufacturing aredone simultaneously.

Benefits of In-Proces sProbing

1. It reduces the inspe ctionpersonnel
2. 100% Inspection isachieved
3. High quality isensured
4. Deviations are corr ected at the manufacturing stageitself.

 5. Inspection time an d cost arereduced.

MACHINING CENTRES

Machining Centres are one of the important types of CNC machine tools. Automatic Tool Changer (ATC) is used here.

The following operations can be carried out here:

1. Milling
2. Drilling
3. Reaming
4. Boring
5. Tapping

lndexable tool magazine is an important character for machining center carrying (16-100) tools. Machining centre has two or more table named as *pallets. Automatic Pallet Changer (APC)* centre is used and time will be reduced i.e. work-in-process(WIP) will bereduced.

Classification of MachiningCentre's

According to the spindle configuration, machining centre's are classified as

1. Horizontal spindle machining centre
2. Vertical spindle machiningcentre
3. Universal machiningcentre.

1. Horizontal spindle machi ning centre

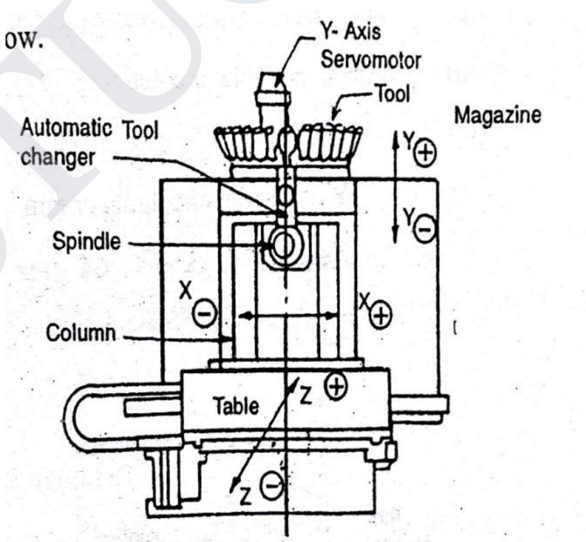


Figure 5.20 Horizontal machining centre

A typical horizontal spindle machining centre configuration is shown in fig 5.10. The features of the horizontal spindle machine are

(i) Single spindle machines

(ii) Automatic tool ch anger(A TC) (iii)Bed type machine .

(iv)Axis X ~ Table orcolumn

Y ~ Spindle head

Z ~ Saddle or column or head stock or spindle head

(v) Rotary indexing t able.

2. Vertical Spindle Machini ngCentre

A Typical vertical spindle m achining centre configuration is shown in figure

The features of the vertical s pindle machineare

(i) Single or Multi spindle

(ii) ATC or Turret head (Automatic Tool Changer).

(iii) Axis X ~ Table o rcolumn.

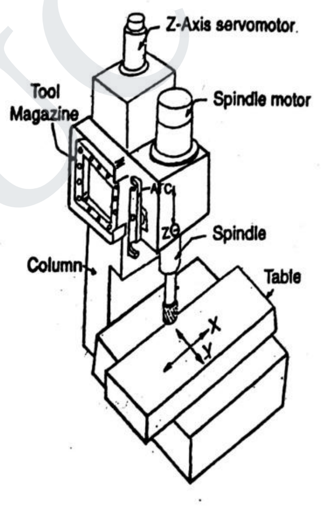


Figure 5.21 Vertical machining centre

Y ~ Saddle or column or ram

Z ~ head stoc k

3. Universal machining centre

The features of the Universal machining centre are:

(i) Single spindle

(ii) Spindle is capable of fitting horizontal tovertical

(iii) Five axis ofmachine.

(iv) Table als o can befitted.

(v) More flexi bility than other twotypes.

(vi) Tool breakage detection ispossible.

(vii) Automat ic loading and unloading ofworkpiece.

TURNING CENTRES

These are other types of popular CNC machines and are generally cla ssified as:

(i) Horizontal machinesand

(ii) Vertical

(iii) Classification of Ho rizontal Machines

Horizontal machines can be classified as:

(i) Chucking machines

(ii) Shaf tmachines

(iii) Universal machines

Some of the latest C NC lathes are twin spindle machines on which the first and second operations can be per formed on the two spindles in succession. The component is removed from the first spindle after the first operation and loaded into the s econd spindle for second operation automa tically. A typical configuration of a turning ce ntre is shown in figure 5.12.

1. Chucking machines

Usually have shorter beds and a single saddle with single drum type turret which accommodates tools or two independent saddles with turret. Many of th present day chucks offer optional swing- in-tailstock to facilitate shaft work. During no rmal working as a chucker, the tailstock is swung away from the workarea.

2. Shaftlathes

Shaft lathes are intended mainly for between centre works. They have hydraulic or pneumatic tailstock and roller steadies for supporting the workpiece. Tooling is mainly for externalworking.

