18ME504

Hall Ticket Number:

III/IV B.Tech (Regular) DEGREE EXAMINATION

February, 2021 **Mechanical Engineering**

Fifth Semester **Metal Cutting & Machine Tools**

Time: Three Hours **Maximum:50marks**

Answer Question No.1 compulsorily. **(10X1 = 10 Marks)**

Answer any four Questions from Section II. **(4X10=40 Marks)**

1 Answer all questions **(10X1=10Marks)**

a) What are the primary and auxiliary motions for turning operation in lathe.
b) Mention the taper turning Methods in lathe.
c) What is the purpose of using back gears in the lathe.
d) How is the size of planer specified?
e) How the machining time in drilling is calculated.
f) Differentiate between up milling and down milling.
g) What is meant by tool signature?
h) What are the applications of super finishing operations?
i) What is the cause of built up edge?
j) Write the formula for calculation of shear strain in metal cutting

SECTION II

2.		Explain the operations performed on lathe(at least 5) with neat diagrams.	10M
3	a)	Specify the work and tool holding devices used in a Lathe machine.	5M
	b)	Explain with the help of neat sketch, the All geared headstock mechanism in lathe.	5M
4	a)	Sketch and describe any one quick return mechanism of shaper.	5M
	b)	With the help of neat sketch explain the radial drilling machine.	5M
5	a)	Differentiate between shaping and planing machines	5M
	b)	What are the various factors to be considered in selection of a grinding wheel? Discuss each in detail.	5M
6	a)	What are the differences between compound indexing and differential indexing? Explain the relative merits.	5M
	b)	Explain any one finishing operation with neat sketch.	5M
7	a)	List the various types of milling cutters. With a neat sketch explain cutter geometry	5M
	b)	Describe schematic diagram of universal milling machine.	5M
8	a)	Explain the various types of chips.	5M
	b)	Derive the expression for shear angle in orthogonal cutting in terms of rake angle and chip thickness ratio.	5M
9	a)	During orthogonal turning of mild steel with a carbide cutting tool of 10^0 rake angle, the following data has been obtained: width of cut = 2 mm; uncut chip thickness=0.25mm; cutting velocity V = 200 m/min; chip thickness = 0.39 mm; F_c = 320 N; F_t = 170 N. Calculate a) shear angle b) shear and normal shear force c) friction angle; d) shear strain; e) specific cutting energy	10M

1. **a) What are the primary and auxiliary motions for turning operation in lathe**

Primary- work rotation , auxiliary-tool feed

b) Mention the taper turning Methods in lathe.

(A) By a broad nose form tool. (B) By setting over the tailstock centre. (C) By swivelling the compound rest. (D) By a taper turning attachment (E) By combining longitudinal and cross feed in a special lathe

c) What is the purpose of using back gears in the lathe.

To provide more speeds for spindle in lathe specially to reduce the speed.

d) How is the size of planer specified?

maximum length of the stroke, no. of tools operate at a time

e) How the machining time in drilling is calculated.

$$T=L/(f*N)$$

f) Differentiate between up milling and down milling.

- **Up milling or Conventional milling**—when feed direction is opposite to the cutter rotation at the point of engagement. Here uncut chip thickness increases with cutter rotation.
- **Down milling or Climb milling**—when feed direction is along the direction of cutter rotation at the point of disengagement. Here uncut chip thickness decreases with cutter rotation.

g) What is meant by tool signature?

The numerical code that describes all the key angles of a given cutting tool. A tool signature may be used for HSS or carbide inserts. • Convenient way to specify tool angles by use of a standardized abbreviated system is known as tool signature or tool nomenclature. • It indicates the angles that a tool utilizes during the cut. • It specifies the active angles of the tool normal to the cutting edge. This will always be true as long as the tool shank is mounted at right angles to the work-piece axis. Tool Signature .The seven elements that comprise the signature of a single point cutting tool can be stated in the following order: Example: Tool signature 0-7-6-8-15-16-0.8 1. Back rake angle (0°) 2. Side rake angle (7°) 3. End relief angle (6°) 4. Side relief angle (8°) 5. End cutting edge angle (15°) 6. Side cutting edge angle (16°) 7. Nose radius (0.8 mm)

h) What are the applications of super finishing operations?

steering rack components, transmission components, fuel injector components, camshaft lobes, hydraulic cylinder rods, bearing races, needle rollers, and sharpening stones and wheels

i) What the cause is of built up edge?

Built up edge (BUE) is an accumulation of material against the rake face, that seizes to the tool tip, separating it from the chip.

shear is strongest at the contact surface with the cutting tool, the first layer of metal impacting and seizing on it work-hardens more than the rest of the volume of metal. As a consequence of this work hardening, this first layer of metal is stronger than the adjacent metal moving away from the workpiece. Effectively, said first layer becomes part of the tool. The process repeats itself and, after some time, a built up edge (which could be several hundred micrometres thick) forms.

The conditions necessary for a noticeable edge to build up are that:

The cutting speed is low. This is because at high cutting speeds the metal moving away from the workpiece becomes hot enough to recover before seizing onto the tool, preventing the formation of a

BUE.The metal being cut is one that work-hardens and is reluctant to recover. A BUE will not form with pure metals since they do not work-harden much. Conversely, alloys, such as steel, do work-harden and recover less so they are prone to forming a BUE.

j) Write the formula for calculation of shear strain in metal cutting

$$\mathrm{Cot}\,\emptyset + \boldsymbol{Tan}\,(\emptyset - \propto)$$

Where,

ε =Shear strain, ϕ = Shear plane angle and α = Rake angle of cutting tool

2

Explain the operations performed on lathe(at least 5) with neat diagrams. 10M

A Lathe Machine consists of the following operation:

Centering

Facing

Turning

Chamfering

Knurling

Thread cutting

Drilling

Boring

Reaming

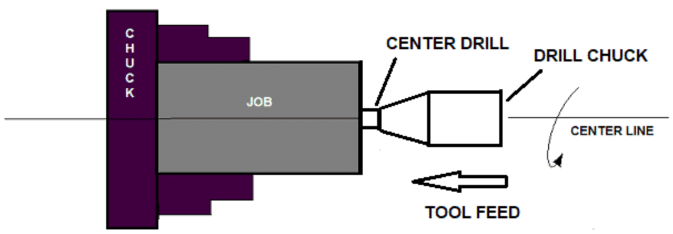
Spinning

Tapping

Parting off

Centering operation in the lathe:

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



Facing operation in the lathe:

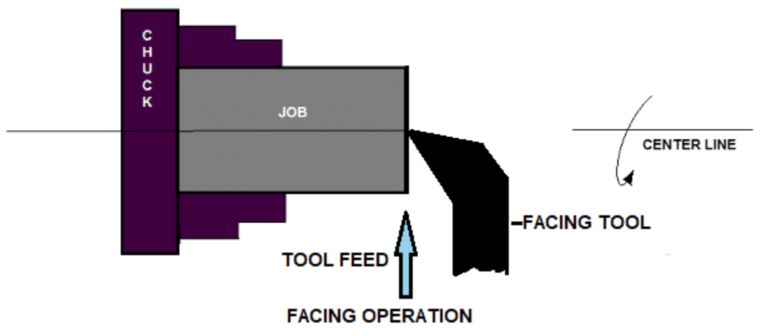
Facing operation is for making the ends of the job to produce a smooth flat surface with the axis of operation or a certain length of a job.

In this operation,

Hold the job on Head-stock spindle using Three or four-jaw chuck.

Start the machine on desire RPM to rotate the job.

Give a desirable feed on the perpendicular direction of the axis of the job



Turning operation in the lathe:

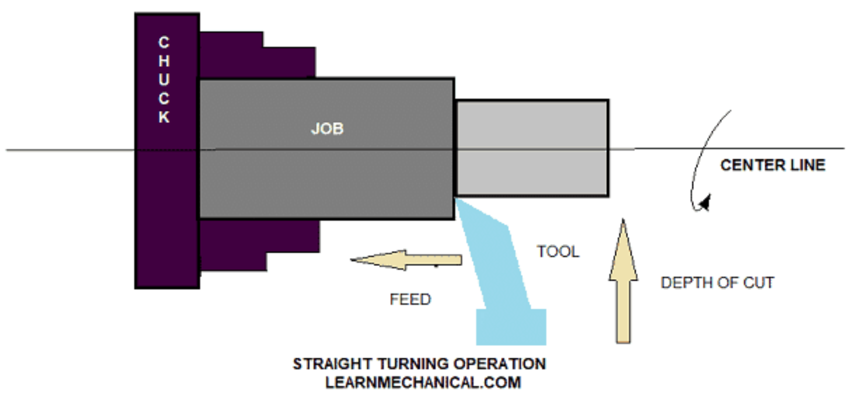
The operation by which we remove the excess material from the workpiece to produce a cone-shaped or a cylindrical surface.

