20ME402

Hall Ticket Number:

II/IV B.Tech (Regular\Supplementary) DEGREE EXAMINATION

July/August,2023 | **Mechanical Engineering**

Fourth Semester | **Metal Cutting and Machine tools**

Time: Three Hours | **Maximum:** 70 Marks

Answer question 1 compulsory. **(14X1 = 14Marks)**

Answer one question from each unit. **(4X14=56 Marks)**

			CO	BL	M
1	a)	Write working principle of lathe	CO1	L1	1
	b)	Define depth of cut in machining	CO1	L1	1
	c)	Give specifications of lathe	CO1	L1	1
	d)	List out various taper turning methods.	CO1	L1	1
	e)	Write a short on universal radial drilling machine.	CO2	L1	1
	f)	Differentiate between shaper and Planar machine	CO2	L1	1
	g)	What is the purpose of Truing in grinding wheel?	CO2	L2	1
	h)	Write the applications of Honing operation.	CO3	L1	1
	i)	Differentiate between Up milling and Down Milling.	CO3	L2	1
	j)	List out types of milling cutters	CO3	L1	1
	k)	Define rake angle	CO4	L1	1
	l)	What are the types of cutting fluids?	CO4	L1	1
	m)	Give reasons of tool wear.	CO4	L1	1
	n)	What are the requirements of cutting tool materials?	CO4	L1	1
		Unit-I			
2	a)	Describe primary motions and auxiliary motions in machine tools.	CO1	L2	7M
	b)	Describe back gear mechanism in belt driven lathe with a neat sketch.	CO1	L2	7M
		(OR)			
3	a)	Give classification of lathes. Describe briefly.	CO1	L2	7M
	b)	Explain thread cutting operation in lathe with neat sketch.	CO1	L2	7M
		Unit-II			
4	a)	Explain the Radial drilling machine with neat sketch.	CO2	L2	7M
	b)	Explain quick return mechanism in shaper with neat sketch.	CO2	L2	7M
		(OR)			
5	a)	Explain the constructional details of Planing machine with neat sketch.	CO2	L2	7M
	b)	Describe briefly about selection and specification of grinding wheel.	CO2	L2	7M
		Unit-III			
6	a)	Explain surface finishing operation Lapping with neat sketch.	CO3	L2	7M
	b)	Explain the Column and knee type universal Milling machine with neat sketch.	CO3	L2	7M
		(OR)			
7	a)	Describe various Milling operations with neat sketch.	CO3	L2	7M
	b)	What are the various types of Indexing methods? Explain any two methods.	CO3	L2	7M
		Unit-IV			
8	a)	Derive the expression for stress and strain in the chip.	CO4	L2	7M
	b)	Explain the mechanics of chip formation with neat sketch.	CO4	L2	7M
		(OR)			
9	a)	Draw the Merchant's circle diagram and derive expressions for various forces acting in the machining	CO4	L3	7M
	b)	What are the functions and requirements of cutting fluids? Explain briefly.	CO4	L2	7M

II/IV B.TECH (REGULAR/SUPPLY) DEGREE EXAMINATION

AUGUST 2023, IVth SEMESTER, MECHANICAL ENGG.

SUB: METAL CUTTING AND MACHINE TOOLS (20ME402)

SCHEME OF EVALUATION

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1) Bits - 1x14 = 14M

a) Write working principle of lathe.

The material is removed as cutting tool is fed against rotating work piece.

b) Define depth of cut in machining.

It is the perpendicular distance measured between the uncut and machined surface of the w/p for each pass or cut expressed in mm.

c) Give specifications of lathe.

1) The height of the centres measured from the lathe bed
2) The swing diameter over the bed
3) The length between centres
4) The swing diameter over the carriage
5) The maximum bar diameter
6) Spindle nose diameter, Centre Morse taper no., No. and range of spindle speeds and feeds, power input etc.

d) List out various taper turning methods.

A taper may be turned on a lathe by following methods.

1) By a broad nose form tool
2) By setting over the tail stock centre
3) By swiveling the compound rest
4) By using a taper turning attachment
5) By combining longitudinal and cross feed in a special lathe

e) Write a short notes on universal radial drilling machine.