3. UniversalLathes

Universal lathes are suitable for both chucking and for bar work. Four axis machines have two turrets each mounted on an independent slide and facilitate simultaneous machining with two tools.

Work HoldingSystem

To locate and hold the workpiece, in CNC machine tool, work holding system is used. The work holding devices used in CNC machines are:

1. Fixtures
2. Hydraulic chuck
3. Collectattachment
4. Bar holdingsystem
5. Steadies

Mostly fixtures are used as a work holding device in CNC machines. The following are the features for CNC machine tools:

(i) Fixture lengthcompensation.

(ii) Quick loading and unloading of fixtures onpallets.

(iii) Better accuracy of thefixture.

(iv) Rigidity to withstand cutting force.

Work Holding Devices

In order to keep setup time to minimum, the work holding devices should be accurate, easy and quick to operate, ensure rigidity against heavy cuts. Commonly used work holding devices are

(i) Colletchucks

(ii) Jaw chucks

(iii) Arbors

(iv) Fixtures

1. ColletChucks

Collet chucks are widely used to clamp bar stock in machining on lathes. Their main feature is a collet which is a steel sleeve with spline tapered portion forming jaw.

2. Jawchucks

Jaw chucks are used to hold irregular shaped individual work pieces. Various Jaw chucks employed for work holding are:

(i) Three jaw self - centre ringchuck.

(ii) Four jaw independentchuck.

(iii) Two jaw boxchuck.

(iv) Powerchucks.

3. Arbors

Arbors may be sometimes used for holding small work pieces having accurately drilled holes. Threaded type and expanding type arbors are in use.

4. Fixtures

Special fixtures may be employed to hold jobs which cannot otherwise be held in collets, jaws or arbors.

ToolingSystem

Tooling system for NC is designed to eliminate operator error and maximize productive machine hours. It can be done in one or more of the following ways:

1. Using quick-change toolholders.
2. Automatic toolselection.
3. Changing tools automatically for sequence operations.
4. Permitting accurate presetting of tools outside themachine.
5. Facilitating tool selection and tool changing through the numerical control program.

While tooling for NC machines might appear to be specialized, the actual components and principles involved have much in common with what could be considered proper practice for conventional machine tools. Numerical control merely hastens the general acceptance of more advanced toolingconcepts.

Tooling System for NC TurningMachines

To take full advantage of the metal cutting capability of the machine, the tooling should be rigid and well supported with quick, simple and accurate provision of adjusting tools. Non-productive time on the machine can be kept to a minimum. Simple tool changing methods reduce greatly the change-overtime between jobs on batch production.

Two basic types of tooling in use are:

(i) Qualifiedtooling

(ii) Presettooling

A *qualified 1001* has tolerance dimensions between the cutting edges and the tool location faces. The tool fits into locations on the machine which are accurately positioned relative to known datum positions on the slide. Thus, the cutting edges of a qualified tool will be located in a predetermined position to achieve closer tolerance on the workpiece. tool offset facility of the control is employed. Fig 5.13shows the qualified tooling for turning centres.

A preset tool has adjustable locating faces. It enables the dimensions between the tool cutting edges and locations faces to be preset to a much closer tolerance than that for a qualified tool. The preset tool usually needs to be removed from the machine for adjustments required during batch production. Of course, these tools can be used on NC lathes that do not have a control facility for entering tooloffsets.

MACHINE CONTROLLER

Machine Controller is the automatic control unit which provide s for manual intervention of the operator. It converts the information from the tape pro gram into the desired command signals. This is also called as Machine Control unit (MCU). The actuation systems come into the desired action on receiving the command signal from the MCU. The MCU may be housed in a separate body or on the machine itsel f. It Controls the path of cutting tool, spe eds and feeds, tool changes and several other functions.

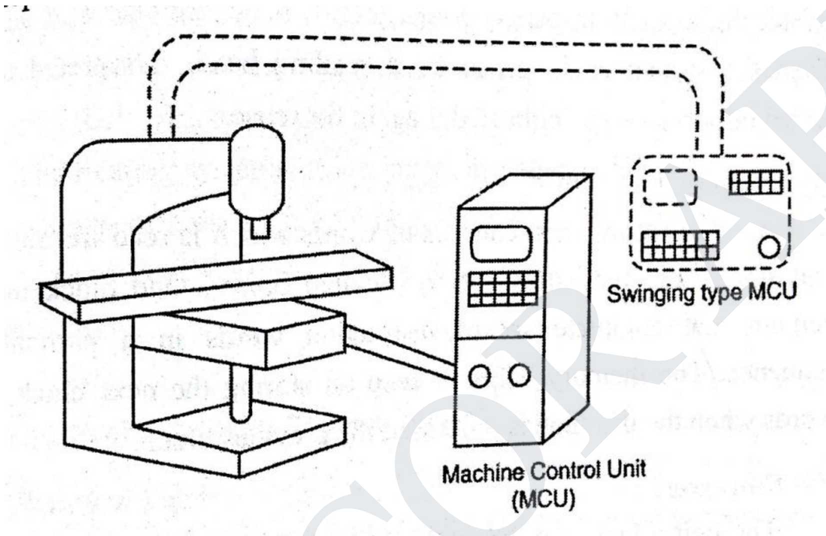


Figure 5.4 Machine Control Unit (MCU)