Straight turning:

This operation is done to produce a cylindrical surface by removing excess material from the workpiece.

It is done in the following ways:

1. Mount the job by suitable job holding device and check the trueness of the job axis with the lathe axis.
2. Hold the cutting tool on the tool post and set the cutting edge at the job axis or slightly above it.
3. Set the spindle as per the desired feed.
4. Give depth of cut as per finish or rough cut.
5. Start the machining.
6. Engage automatic feed to move the carriage with the tool to the desired length, then disengage the feed and carriage is brought back to its starting.
7. The process is repeated until the job finished.



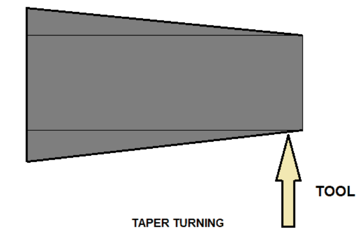
Taper turning:

First, let me give you an idea about the taper.

A taper is defined as a uniform decrease or increase in the diameter of a workpiece along with its length.

The operation by which a conical surface of the gradual reduction in diameter from a cylindrical workpiece is produced is called taper turning.

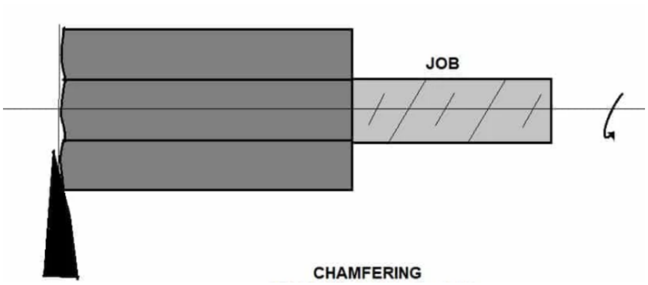
TAPER TURNING OPERATION



Chamfering operation:

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

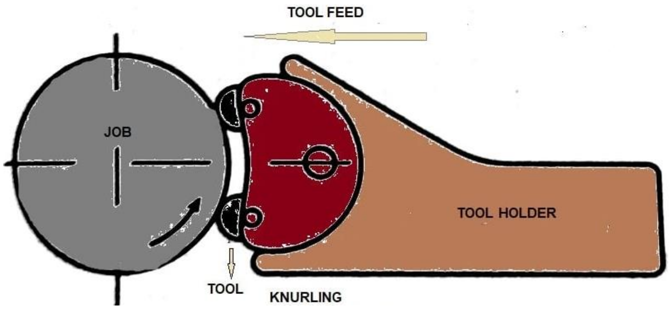
This operation is done after thread cutting, knurling, rough turning.



Knurling operation:

It is the process of producing a rough surface on the workpiece to provide effective gripping.

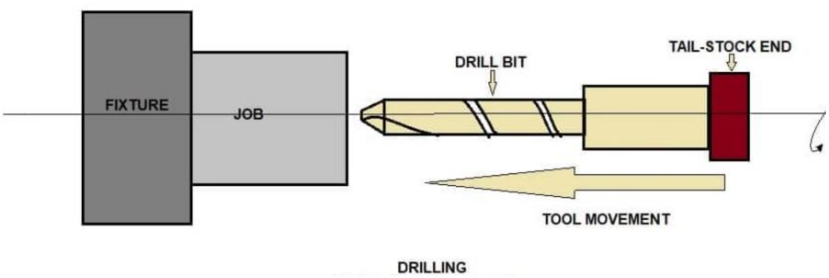
Knurling tool is held rigidly on the tool post and pressed against the rotating job so that leaving the exact facsimile of the tool on the surface of the job.



Drilling operation:

Drilling is an operation by which we can make holes in a job.

In this operation, the job is rotated at the turning speed on the lathe axis and the drilling tool fitted on the tail-stock spindle. And the tail-stock is moved towards the job by hand feed.



3 a) Specify the work and tool holding devices used in a Lathe machine.

WORK HOLDING DEVICES OF LATHE MACHINE

The work holding devices are used to hold and rotate the workpieces along with the spindle. Different work holding devices are used according to the shape, length, diameter and weight of the workpiece and the location of turning on the work. They are

1. Chucks

2. Face plate

3. Driving plate

4. Catch plate

5. Angle Plate

6. Carriers

7. Mandrels

8. Centers

9. Rests

1. Chucks

Workpieces of short length, large diameter and irregular shapes, which can not be mounted between centres, are held quickly and rigidly in chuck.There are different types of chucks namely, Three jaw universal chuck, Four jaw independent chuck, Magnetic chuck, Collet chuck and Combination chuck.

Chucks are efficient and true devices for holding the work on the lathe during the operation. The most common types of chucks are:

(a) Three jaw chuck

(b) Four jaw chuck

(c) Magnetic chuck

(d) Combination chuck

(e) Collet chuck

(a) Three Jaw Chuck.

It is also known as three jaw self centering chuck. It consists of a cylindrical body having three jaws fixed radially at its front. Further, it carries a through hole at its centre to enable the long job to project backward in the spindle. It consists of a circular disc having spiral scroll at its front and a rack at its back. The rear face of jaws is provided with slots corresponding to the scroll serrations. The bevel pinions are fitted radially at the back of the disc and they mesh with the rack at its back. Top of these pinions are matching with the outer surface of the chuck and have square slots to accommodate the chuck key. For operating the chuck anyone of these pinion can be rotated by means of the chuck key which, intern, revolves the scroll disc. This causes all the jaws to move in the radial direction simultaneously. Normally two sets of jaws are provided with each chuck, one for gripping on the outside surface & other for inside.

(b) Four Jaw Chuck.

In outside appearance, It is very much similar to the three jaw chuck except that it has four jaws, but its internal mechanism differs totally. The rear portion of its jaws is threaded & is engaged with separate adjusting screws. With the result all the jaws can be moved separately and adjusted at desired distance from the centre of the chuck. Due to this it is also known as independent jaw chuck. This enables the chuck to successfully hold irregular or eccentric jobs in addition to the regular cylindrical shaped jobs. It is possible to reverse the same jaws so that the work can be gripped from inside surfaces also.

(c) Magnetic Chuck.

It holds the job by magnetic force. The following are the two types of magnetic chucks. These are explained in the subsequent paragraphs:

(i) Permanent Magnetic Chuck.

It is generally used on lathes and surface grinders. For this no electric current is needed. When the operating lever brings the magnet to ‘ON’ position the flux created inside. The magnetic flux passes through the work and hence holds it. It can hold light and thin jobs without any clamp. The complicated jobs, which are difficult to be clamped in other chucks, can be held on it without use of clamping. These are made either in rectangular or circular shape. The following are different parts of permanent magnetic chuck:

• Body. It is made of cast iron. There is a provision in the body for keeping the magnetic plates. The body of the round chuck is connected with a back plate, which is threaded to be screwed on the nose of the spindle.

• Base. It is also made of cast iron. In rectangular chuck the base is used for mounting on the table. In round chuck the base plate is used for mounting on the lathe spindle.

• Magnetic Plates. These are magnetic plates of high strength, which are kept in the body.

• Non-Ferrous Metal Plate. A non-ferrous metal plate such as brass or aluminium is kept around the magnetic plates. This plate does not allow having any magnetic effect in the body of chuck.

• Lever or Handle. A lever is provided in the chuck, which converts the magnetic field, and the magnet is "on".

(ii) Electro Magnetic Chucks.

These are also called temporary captivating chucks. It implies the use of electric current for developing a strong electromagnet, which holds the job centrally in chuck.

Precautions

Following precautions to be observed while handling the magnetic chucks:

• Light works should be clamped on magnetic chucks.

• Always take light cuts.

• When the job is to be machined on lathe, the speed and feed should be kept low.