In a plain radial drilling m/c provisions are made for vertical adjustment of the arm, horizontal movement of the drill head along the arm, and circular movement of the arm about the vertical column. In semi-universal radial drilling machine, in addition to above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. In universal radial drilling machine in addition to the above four movements, the arm holding the drill head may be rotated on a horizontal axis. All these five movements in a universal drilling m/c enables it to drill on a w/p at any angle.

f) Differentiate between shaper and Planar machine.

The relative movement between the tool and the work is different in a shaper and a planer. In a planer the work is mounted on a table which reciprocates while the tool is held rigid on the machine frame and fed in to the work.

In a shaper the tool is held on a ram which reciprocates and the work which is mounted on the table remains stationary and provides the feed.

g) What is the purpose of truing in grinding wheel?

Truing is a dressing operation by which a wheel is restored to its original shape. Thus a round wheel is dressed to make its circumference a true circle. The wheel becomes out-of-round due to wear and breaking away of the abrasive and bond. Truing is done to make the wheel true and concentric with the bore so that minimum vibrations are produced during grinding for improving surface finish on job. Truing is done for new wheels before static balancing. After balancing, the wheels are mounted on the spindle.

h) Write the applications of honing operation.

Honing is often used for finishing gun barrels, hydraulic cylinder bores, crank shaft journals and automobile cylinder liners etc.

i) Differentiate between Up milling and Down milling.

The up milling, which is also called conventional milling, is the process of removing metal by a cutter which is rotated against the direction of travel of the work piece.

The down milling, which is also called climb milling, is a process of removing metal by a cutter which is rotated in the same direction of travel of the work piece.

j) List out types of milling cutters.

1) Plain milling cutter 2)Side milling cutter 3)Slitting saw 4)Angle milling cutter 5)End mill 6) T-slot milling cutter 7)Woodruff key slot milling cutter 8)Fly cutter 9)Formed cutter.

k) Define rake angle.

The angle of inclination of the cutting tool rake surface from the reference plane i.e. the plane perpendicular to the velocity vector.

l) What are the types of cutting fluids?

There are basically two main types of cutting fluids.

1) Those which are mixed with water, such as, soluble oils and soaps. These are emulsions of oil and water or soap and water.
2) Those which are not mixed with water, called cutting oils, which can be pure oils or a mixture of two or more oils.

m) Give reasons of tool wear.

Tool wear or tool failure may be classified as follows.

a) Flank wear b) Crater wear c) localized wear such as rounding of the cutting edge d) Chipping off of the cutting edge. Wearing action takes place on those surfaces along which there is relative sliding with other surfaces. Thus the wear takes place on the rake surface, where the chip flows over the tool, and on the flank surface, where rubbing action between the work and the tool occurs. These wears are called Crater and flank wears respectively.

n) What are the requirements of cutting tool materials?

1) Cold hardness 2) Hot hardness 3) Wear resistance 4) Toughness 5) Thermal conductivity and Specific heat 6) Coefficient of friction.

<u>UNIT – I</u>

2 a) Describe primary motions and auxiliary motions in machine tools.

A) <u>Primary or working motions in machine tools:</u>

For obtaining the required shape on the w/p it is necessary that the cutting edge of the cutting tool should move in a particular manner with respect to the w/p. The relative movement between the w/p and cutting tool can be obtained either by the motion of the w/p, the cutting tool or by a combination of the motions of the w/p and cutting tool both. These motions which are essential to impart the required shape to the w/p are known as primary or working motions. Working motions are further classified into two categories.

1) Drive motion or primary cutting motion 2) Feed motion or secondary motion

Working motions in m/c tools are generally of two types, rotary and translatory. Working motions of some important groups of m/c tools are shown below.

1) <u>For lathes and boring machines</u>:

Drive motion – Rotary motion of w/p.

Feed motion – Translatory motion of cutting tool in the axial or radial direction.

2) <u>For drilling machines:</u>

Drive motion – Rotary motion of drill.

Feed motion - Translatory motion of drill.

3) For milling machines:

Drive motion – Rotary motion of the cutter.

Feed motion – Translatory motion of the w/p.

4) For shaping machines:

Drive motion – Reciprocating motion of cutting tool.

Feed motion – Intermittent translatory motion of w/p.

5) For grinding machines:

Drive motion – Rotary motion of the grinding wheel.

Feed motion – Rotary as well as translatory motion of the w/p.