Capabilities of TheMCU

The machine control unit (MCU) should capable of doing the followi ng functions:

1. Machine tool spindle start andstop.
2. Varying the spindlespeed.
3. Changing t he direction of rotation of thespindle.
4. Stan and st op coolantsupply.
5. Changing t he desiredtool.
6. Changing t o the desiredworkpiece.
7. Lock and unlock fixtures andworkpieces.
8. Guiding the cutting tool tip along the desired path.
9. Controlling the feed rate of movement of thetip.

Open-Loop and Closed-LoopSystems

Every control proces s, and NC system tool, may be designed as an open-or a closed-loop control. The ter m open-loop control means that, since the loop is open there is no feedback and the action of the controller has no reference to the result it produces.

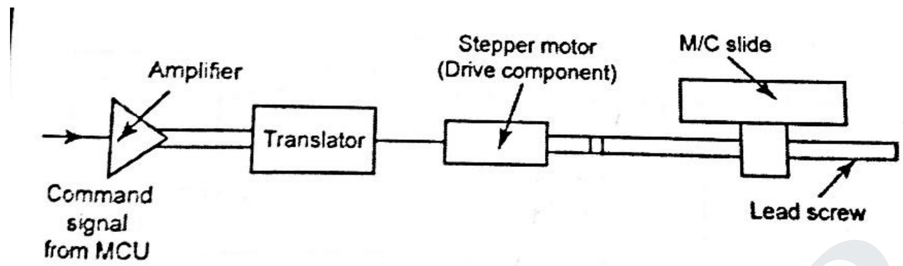


Figure 5.5 Open loop machine slide control

The open-loop NC systems are always of digital type and are u sing stepping motors for driving the slide s. A stepping motor is defined as one whose output shaft rotates through a fixed angle in response to an input pulse. The stepping m otors are the simplest way for converting digital electrical signals into proportional mom ent. So,they are a relatively cheap solution to the control problem. Since there is no check on the slide position, the system accuracyy is solely a function of the motor's ability to ste p through the exact number of steps provided at the input.

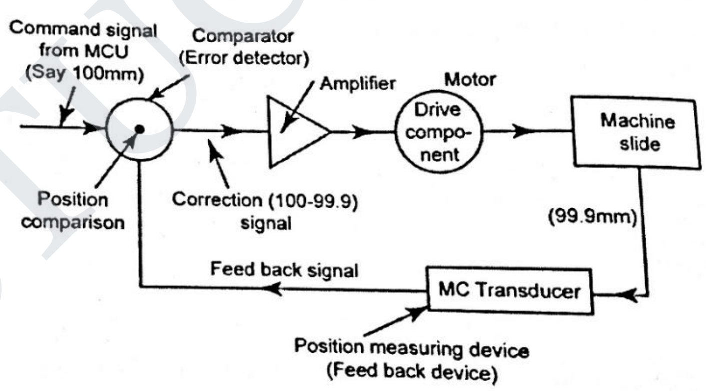


Figure 5.6 Closed loop positioning control

In closed loop, feedb ack system is used to close the loop. Position transducer acts as a feedback device. Figur e 5.16 and 5.17 compare an open-loop and a closed-loop digital control for one axis of motion. The closed-loop control measures t e axis actual position and compares it with the desired reference position. The difference between the actual and the desired valves is the error, and the control is designed in such a way as to eliminate or to reduce the e rror to a minimum. In this case, the system is a negative feedbackone.

CNC CONTROLLER

CNC systems also contain other features associated with the compute r of the CNC controller. These include a keyboard to aid in tape editing and a cathode-ray tube (CRT) screen on which messages are displayed for the operator. The availability of MCU features is important since they contribute to the satisfactory performance of the entire CNCsystem.

COORDINATE MEA SURINGMACHINE

In modern automated inspection procedure, sensors are having important role to control and communicate dat a. There are two main types of sensors like

1. Contactsensors 2. Non-contactsensors.

There are following t hree methods of automated contact inspection:

(i) Coordinate Measuring Machines(CMM).

(ii) Flexible in spectionsystems.

(iii) Inspectio nprobes.

Construction ofCMM

There are four major types of CMM construction. They are:

a) Cantileverconstruction b) Bridgeconstruction

c) Columnconstruction d) Gantry construction

All types of CMM constructions are shown in fig5.18.