• Small packing should be provided around the work.

• The surface of the job and the chuck should be properly cleaned from oil etc.

(d) Combination Chuck.

As the name implies, a combination chuck may be used as a self centering or as an independent chuck to take the advantages of both types. The jaws may be operated individually by separate screws or simultaneously by the scroll disc. The screws mounted on the frame have teeth cut on its underside which messes with the scroll and all the jaws together with the screws move radially when the scroll is made to rotate by a pinion.

(e) Collet Chuck.

It fits in to the spindle nose of the headstock. It can be used on a centre lathe, Capstan lathe, or turret lathe for producing items form bar stock. It is constructed with a hollow body having internal threads for screwing on the spindle nose. The slits in collets provides it with springing action to allow the bar for easy passing. These are of two types:

• Draw in type

• Push out

2. Face plate

Faceplate is used to hold large, heavy and irregular shaped workpieces which can not be conveniently held between centres. It is a circular disc bored out and threaded to fit to the nose of the lathe spindle. It is provided with radial plain and ‘T’ – slots for holding the work by bolts and clamps.

It is usually a circular cast iron disc having threaded hole at its centre so that it can be screw to the threaded nose of the spindle. It consists of number of holes and slots by means of which the work can be secured.

3. Driving Plate

The driving plate is used to drive a workpiece when it is held between centres. It is a circular disc screwed to the nose of the lathe spindle. It is provided with small bolts or pins on its face. Workpieces fitted inside straight tail carriers are held and rotated by driving plates.

It is a cast circular disk having a projected boss at its rear. The boss carries internal threads so that it can be screwed on spindle nose. It also carries a hole to accommodate a pin which engages with the tail of a lathe dog or carriers.

4. Catch Plate

When a workpiece is held between centres, the catch plate is used to drive it. It is a circular disc bored and threaded at the centre. Catch plates are designed with ‘U’ – slots or elliptical slots to receive the bent tail of the carrier. Positive drive between the lathe spindle and the workpiece is effected when the workpiece fitted with the carrier fits into the slot of the catch plate.

5. Angle Plate

It is employed for holding odd shape work in conjunction with a faceplate. When the shape of the work is such that it is not possible to mount it directly on the face plate it can be mounted on angle plate.

6. Lathe Carriers or Lathe Dogs

These are used in conjunction with the driving plate. The work to be inserted in the ‘V’ shaped hole of the carrier and then firmly secured in position by means of a screw, When a workpiece is held and machined between centres, carriers are useful in trans- mitting the driving force of the spindle to the work by means of driving plates and catch plates. The work is held inside the eye of the carrier and tightened by a screw.

Lathe dogs have two types of tails:

(a) Straight tail

(b) Bent tail

Straight tail carrier is used to drive the work by means of the pin provided in the driving plate. The tail of the bent tail carrier fits into the slot of the catch plate to drive the work.

7. Mandrel

A previously drilled or bored workpiece is held on a mandrel to be driven in a lathe and machined. There are centre holes provided on both faces of the mandrel. The live centre and the dead centre fit into the centre holes. A carrier is attached at the left side of the mandrel. The mandrel gets the drive either through a catch plate or a driving plate. The workpiece rotates along with the mandrel. There are several types of mandrels and they are:

1. Plain mandrel

2. Collar mandrel

3. Step mandrel

4. Cone mandrel

5. Gang mandrel

6. Expansion mandrel

A. Plain mandrel

The body of the plain mandrel is slightly tapered to provide proper gripping of the workpiece. The taper will be around 1 to 2mm for a length of 100mm. It is also known as solid mandrel. It is the type mostly commonly used and has wide application.

B. Gang Mandrel

It has a fixed collar at one end and a movable collar at the threaded end. This man- drel is used to hold a set of hollow workpieces between the two collars by tightening the nut.

C. Screwed Mandrel

It is threaded at one end and a collar is attached to it. Workpieces having internal threads are screwed on to it against the collar for machining.

D. Cone Mandrel

It consists of a solid cone attached to one end of the body and a sliding cone, which can be adjusted by turning a nut at the threaded end. This type is suitable for driving workpieces having different hole ameters.

8. Centres

Centres are useful in holding the work in a lathe between centres. The shank of a centre has Morse taper on it and the face is conical in shape. There are two types of centres namely

• Live centre

• Dead centre

The live centre is fitted on the headstock spindle and rotates with the work. The centre fitted on the tailstock spindle is called dead centre. It is useful in supporting the other end of the work. Centres are made of high carbon steel and hardened and then tempered. So the tip of the centres are wear resistant. Different types of centres are available accord- ing to the shape of the work and the operation to be performed. They are

1. Ball centre

2. Ordinary centre

3. Half centre

4. Tipped centre

5. Pipe centre

6. Revolving cenrte

7. Inserted type centre

9. Rests

A rest is a mechanical device to support a long slender workpiece when it is turned between centres or by a chuck. It is placed at some intermediate point to prevent the workpiece from bending due to its own weight and vibrations setup due to the cutting force. There are two different types of rests

• Follower rest

• Steady rest

A. Steady rest

Steady rest is made of cast iron. It may be made to slide on the lathe bedways and clamped at any desired po- sition where the workpiece needs sup- port. It has three jaws. These jaws can be adjusted according to the diameter of the work. Machining is done upon the distance starting from the headstock to the point of support of the rest. One or more steady rests may be used to sup- port the free end of a long work.

B. Follower rest

It consists of a 'C' like casting having two adjustable jaws to support the workpiece. The rest is bolted to the back end of the carriage. During machining, it supports the work and moves with the carriage. So, it follows the tool to give continuous support to the work to be able to machine along the entire length of the work.

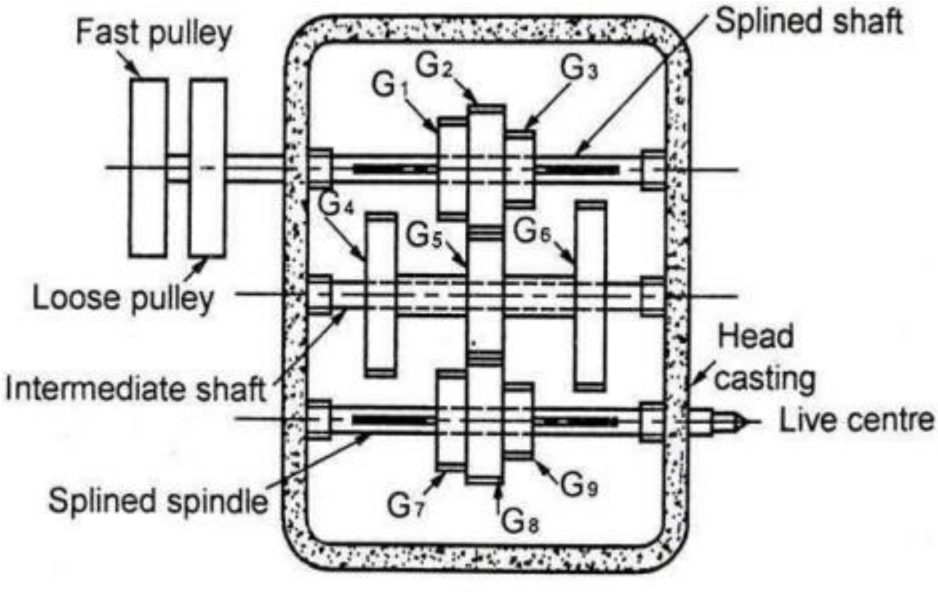
In order to reduce friction between the work and the jaws, proper lubricant should be used.

Tool holding devices- tool posts

1. Single screw tool post
2. Four bolt tool post
3. Open side tool post
4. Four way tool post

b) Explain with the help of neat sketch, the All geared headstock mechanism in lathe. 6M

An all geared headstock is more complicated than an ordinary belt-driven headstock. It is equipped with gears which can be used to adjust the speed of the headstock thereby enabling a convenient operation of the machine to carry out a specific task with the required speed. The gears of an all geared lathe are similar to the gears of an automobile except that these have more gear shifting combinations that enable more changes in speed to be done. Hence you can adjust your lathe for variant speeds. Attached to this headstock is a speed index plate which indicates the lever positions for the spindle speeds.