1. Cantileverconstruction

In the *cantilever configuration*, the probe is attached to a vertical qu ill that moves in Z-axis direction relative t o a horizontal arm that overhangs the workta ble. The quill can also be moved along the length of arm to achieve Y axis motion and th e arm can be moved relative to the work table to achieve X-axis motion and enable quick despatch or right spare parts or spare boards to the user of the machine.

2. Bridge construction

The bridge configur ation is most common type used in industry. Instead of a cantilevered arm to achieve the Y-axis movement of the probe, the arm is supported on

both ends like a bridge. This construction provides greater inherent rigidity. 1t gives more accuracy than cantilevered CMM.

3. Columnconstruction

This construction is similar to the construction of a machine tool. Instead of achieving the relative motion by moving the probe, the column-type CMM obtains X-axis and Y-axis relative motion by moving the work table. The probe quill is moved vertically along a rigid column to obtain the Z-axismotion.

4. Gantryconstruction

This construction is generally intended for inspecting large objects. X-axis and Y-axis motions are achieved by a construction similar to a gantry crane. The probe quill (Zvaxis) moves relative to the horizontal arm extending between the two rails of the gantry.

CMM can be operated by means of the following methods.

1. ManualControl
2. Manual Computer-assistedControl
3. Motorized Computer-assistedControl
4. Direct ComputerControl

CMMBenefits

Benefits of CMM are:

1. Increasedproductivity
2. Flexibility can beincreased
3. Reduced operatorerror
4. Greater accuracy andprecision

MAINTENANCE FEATURES OF CNCMACHINES

CNC machines and systems are designed with a high degree of reliability. The mean time between failures (MTBF) of some CNC systems is quoted today at more than hundred months. System failure in such cases is thus a very rare this aspect before deciding on the purchase of the machine. Systems with high reliability but higher cost is advisable than low cost systems which are invariably less reliable. Emphasis oncost reduction may often prove costly in the long run. It is also necessary to assess the strengths of the machine tool manufacturer or supplier in the following areas:

1. Inventory of spares and spare partssupport
2. Availability of enough persons with theseller to carry out maintenance in electrical, mechanical, hydraulic and electronichardware.
3. The time elapsed between the intimation of the failure and responseby the machinesupplier.
4. Arrangements made by the supplier to obtain spares from hisprincipals.

Diagnostic programs available in CNC machines are a very helpful feature to identify the causes of malfunctioning. The machine manuals give the alarm, message and the remedial action. With the help of these a large number of snags in the operation of CNC machines can be rectified by the maintenance staff or even by the operator himself. These diagnostics check the various sections of the system at the time of start up and only if all the systems are working satisfactorily, the "ready" signal is displayed.

In advanced countries, the maintenance of CNC machines are facilitated by connecting the CNC system through telephone cables to the manufacturer's works so that the experts can check up the machine through remote access and identify the cause for snag, this will avoid unnecessary visit by the service engineers.

5.16.1. Training in maintenance

The need for having trained maintenance staff for attending the CNC machines is to be emphasized. The staff can be trained at the manufacturer's works. Training can be imparted through special programmes organized by system manufacturer's or training

organizations. The modular design of today's CNC machines enables maintenance to be carried out quickly. As far as PCB's are concerned, maintenance is done by replacing them rather than trying todetermine
which chip is defective. Similarly the maintenance procedures of hydraulic, mechanical and electrical items are also fairly simple so that persons with good training for a short period can attend to the machines successfully.

INTRODUCTION TOO PARTPROGRAMMING

The conversion of E ngineering blueprint to a partprogramcan be performed manually or with the assi stance of a high-level computer language. I n both, part programmers determine the cutting parameters, such as spindle speed an d feed,based upon characteristics of the w orkpiece, tool material and limitations of the machine tool. Therefore, they must have ex tensive knowledge of machining process, arid machine tool.

PartProgram

The part program is a set of instructions proposed to .get the m achined part starting with the desired bl ank and the NC machine tool. Each line of instruction is capable of specifying dimen sional and non dimensional data and. is written in a specific format. This format is known as *NC block.* Fig 5.19 shows the part programprocedure.

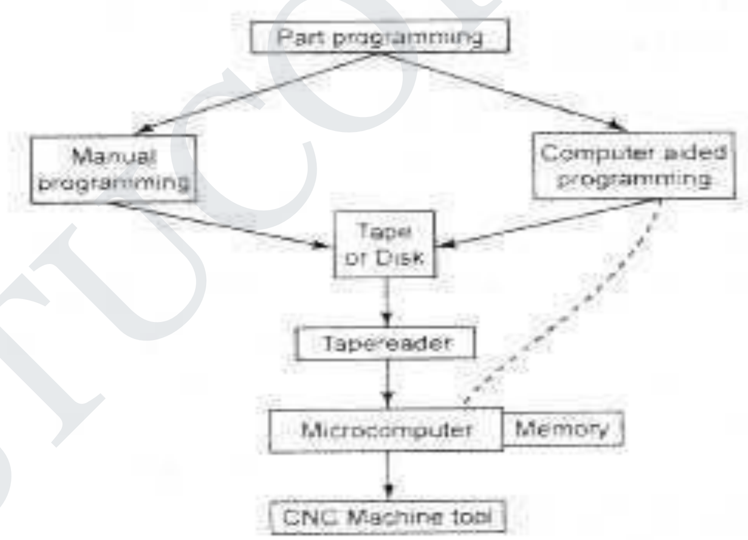


Fig 5.19. Layout of part program procedure

This work is carried out by a part programmer. He prepares the planning sheet and writes the instructions in a coded form which is acceptable to the con troller of the machine tool.