The power from the constant speed motor is delivered to the spindle through a belt drive. Speed changing is made by levers. The different spindle speeds are obtained by shifting the levers into different positions to obtain different gear combinations. This mechanism has a splined spindle, intermediate shaft and a splined shaft. The splined shaft receives power from motor through a belt drive.

This shaft has 3 gears namely G1, G2 and G3. These gears can be shifted with the help of lever along the shaft. Gears G4, G5 and G6 are mounted on intermediate shaft and cannot be moved axially. Gears G7, G8 and G9 are mounted on splined headstock spindle and can be moved axially be levers. Gears G1, G2 and G3 can be meshed with the gears G4, G5 and G6 individually. Similarly, gears G7, G8, G9 can be meshed with gear G4, G5 and G6 individually. Thus, it provides nine different speeds.

4 a) Sketch and describe any one quick return mechanism of shaper.

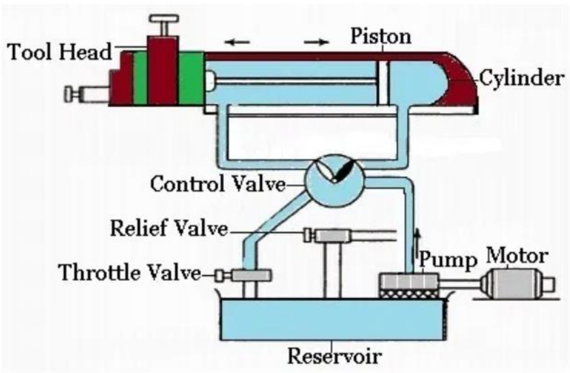
There are three types of quick return mechanism

1. Hydraulic drive 2. Crank and slotted link mechanism 3. Whitworth mechanism

A quick return mechanism is a mechanism which produces a reciprocal effect so that the system takes less time in the return stroke while comparing with forward stroke. In the quick-return mechanism, a circular movement like the crank and lever mechanism is converted into reciprocal movement but the return time is different from the forward moment. In several applications, this process is used. Some of them are shaper, slotter, screw-press, mechanical drive, etc. The time required for cutting is reduced with the assistance of a quick return mechanism.

HYDRAULIC DRIVE

Inside the hydraulic cylinder a piston reciprocates. Between the piston and the ram a piston rod is connected. So, the ram reciprocates along with the piston. Two entries are provided near the each end of the cylinders. A four-way control valve connects these two entries with the reservoir which contains the fluid. The reservoir is connected to the valve with the help of a drain pipes and a supply pipe.



Hydraulic drive mechanism

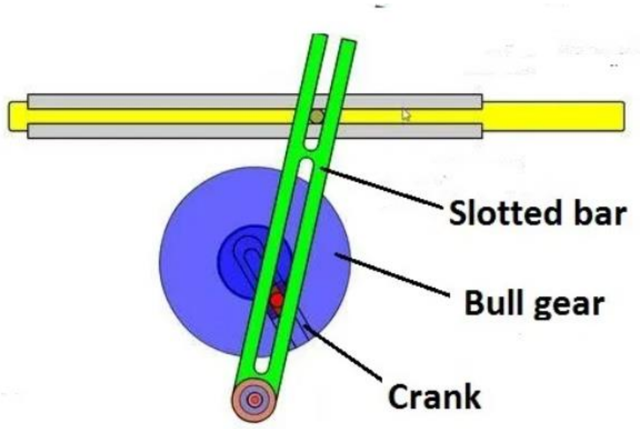
The supply pipe is again connected to the reservoir by a pump and relief valve. The valve is actuated by the lever and trip dog fitted to the ram. Oil is sucked by the gear pump from the reservoir at a particular pressure. This high pressure oil goes to the cylinder through the four-way valve.

The oil allowed from the pump to the left side of the piston which forces the piston to move the ram towards right (R). It is called as forward or cutting stroke. In this stroke, oil flows out on the right side entry to the reservoir through the four-way valve and drain pipe. The lever hits one trig dog at the end of this stroke.

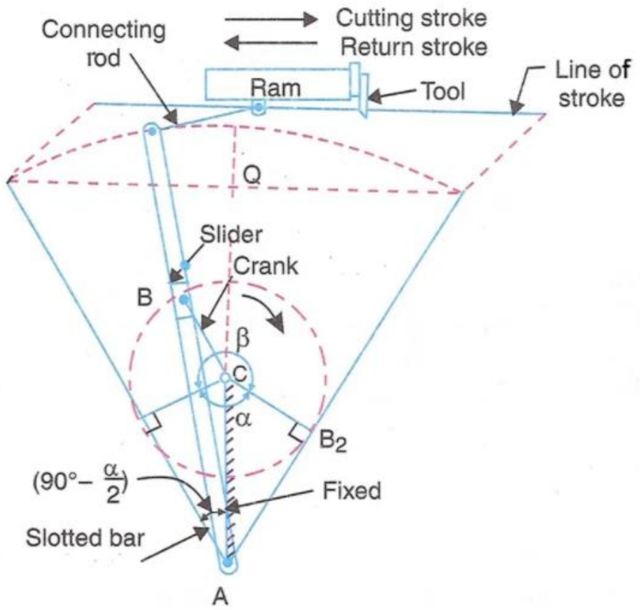
Now, the lever position is changed. Due to this, the supply pipe supplies the oil on the right side of the piston which moves the ram towards left called as return stroke or nan-cutting stroke.in this stroke the high pressure oil covers on lesser area on the cylinder. Due to this, the pressure force will increase. Hence, this return stroke is faster by supplying the same quantity of oil.

CRANK AND SLOTTED LEVER MECHANISM

In this mechanism the ram is actuated by gear drives associated with electric motor. First, the electric motor drives the pinion gear. Next, the pinion gear drives the bull gear which rotates in opposite direction due to external gear meshing. A radial slide is provided on the bull gear. A sliding block is assembled on this slide. The block can be positioned in radial direction by rotating the stroke adjustment screw.



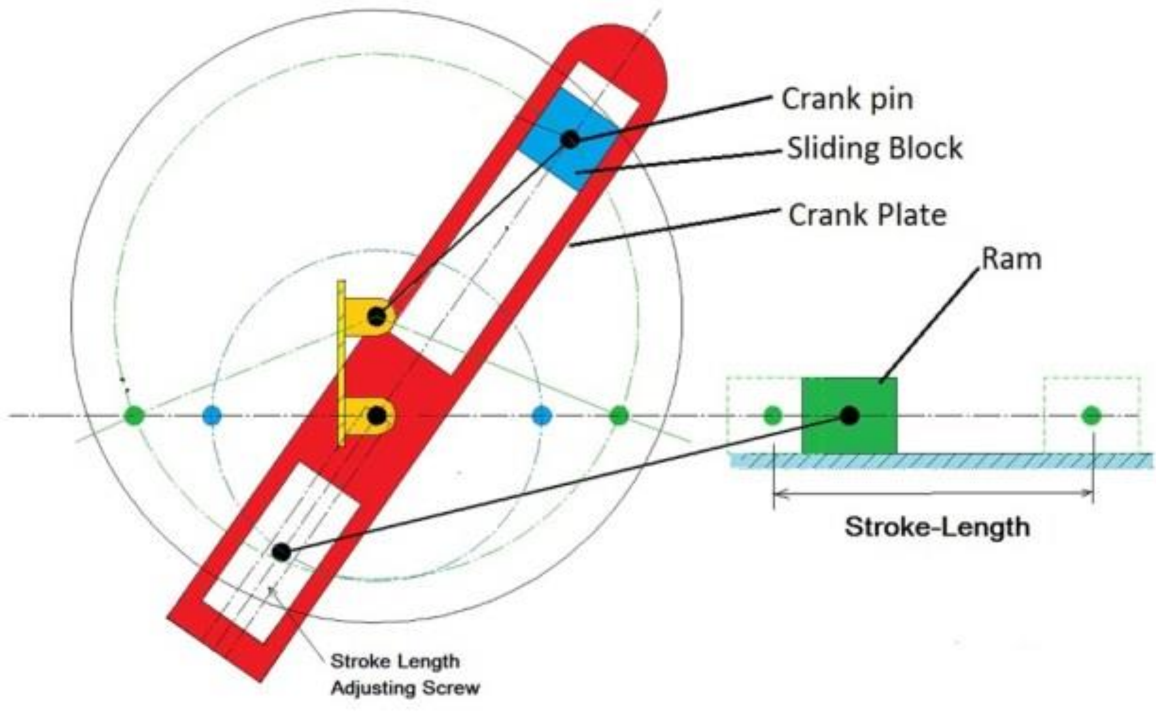
The sliding block has a crank pin. A rocker arm is freely fitted to this crank pin. The rocker arm sliding block slides in the slot provided in the rocker arm called as slotted link. The upper end has fork which is connected to the ram block by a pin while the bottom end of the rocker arm is pivoted.



When the pinion gear rotates along with the bull gear, the crank will also rotate. Due to this, the rocker arm sliding block also rotates in the same circle. Simultaneously, the sliding block slides up and down in the slot. This movement is transmitted to the ram which reciprocates. Hence, the rotary motion is converted in reciprocating motion.

WHITWORTH QUICK RETURN MECHANISM

The shaft of an electric motor drives the pinion which rotates the bull gear. The bull gear has a crank pinion. A sliding block slides over this crank pin and slides inside the slot of a crank plate. A connecting rod connects the pin at one end and ram at the other end.

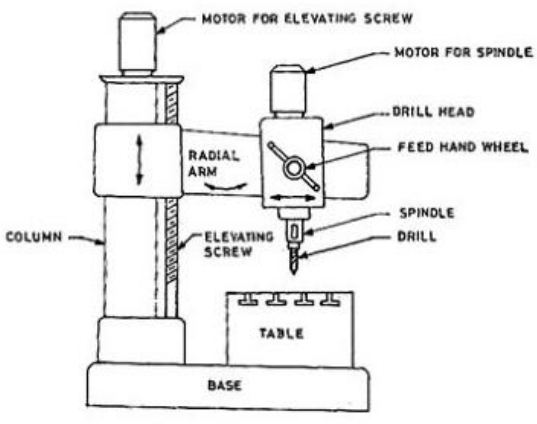


Withworth quick return mechanism

When the pinion rotates, the bull gear is also rotated along with the crank pin. At the same time, the sliding block slides on the slot provided on the crank plate. This makes the ram to move up and down by the connecting rod.

b) With the help of neat sketch explain the radial drilling machine. 6M

The radial drilling machine is intended for drilling medium to large and heavy work pieces.



The machine consists of a heavy, round, vertical column mounted on a large base. The column supports a radial arm which can be raised and lowered to accommodate work pieces of different height. The arm may be swung around at any position over the work bed. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide ways and can be clamped at any desired position. These three movements in a radial drilling machine can be combined together to permit the drill to be located at any desired point on the work piece for drilling the hole. When several holes are drilled on a large work piece, the position of the arm and drill head is altered so that the drill spindle may be moved from one position to the other after drilling the hole without altering the setting of the work. This versatility of the machine allows it to work on large work pieces. The work may be mounted on the table or when the job is large it may be placed on the floor or in a pit. The figure illustrates a radial drilling machine with its principal parts.

5 a) **Differentiate between shaping and planing machines** **6M**

Shaping	**Planing**
Shaping is one machining operation where workpiece is held stationary while cutting tool (ram) is reciprocated across the work.	Planing is similar machining operation but here the cutting tool remains stationary while workpiece (worktable) is reciprocated under the cutter.
Workpiece (bed) imparts feed motion, while cutting tool gives cutting motion.	Workpiece (table) imparts cutting motion, while cutting tool gives feed motion.
Shaping operation is performed in a machine tool called Shaper (also called shaping machine).	Planing operation is performed in a machine tool called Planer (also called planing machine).
Here quick-return mechanism is integrated with the ram that holds the cutter. So shaping machine uses quick return mechanism for tool movement.	Here quick-return mechanism is integrated with the worktable that holds the workpiece. SO planing machine uses quick return mechanism for worktable movement.
Shaper is traditionally a small machine and preferred for smaller jobs.	Planer is larger machine and can accommodate heavier and larger jobs.
It provides low MRR, thus shaping is less productive.	Planer has longer stroke length and can take heavy cuts, so MRR is high and the operation is productive.
Only one cutting tool can be used at a time.	Facility to accommodate multiple tools and simultaneously using all of them is also available in some planing machines.

b) **What are the various factors to be considered in selection of a grinding wheel? Discuss each in detail.**

Rules for selection of abrasive wheel or segment characteristics are as follows.

1. Worked material. Type and condition

chemical composition
hardness
type of treatment prior to grinding operation
This is important for selection of:
Abrasive material type
as a general rule, the synthetic corundum abrasive is preferred on steel and cast iron
silicon carbides are preferred on sintered carbides, ceramics, concrete, hard, brittle cast iron, etc.
Grain size
Fine grains are used on hard and brittle materials
Coarse grains are used on soft and ductile materials
Hardness grade
low hardness grades are preferred on hard material
high hardness grades are preferred on soft materials

2. Type and nature of grinding operation

rough grinding (snagging)
cutting-off
precision grinding (rough or finish) and consequently: rate of stock removal and required surface roughness.
This is important for selection of:

Grain size
coarse grain for a quick removal of heavy stock, high depth of grinding and low surface roughness requirements
fine grain for finishing and high surface roughness requirements

Bonds
vitrified bonds for precision grinding but also resinoid bonds that enable surface finishing to be performed
rough grinding and cutting-off - only resinoid and reinforced resinoid bonds. At low operating speeds the vitrified bonds for rough grinding may be used as well.

3. Operating speed of grinding wheel

The standard vitrified bond straight grinding wheels are intended for operation at operating speed of 35 [m/s] (40 and 45 [m/s] depending on the grain size and hardness grade).
For resinoid bond, the conventional operating speeds are correspondingly 50 and 63 [m/s].
Increased speeds are: 45, 50 and 63 [m/s] - depending on the bond.
High speeds are: 80, 100 [m/s]
Notes:
The increased operating speeds result in a higher "dynamic hardness" and, in contrary, the lower operating speeds result in the more soft grinding.
In case the increased and high operating speeds are necessary, consult this with the manufacturer.
The maximum safety operating speed, specified on the grinding wheel must not be exceeded.

4. Contact area between the grinding wheel and ground material

This is important for selection of:
Grain size
fine grains for small, narrow contact areas
coarse grains for large contact areas
Hardness grade
higher hardness grade for small, narrow contact areas and vice versa

5. "Dry" grinding or "wet" grinding (with coolant)

This is important for selection of:
Hardness grade
As a general rule, the wet grinding enables use of one grade higher hardness in compare with dry grinding.

6. Difficulty rate of grinding operation

This is important for selection of:
Abrasive material
heavy conditions of rough operation (snagging) requires normal aluminium oxide 95A and zirconia aluminium oxide ZrA or black silicone carbide 98C.
brittle, refined abrasive materials - noble aluminium oxide, white 99A, chromium aluminium oxide CrA, monoco¬rundum MA and their mixtures are used for finish grinding of hard, hardened high-quality steel
intermediate abrasives: semi-noble aluminium oxide 97A and mixtures are used for grinding operations of medium working conditions and for special applications
green silicon carbide 99C is used for grinding of sintered carbides and ceramics.

7. Grinding machine power

This is important for selection of:
Hardness grade of grinding machine
the higher power of grinding machine, the higher hardness grade of grinding wheel

6 a) What are the differences between compound indexing and differential indexing? Explain the relative merits.

Compound Indexing:

The principle of operation of compound indexing is the same as that of simple indexing, but the only difference is that compound indexing uses two different circles of one plate and hence also sometimes referred to as hit and trial method.

The principle of compound indexing is to obtain the required division in two stages:

(i) By rotating the crank or handle in usual way keeping the index plate fixed.

(ii) By releasing the back pin and then rotating the index plate with the handle.

For example, if a 27 teeth gear is to be cut, then T = 40/27 i.e., the rotation required for one tooth spacing is 40/27 which may be written as 2/3 + 22/27 or 12/18 + 22/27.

So for each tooth, the worm will be rotated by 12 holes of 18 hole circle with the help of the crank and then the index plate is rotated by 22 holes of the 27 hole circle.

4. Differential Indexing:

Available number of index plates with different hole circles, sometimes confine the range of plain indexing. In such cases, differential indexing is found to be more suitable. Between the indexing plate and spindle of dividing head, a certain set of the gears is incorporated extra. Dividing heads are provided with such standard set of gears.