Methods of Creatin g PartProgramming

The following are var ious methods of creating part programming.

(i) Computer - assisted part programming system.

(ii) Manual datainput.

(iii) Computer automated partprogramming.

MANUAL PARTPROGRAMMING

To prepare a part program using manual method, the programmer writes the machining instructions on a special format called *part programming manuscript.* The instructions must be prepared in a very precise manner because the typist prepares the NC tape directly from the manuscript. Manuscripts come in various forms depending on the machine tool and tape format to be used. The manuscript is the relative tool and workpiece locations. It includes preparatory functions, miscellaneous instructions and speed / feed specifications all of which are needed to operate the machine under tape control. Manual programming jobs can be divided into twocategories.

(i) Point-to-pointjobs

(ii) Contouringjobs.

Except for complex work parts with many holes to be drilled, manual programming is ideally suited for point-to-point applications. On the other hand except for the simplest milling and turning jobs, manual programming can become quite time consuming for application requiring continuous path control of tool. So, contouring is much more suitable for computer - assisted partprogramming.

Data Required ForProgramming

(i) JobDimension/workpiece.

(ii) Workholding (damping,lnchucking).

(iii) Feed/cuttingspeed.

(iv) Finished dimension withtolerance.

(v) Sequence ofoperation.

(vi) Types oftools.

(vii) Mounting oftools.

COORDINATESYSTEMS

To determine the sequence of positions and movements of the cutting toolrelative to the workpiece, it is necessary to establish a standard axis system. Two axes X and Yare defined in the plane of the table: The Z axis is perpendicular to this plane andmovement in the Z direction is controlled by the vertical motion of the spindle. The positive and negative directions of motion of the tool relative to table along these axes are shown in fig 5.20.

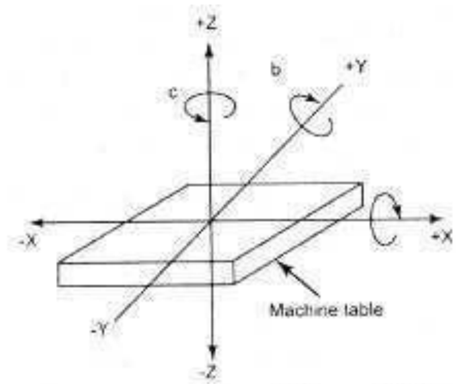


Fig 5.20. Coordinate system for milling and drilling process

There are 3 rotationa l axes a, b, c as shown in figure 5.20. These axes specify angles about the X, Y, and Z axes, respectively. To differentiate positive from negative angular motion, the right-han d rule is normally used. Using the right hand with the thumb pointing in the positive line ar axis direction, the figures hand are curled t opoint in the positive rotational direction.

For turning operation s, two axes are required to command the mov ement of the tool relative to the rotating w orkpiece. The Z axis is the axis of rotation of the work part and X axis defines the radial location of the cutting tool.

5.19.1. Zero Points and Reference Points

Origin is considered as zero point of the coordinate system. NC m achines have either of two methods for sp ecifying the zero point. They are *fixed zero* and *floating zero.* In fixed zero, the origin is always located at the southwest corner (i.e) lo wer left-hand corner of the table and all too l locations will be defined by positive X and Y coordinates.

In floating zero, the machine operator set the zero point at any po sitions on the machine table. The part programmer decides the zero point to' be located . This is also known as *reference point.* At the beginning of the job, the operator moves the tool under manual control to some 'target point' on the table. The target point is som e convenient place on the workpiece or t able for the operator to position the tool. Then the operator presses zero buttons on the m achine tool which tells the machine as a zero point.

The purpose of the cooordinate system is to provide a means of locating the tool in relation to the workpiece. De pending on the NC machine, the part program mer may have several different locationsavailable.

NC RELATED DIMENSIONING

There are two progra mming available for the part programmer.

1. Absolute positioning
2. Incrementalpositioning

Absolute positioning means that the tool locations are always defined in relation to the zero point. G90 code i s used in part programme to represent absolute mode.

Incremental position ing means that the next tool location must be defined with reference to the previous too l location. G91 code is used in part programm e to represent incremental mode.