During the differential indexing, the index-plate is unlocked and connected to a train of gears which receive their motion from the worm gear spindle. As the handle is turned, the index plate also turns, but at a different rate and perhaps in the opposite direction. Differential indexing makes it possible to rotate the work by any fraction of revolution with the usual index plates furnished with the equipment.

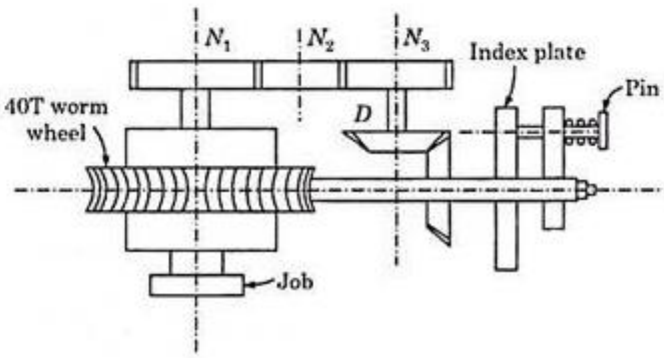


Fig. 16.62

For making the necessary calculations and to find the change of gears to be placed between the spindle and the worm shaft, use the following relation:

$$\frac{\text{Driver}}{\text{Driven}} = (n - N) \times \frac{40}{\pi} \quad \text{...(1)}$$

$$\text{Crank movement} = T = \frac{40}{n} \quad \text{...(2)}$$

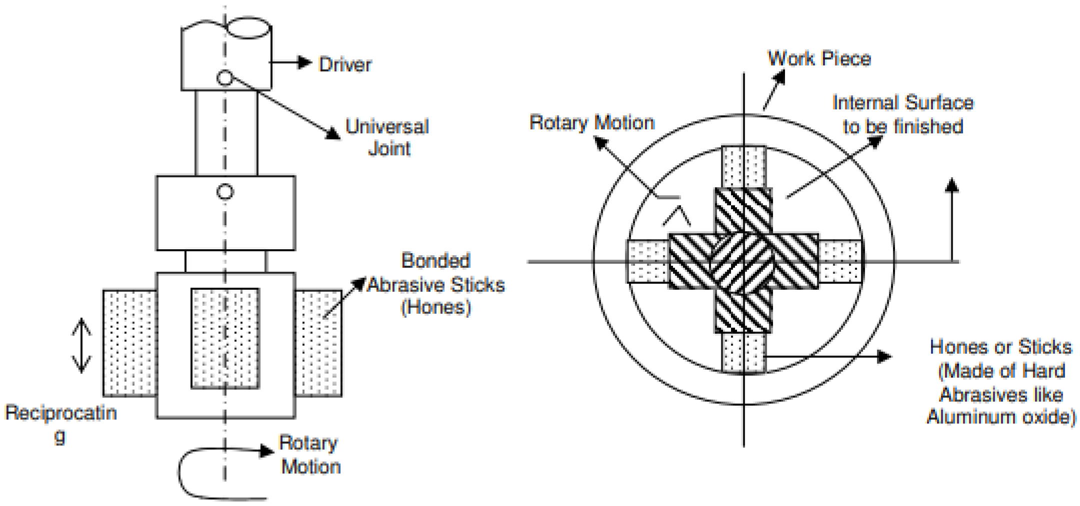
where N is the number of divisions to be indexed and n is a number slightly greater or less than N. The relation given by equation (1) will give a gear ratio to be placed on spindle (Driver) and the work shaft (Driven). The arrangement of gears can be in the form of simple wheel train or compound wheel train or compound wheel train depending upon the suitability and requirements.

The difference of N and n causes the index plate to rotate itself in a proper direction relative to crank. If (n — N) is positive, the index plate will rotate in the direction in which crank is rotated and if (n — N) is negative, it will rotate in opposite direction to that of crank.

b) Explain any one finishing operation with neat sketch. **6M**

Honing

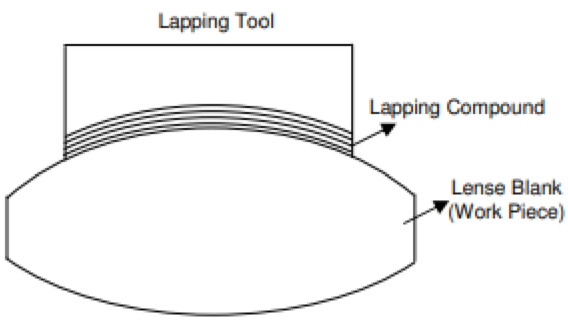
Honing is a surface finishing operation based on abrasive action performed by a set of bonded abrasive sticks. It is generally used to finish bores of cylinders of IC engine, hydraulic cylinders, gas barrels, bearings, etc. It can reduce the level of surface roughness below 32 µm. It produces a characteristics surface pattern as cross hatched which is a fit case to retain lubrication layer to facilitate motion to moving parts, their best example is IC engine. The honing tool used to finish internal surface is shown in Figure 3.2. The honing tool consists of a set of bonded abrasive sticks. The number of sticks mounted on a tool depends on its circumferential area. Number of sticks may be more than a dozen.



The motion of a honing tool a combination of rotation and reciprocation (linear).The motion is managed in such a way that a given point on the abrasive stick does not trace the same path repeatedly. The honing speed may be kept upto 10 cms per sec. Lower speeds are recommended for better surface finish. Manufacturing defects like slight eccentricity a way surface, light tapper, less of circulating can also be corrected by honing process.The process of honing is always supported by flow of coolants. It flashes away the small chips and maintains a low and uniform temperature of tool and work.

Lapping

Lapping is also one of the abrasive processes used to produce finished (smoothly accurate) surfaces. It gives a very high degree of accuracy and smoothness so it is used in production of optical lenses, metallic bearing surfaces, measuring gauges, surface plates and other measuring instruments. All the metal parts that are subjected to fatigue loading or those surfaces that must be used to establish a seal with a mating part are often lapped. The process of lapping uses a bonded abrasive tool and a fluid suspension having very small sized abrasive particles vibrating between the workpiece and the lapping tool. The process of lapping is shown in Figure 3.3. The fluid with abrasive particles is referred as lapping compound. It appears as a chalky paste. Normally the fluid used in lapping compound is oil or kerosene. The fluid should have slightly lubricating properties to make the action of abrasive mild in nature. Abrasives used in lapping compound are aluminium oxide and silicon carbide. Their girt size is kept 300 to 600 µm. It is hypothesized that two alternative cutting mechanisms are working in the process of lapping.



In first mechanism the abrasive particles roll and slide between the lapping tool and workpiece. These particles produce small cuts on both surfaces. Another mechanism suppose to work in lapping is that the abrasives become imbedded in the lap surface to give cutting action like in case of grinding. It is assumed that lapping is due to the combination of these two above mentioned mechanism. Lapping can be done manually but use of lapping machine makes the process accurate, consistent and efficient.

Machine Lapping

Machine lapping is recognized as fast lapping process. Gudgeon pins with 25 mm diameter and 75 mm long can be lapped at the rate of 500 units per hour. Mechanical lapping machines have vertical construction with the work holder mounted on the lower table which is given oscillatory motion. The upper lap is stationery and floating while lower one revolves at 60 rpm. Some special purpose lapping machines are available for lapping of small parts such as piston pins ball bearing races, etc. in machine lapping a pressure upto 0.02 N/mm2 for soft material and 0.5 N/mm2 for hard material is applied.

Lapping Applications

Materials processed by lapping range from steel, cast iron to non-ferrous metal like copper, brass and lead. Wooden parts, made of hard wood, can also be finished using wood laps. Lapping removes material at a very slow rate. So lapping is generally followed by accurate machining of workpieces.

7 a) List the various types of milling cutters. With a neat sketch explain cutter geometry

The most common types of milling cutters are:

End mill

Face mill

Ball cutter

Slab mill

Side-and-face cutter

Involute gear cutter

Fly cutter

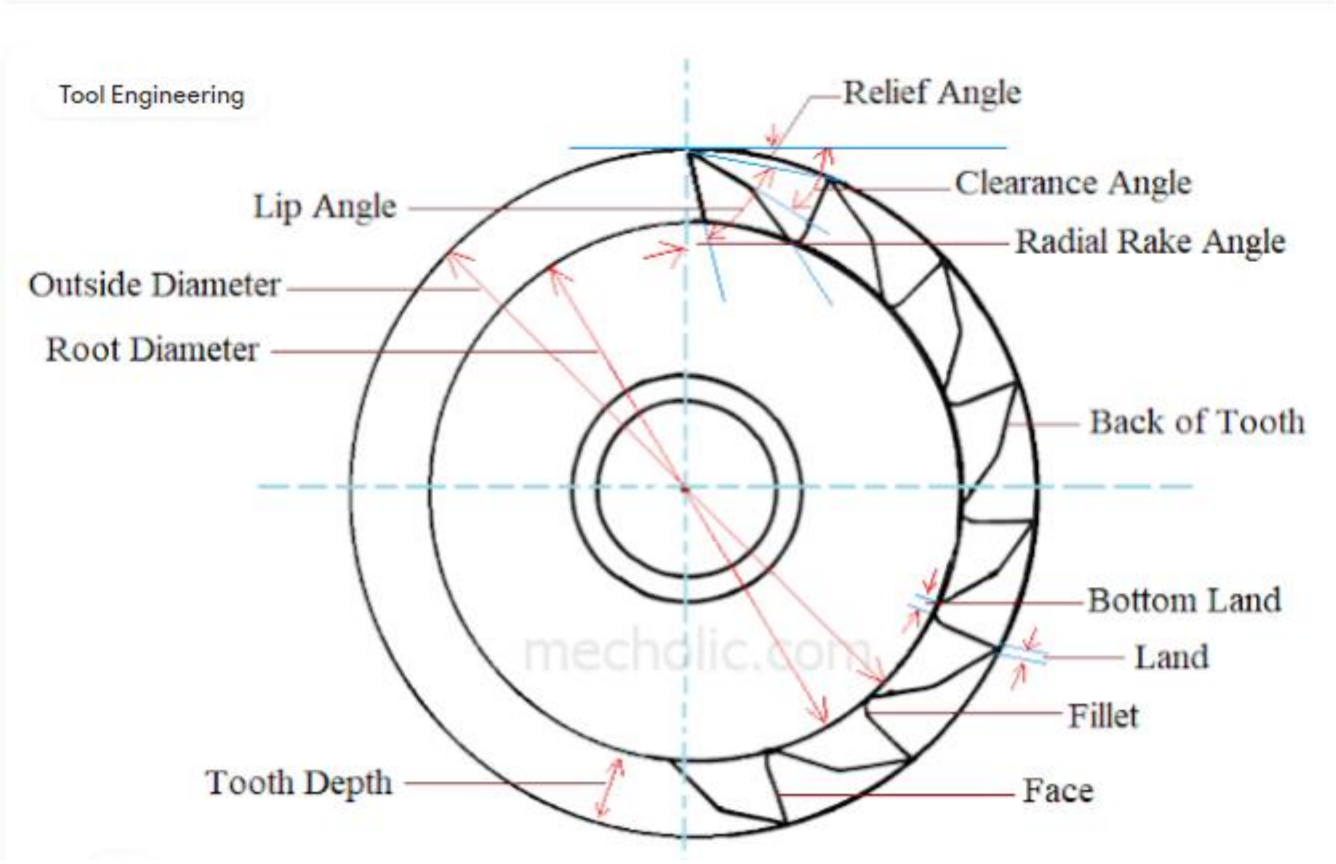
Hollow mill

Shell mill

Roughing end mill

Dovetail cutter

Wood ruff cutter



A milling cutter can be considered as the cluster of single point cutting tool. Above figure shows a plain milling cutter. The various parts of milling cutter teeth are cutting edge, face, filling, and body. The teeth of milling cutter either straight (the cutting edge is parallel to the axis of rotation) or helical shaped.

Elements of plain milling cutter

Body of cutter: It is the main frame of milling cutter, on which the teeth rest.

Periphery: It is defined as the locus of cutting edges of tooth of cutter.

Cutting edge: It is the portion that touches the workpiece during cutting action. It is the intersection of teeth face and tooth flank.

Fillet: portion where one teeth joins the face of another tooth. It is a reinforcement to cutting tooth.

Face of teeth: it is the surface upon the chip is formed while cutting. It may be curved or flat.

Back of tooth: it is the created by fillet and the secondary clearance angle.

Land: it is the narrow surface on the back of cutting edge. Land is the result of providing the clearance angle.

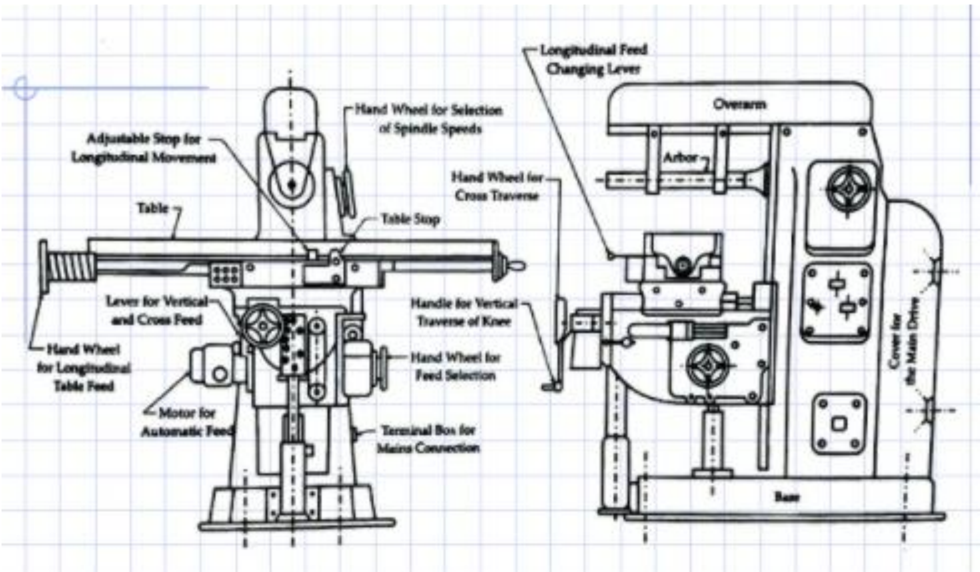
Bottom Land: the blank space between the consecutive teeth.

Root diameter: diameter passing through centre of cutter and joining two ends of the periphery.

Root diameter: passing through centre of cutter and joining two bottom fillet.

b) Describe schematic diagram of universal milling machine. **6M**

A universal milling machine is named so as it is used to do a large variety of operations. The distinguishing feature of this milling machine is it table which is mounted on a circular swiveling base which has degree graduations. The table can be swiveled to any angle upto 45^{o} on either side of normal position. Helical milling operation is possible on universal milling machine as its table can be fed to cutter at an angle. Provision of large number of auxiliaries like dividing head, vertical milling attachments, rotary table, etc. make it suitable for wide variety of operations.



Universal Milling Machine

8 a) Explain the various types of chips.

Types of chips

The three common types of chip from a single point tool are.

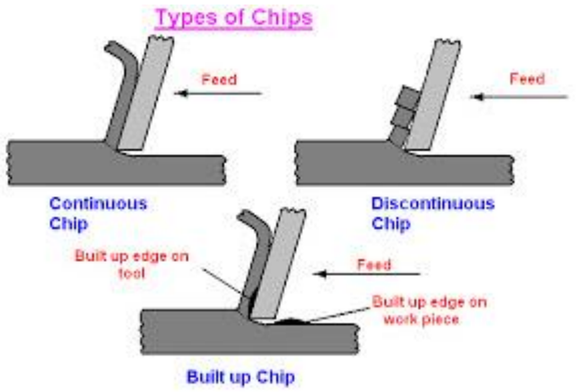
1;:Discontinuous or segmental chip:

Discontinuous chips is formed by a series of rupture occurring approximately perpendicular to the tool place face’ each chip element passing off along the tool face the chip element’ in the form of small segment may adhere loosely to each other and becomes slightly longer.

Since the chips break up into small segments the friction between the tool and the chips reduces’ resulting in better surface finish. These chips are convenient to collect’ handle and dispose off. Discontinuous chips tends to be formed when one or more or the following conditions exist:

1. Brittle material , such as cast iron and bronze.
2. large chip thickness
3. low cutting speed
4. small rack angle

Discontinuous chips are also produced when cutting more ductile material with the use of a cutting fluid.