Specify x = 6 and y = 8 for absolute programming

Specify x = 2 and y = 3 for incremental programming

While doing progra mming, there are two types of units system for making dimensions. They are:

1. Inchsystem
2. Metricsystem

For denoting Inch system, G70 command is used and for metric system G71 is used.

PROGRAMMINGPROCEDURE

Basically, we can write program in two ways. They are

1. Absolute programming
2. Incrementalprogramming

The computer will be however informed to interpret properly.

The G codes for the above two types are

G 90 - Absolute programming

G 91-lncremel)tal programming

For example in absolute programming, the distance at my point at any instant will be measured from the origin (X=O, Y=O).

Whereas in incremental programming, the instant point will be noted as (X=O, Y=O). Further measurement will be made from the particular point only.

The following steps should be kept in mind while writing the programme.

1. Fixation of coordinatesystem.
2. Reference of G and Mcodes
3. Dimensions of work andtools.
4. Locating the fixture and machinetable.
5. Speed and feed according to the work and toolmaterial.

Part Program Format andSymbols

The program format is *N4/G2/X431Y43/F03/S200/M03*. From the above format, we should understand the following

(i) N indicates the *block number* which has the number 1 to9999.

(ii) G denotes the *preparatory function* having two digits 00 to99.

(iii) X and Y co-ordinates may have up to seven digits each like1234567.

(iv) F indicates the *Feed*given.

(v) S indicates the speed of work (or) Spindle.

TOOL INFORMATION

Speed

Normally, speed in C NC machines refers to spindle speed whose unit is *rpm*. In programming, *rpm* should be noted as S (numerical value) for example S 1800 means that the speed of the spindle is 1800 *rpm*.

The code of preparatory function used for spindle speed is G 97. If code of preparatory function used for spindle speed is G 97 and cutting speed in *m/min* is given. The corresponding spindle speed will be considered automatically. The format used is G 97 V 250 X 25 which means setting spindle speed corresponding to the cutting speed of 250 *m/min* of diameter*25mm.*

Feed

It is used to measure the distance travelled by the tool. The unit used is *mm/min* or *mm/rev,* The rapid feed is up to *10m/min.* Manually or using preparatory function, we can use the rapid feed or vary the feed.

ToolsNumber

The cutting tool will be coded using 1-5 digit numbers. From this code, the respective tool and its position can be automatically identified and changed by means of tool changer. For example, T 121 means that the tool from station I is used having second cutting edge.

ToolOffset

To calculate the tool path, tool length information should be given as input.

(i) Presetting device will be used in some machiningcentres.

(ii) Tool tip is given in programmes.

(iii) Automatic tool calculation is used in somemachines.

(iv) To hold the blank in chuck and jog the tool to touch the diameter and a face of work piece, these diameter and length will be the input tomemory.

Tool LengthCompensation

The setting of the depth of the tool to an exact figure is very difficult and time consuming. Therefore, it may be convenient to set the tool to an approximate dimension and then adjust the difference by some external means such as switches on control systems. These practices are found very useful when the tool needs to be replaced and then the machine instructions need not to be changed and only the difference in two dimensions are fed through the switches. Further, this facility can be usefullyemployed to program a number of tools with the same instructions for tool travel.

INTERPOLATION

It is the process of developing coordinate points in between start and finish coordinates. The interpolation function could be spot between the microprocessor and hard wired interpolators. It is splitted as *coarse* interpolation and fine interpolation. Software is used for coarse interpolation and hardware is for fine interpolation.

Interpolator

Mostly contouring systems are done by interpolator. Two types of interpolators used are:

1. ExternalInterpolator
2. InternalInterpolator

External Interpolation means that crowding the points on punched tape (or) program and giving instruction of the velocity in each axis and changing this from point to point. *Internal Interpolation* is a general instruction given by the program to follow a specified curve between two points widely spaced.

Classification ofInterpolation

1. Linear Interpolation (GO I code is used in partprogram)
2. Circular Interpolation (G02, G03 codes are used in partprogram).
3. HelicalInterpolation
4. Parabolic Interpolation.

MACROS

Macro is similar to subroutine used in FORTRAN language. It would be used where certain motion sequences would be repeated several times, within a program. It is used to reduce the total number of statements required in the APTprogram.

It is a programming concept used

(i) toprogram

(ii) tostore

(iii) to recalland

(iv) to execute automatic cycles and family ofprograms.

The Features of macros are

(i) Variables are allowed.

(ii) Mathematical operations +, -, x, ÷ arepossible.

(iii) Interrupt control can be done.

The Format used for Macro Statementis

Symbol = MACRO/Parameter definitions.

Symbol should have six characters or fewer and at least one of the characters must be a letter of alphabet. Parameters are used for identifying certain variables which might be changed each time the subroutine was called.

For performing drilling operation, we can use MACRO statement as shown below:

DRILL

MACRO/PX

GOTO/PX

GODLTA 10, 0, -1.0

GODLTA 10, 0, + 1.0

TERMAC

FROM/PO

CALL I DRILL, PX = Pl

CALLI DRILL, PX = P2

CALL / DRILL, PX = P3

GOTO/PO

SUBROUTINES

If the same machining operation, which was carried out already, is to be performed at many different positions on the work piece, it can be executed by means of a program called as *Subroutines.*

Subroutine can be used anywhere in the part program. (If the machining operation is to be done at the same place repeatedly. The program used will be called as repeat loop).

5.27.1. Programming Structure

The block structure of Subroutine is L XXXXYY - (Some digits) Where LO - Subroutine end

LXXXX - Program Jump

LXXXXO I - Subroutine call

LXXXXYY - Repeat loop call

CANNED CYCLES

A *Canned cycle* is a combination of machine moves that performs any one particular machining function such as drilling, turning, milling, boring, tapping etc.

The preparatory function for canned cycle:

(i) G81 to *G89* are used for cannedcycles

(ii) G80 is used for cancelling the cannedcycle.

For roughing cycle, using G81 the following parameters should be given as input:

G81; Total cut depth; Total cut length; cut per pass;

Length to pull-in; Length to pullout; Rapid in

(iii) End of block.

ELECTRICAL DISCHARGE MACHINING(EDM)

EDM is also known as spark machining. At some time or otheryoumay have observed and caused by an accidental short circuit&noticed the pitting that occurred on the surface of the shorted material. This is the principle ofEDM.

It consists of

1. Power supply(40-300v)
2. Toolhead
3. Servomechanism
4. Coolant

The following types, of EDM are used in CNC.

(i) RAM typeEDM

(ii) Orbital typeEDM

(iii) Wire cutEDM

RAM-EDM

In this machine, the electrode has to get the similar size and shape of its counter part of the work piece which is to be machined. Servo control is used to maintain the gap between the electrode and the workpiece.

OrbitalEDM

In this type of machines, the electrode is in the form of a ball ended cutter and spins about its own axis. The relative position of the electrode and workpiece is regulated by a three axis CNC system to ge nerate any three dimensionalsurface.

Wire cutEDM

It is an indispensable machine in tool room. It is used for blanking and piercing. Electrode is in the form of w ire. A small hole is drilled in the workpiece. The movement of work table through CNC in X and Y directions enable cutting the component to the required shapes. In some cas e three axis NC isuse

IV.

V. CANNED CYCLES (TU RNING) Program10

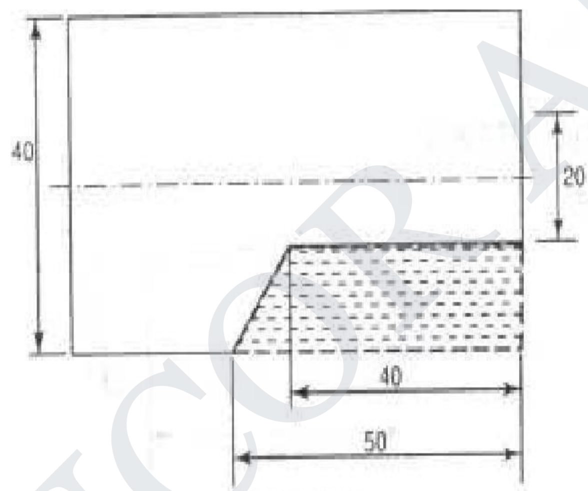


Fig. 5.32.

```
%      TPT *
N0010  G00          G90 TO x20* (Tool change position)
N0020  T0101        M06 * (Tool change)
N0030  X44 Z2       G94 F200      M03*(Cycle start point)
N0040  G81; 20; 52; 0; 42; 0*     (Cycle parameters)
N0050  G00 G90 TO x          Oz0m05*
                             (back to tool change position)
N0060  M03*                  (End of program)
```

APT PROGRAMMING

It is the abbreviation of *Automatically Programmed Tools.* Massachusetts Institute of Technology (MIT), USA, developed this language in June ~956. Firstly, it was used for contesting programmes. Today it is used for continuous path programming up to five axes.

It includes

APTURN for Lathes

APTMIC for mill & drill

APT POINT for point -point operation.

APT program is used to command the cutting tool through it sequence of machining process. APT is also used to calculate the cutter positions. APT is a three dimensional system controlling up to live axes including rotationalco-ordinates.

APTStatements

There are four types of statements in the APT language.

(i) Geometric statements

(ii) Motionstatements

(iii) Postprocessorstatements

(iv) Special control or Auxiliarystatements

1. Geometric statements

These statements are used to define the part configuration, which includes points, lines, circles, planes, cylinders. ellipses, cones, general conics and quadrics with a totalof fifteen differentsurfaces.

The format used for geometry statement is: Symbol

= geometry type / descriptive data.

2. Motionstatements

These statements are used to control the cutter path to generate the part and include start-up procedures, point-to-point programming. Cutter description and direction modifiers.