2: Continuous Chips:

Continuous chips are formed by the continuous plastic deformation of metal without fracture in front of the cutting edge of the tool and is formed by the smooth flow of the chip up the tool face. Mild steel and copper are considered to be most desirable materials for obtaining continuous chips. The chips obtained have same thickness throughout. This type of chip is the most desirable. Since it is stable cutting, resulting in generally good surface finish. On the other hand these chips are difficult to handle and dispose off.

Continuous chips tend to be formed when the following condition exist:

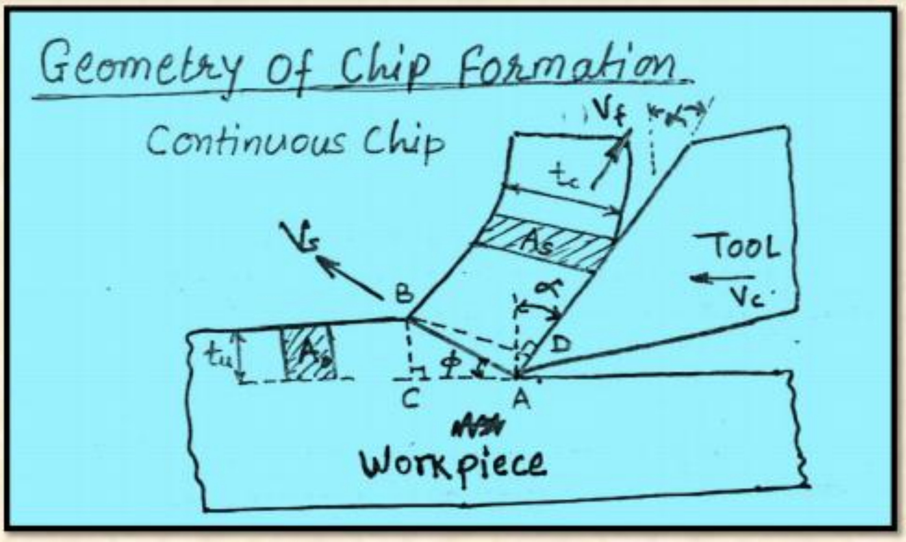
1. ductile material
2. high cutting speed
3. small chip thickness
4. large rack angle
5. minimum friction of chip on tool face by :

- polished tool face
- use of efficient cutting lubricants.
- Use of tool material with low-coefficient of friction.

3: Continuous Chip with Built up Edge:

This type of chip is very similar to the continuous chip. With the difference that it has a built up edge adjacent to tool face and also it is not so smooth. It is obtained by machining on ductile material, in this condition of high local temperature and extreme pressure in the cutting and high friction in the tool chip interference, may cause the work material to adhere or weld to the cutting edge of the tool. Successive layers of work material are then added to the built up edge. When this edge becomes larger and unstable , it breaks up and part of it is carried up the face of the tool along with the chip while the remaining is left over the surface being machined, which contributes to the roughness of the surface. The built up edge changes its size during the cutting operation. It first increases , then decreases, then again increases etc.

b) Derive the expression for shear angle in orthogonal cutting in terms of rake angle and chip thickness ratio.



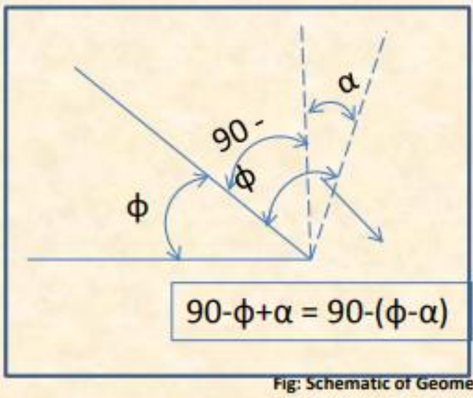
t_c : Chip thickness
t_u : Uncut chip thickness
V_f : Chip Sliding Velocity
V_s : Shear Velocity
V_c : Cutting Velocity
ϕ : Shear Angle

$\Delta ABC \;\&\; \Delta ABD$

$$AB = \frac{t_u}{\sin\phi}$$

$$also,\ AB = \frac{t_c}{\sin(90-(\phi-\alpha))} = \frac{t_c}{\cos(\phi-\alpha)}$$

$$\frac{t_u}{t_c} = \frac{\sin\phi}{\cos(\phi-\alpha)}$$



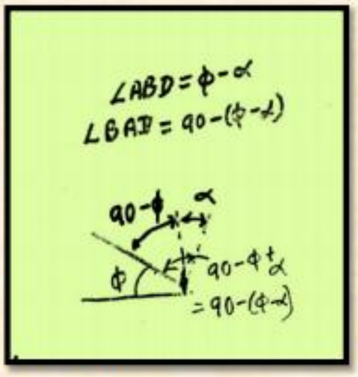


Fig: Schematic of Geometry of chip formation

SHEAR ANGLE AND CHIP THICKNESS RATIO EVALUATION

$$r_c = \frac{t_u}{t_c} : Chip\ thickness\ Ratio / Coeffinicient$$

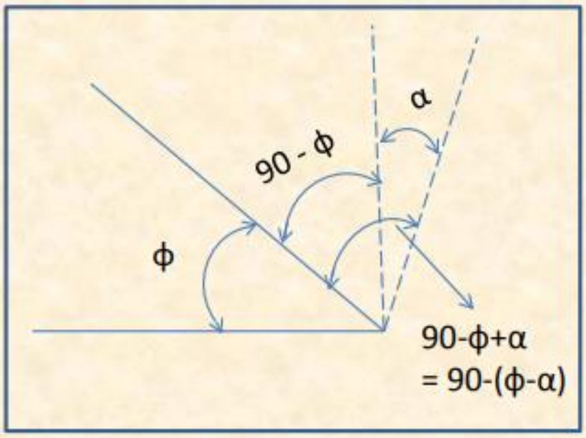
Substitute the value of t_u/t_c from earlier slide and simplify to get:

$$\frac{1}{r_c} = \frac{\cos\phi\cos\alpha + \sin\phi\sin\alpha}{\sin\phi}$$

$$1 = r_c\cot\phi\cos\alpha + r_c\sin\alpha$$

$$r_c\cos\alpha = (1 - r_c\sin\alpha)\tan\phi$$

$$\therefore \boxed{\tan\phi = \left(\frac{r_c\cos\alpha}{1 - r_c\sin\alpha}\right)}$$



9. During orthogonal turning of mild steel with a carbide cutting tool of 10^0 rake angle, the following data has been obtained: width of cut = 2 mm; uncut chip thickness=0.25mm; cutting velocity V = 200 m/min; chip thickness = 0.39 mm; F_c = 320 N; F_t = 170 N. Calculate

a) **shear angle**
b) **shear and normal shear force**
c) **friction angle; d) shear strain; e) specific cutting energy**

Given $\gamma = 10^\circ$

width of cut $b = 2\,mm$

uncut chip thickness $t_o = 0.25\,mm$

chip thickness $t_c = 0.39\,mm$

$F_c = 320N$, $F_t = 170N$, cutting velocity $V = 200\,m/min$

chip thickness ratio $r = \frac{t_o}{t_c} = \frac{0.25}{0.39} = 0.641$

a) shear angle $\phi = Tan^{-1}\left(\frac{r\cos\gamma}{1 - r\sin\gamma}\right) = Tan^{-1}(0.71) = 35.376^\circ$

b) Shear force $F_s = F_c\cos\phi - F_t\sin\phi$

$= (320)\cos(35.376) - (170)\sin(35.376)$

$= 162.5N$

Normal shear force $F_N = F_c\cos\phi + F_t\sin\phi$

$= 323.9\,N.$

c) Friction angle $\beta = \gamma + Tan^{-1}\left(\frac{F_t}{F_c}\right) = 10 + Tan^{-1}\left(\frac{170}{320}\right)$

$= 37.98^\circ$

d) Shear strain $\xi = \cot\phi + Tan(\phi - \gamma)$

$= \cot(35.376) + Tan(35.376 - 10)$

$= 1.408 + 0.474 = 1.882$

e) Specific cutting energy $= \frac{F_c}{bt_o} = \frac{320}{2 \times (0.25)} = 640\,N/mm^2$

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