The format used for motion, statement is:

Motion command / descriptive data

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3. Postprocessorstatements

To write a complete part program, statements must be written t o control the operation of the spindle, fee d, and other features of the machine tool. The se are called *postprocessor statements*. Th e postprocessor allows the transformation of a postprocessor control statement into an ap propriate code of the control. Examples of post-processor statementsare:

COOLNTION

SPINDLION

FEDRAT/20

SPINDLIISO O, CCW

END

4. Auxiliarystatements

Auxiliary statements are used for cutter size definition, part identification and so on. These statements contr ol the output listing, translation, rotation and repetitive programming techniques. Examples of auxiliary statement are:

CLPRNT Cutter location print

OUTTOL Ou tside tolerance

INTOL Inside tolerance

FINI Termination of the program.

APTprogram

Program 1

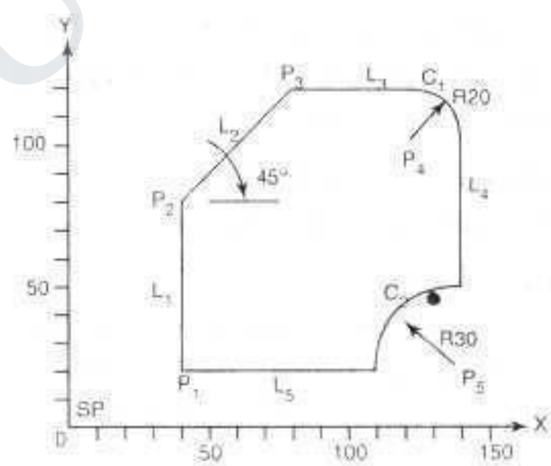

Fig. 5.33.

MICROMACHINING:

Micro-machining involves features smaller than about 0.001" (what they actually say is smaller than 0.00098"). Given that we typically want accuracies that are about 1/10 of the tolerances required, micro-machining requires accuracies in the 0.0001" or less range. Cutters smaller than 1/8" or about 3mm are used for micromachining. The world of micromachining is all about either very small features on normal-sized parts, or very tiny parts. Some of the work done with micromachining is truly beautiful and spectacular.

With micromachining there is a pronounced minimum chip thickness that must be observed if the machining operation is to be successful. Below that thickness, chips simply do not form. In fact, most micro-milling involves a relationship between chip thickness (chipload per tooth) and cutting edge radius that is marginal. Often, a chip is not formed by every revolution. In other words, chips are formed intermittently, and when they do form, they're larger than would be predicted by the calculated chiploads. The difference between the volume of chips formed by "normal" milling operations and micro-milling can be as high as 9x for micro-milling and is typically on the order of 2-3x.

Compounding the problem of higher cutting forces is that the micro-machining cutters themselves are small and less able to resist tool deflection. They're more delicate and more likely to break in the face of deflection, higher chip loads relative to their size, and higher cutting forces.

ADVANTAGES:

1. **Accuracy:** As described, micro-machining begins with features around 0.001" insize and this requires accuracies in the 0.0001"range.

2. **Care for Deflection and Cutting Forces:** Small tools deflect much more easily and the forces involved are 2-20 times greater than conventional machining models would predict. Always use the shortest possible tool to maximize rigidity. Toolpaths mayneed to combine roughing and finishing as the feature may be too thin for separate roughing and finishingpaths.

3. **Care for Chiploads and Feedrates:** Once the cutting edge radius is the same as the chipload, the actual rake of the cutter is irrelevant and it behaves as a negative rake cutter. There is a very narrow range of acceptible chiploads before tool life and outright breakage become aproblem.

4. **High Spindle** RPMS to allow reasonable feedrates within the limitations of the chiploads micro-cutters can tolerate. Given that chiploads are baked in by cutter geometry considerations at the micro-scale, the only way to increase machine speeds isto use high spindle rpms to allow reasonable feedrates within the chiploadlimitations micro-cutters can tolerate.

TROUBLE SHOOTING OF CNC MACHINES

Trouble shooting is nothing but repairing CNC Machines which consumes.

(i) time

(ii) Cost

The following factors are involved in trouble shooting.

(i) Spares are notavailable

(ii) Delay in gettingspares.

(iii) Lack of manpower to troubleshoots.

Preventive maintenance is therefore chosen than any other maintenance to

(i) Maximize machineavailability.

(ii) Minimize downtime.

(iii) Increase the life of themachine.

Preventive maintenance are consisting

(i) Dailyschedule.

(ii) Weekly preventivemaintenance.

(iii) Monthly preventive maintenance.

Preventive maintenance concentrates on thefollowing:

(i) Oilchecks.

(ii) Cleaning of machines.

(iii) Hydraulic pressuresetting.

(iv) Checking tool changers, turrets, probesetc.

(v) Cleaning of switches, filters, tapereader.

(vi) Checking tool change time, table indexing time, feed rate spindle speed etc.