Auxiliary motions in machine tools:

Besides the working motions, a machine tool also has provision for auxiliary motions. The auxiliary motions do not participate in the process of formation of required surface but are necessary to make the working motions fulfill their assigned function. Examples of auxiliary motions in m/c tools are :

- Clamping and unclamping of the w/p
- Idle travel of the cutting tool to the position from where cutting is to proceed
- Changing the speed of drive and feed motions
- Engaging and disengaging of working motions etc.

In machine tools the working motions are powered by an external source of energy (electrical or hydraulic motor). The auxiliary motions may be carried out manually or may also be power operated depending up on the degree of automation of the m/c tool.

(Primary motions – 4M, Auxiliary motions – 3M)

b) Describe back gear mechanism in belt driven lathe with a neat sketch.

A) The cone pulley is not keyed to the spindle and revolves freely on it. The gear 'D' called the bull gear is keyed to the spindle. In order to transmit motion from the cone pulley to the spindle to obtain direct speed a lock pin is introduced in to the hole provided on the face of the cone pulley. This lock pin engages the bull gear 'D' with the cone pulley. A cone pulley with 4 steps will give 4 direct speeds.

The back gears 'B' and 'C' are both fastened to a quill. This is a hollow shaft that revolves on a fixed shaft which is housed on an eccentric bearing.

This construction permits the changing of the position of the back gears putting them into engaged with the gears 'A' and 'D' by partly rotating the shaft by means of a back gear handle.

The gear 'A' is permanently connected with the cone pulley, while the gear 'D' is keyed to the spindle. The back gears are engaged when the lock pin connecting the bull gear 'D' with the step cone pulley is out.

In using back gears, the power is transmitted from the cone pulley and gear 'A' to the back gears 'B' and 'C', from 'C' to gear 'D' and from the gear 'D' to the spindle. Gears 'B' and 'C' being both fastened to the quill will revolve at equal speed.

For a particular speed of the cone pulley, the gear 'D' or the spindle will rotate at a speed,

$N_D / N_A = Z_A/Z_B \times Z_C/Z_D$

$N_D = Z_A/Z_B \times Z_C/Z_D \times N_A$

Where Z_A, Z_B, Z_C, Z_D are the no. of teeth on gears A, B, C and D and N_D and N_A are the speeds of the spindle and the cone pulley respectively.

A lathe with 4 steps on the cone pulley and with back gear will have 8 spindle speeds – 4 direct and 4 indirect, the latter being slower.

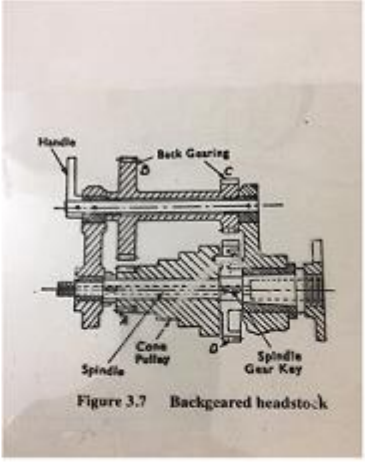


Figure 3.7 Backgeared headstock

(Fig – 1M, Description – 6M)

3) a) Give classification of lathes. Describe briefly.

A) Types of lathe: Lathes of various designs and constructions have been developed to suit various conditions of metal machining.

1) Speed lathe – a)Wood working b)Centering c)Polishing d)Spinning
2) Engine lathe or Centre lathe – a)Belt drive b)Individual motor drive c) Gear head lathe
3) Bench lathe
4) Tool room lathe
5) Capstan and Turret lathe
6) Special purpose lathe – a)Wheel lathe b)Gap bed lathe c)T-lathe d)Duplicating or copy lathe
7) Automatic lathe

1) The Speed lathe: In construction and operation it is the simplest of all types of lathe. It consists of a bed, a head stock, a tail stock and tool post mounted on an adjustable slide. There is no feed box, lead screw or conventional type of carriage. The tool is mounted on an adjustable slide and is fed into the work purely by hand control. The high spindle speeds usually range from 1200 to 3600 rpm. The head stock construction is very simple and only two or three spindle speeds are available. Light cuts and high speeds necessitate the use of this type of machine, where cutting force is minimum such as in wood working, spinning, centering, polishing etc.
2) The engine lathe or centre lathe: This lathe is most important type and most widely used. The term engine is used because earlier lathes were driven by steam engines. Similar to the speed lathe, the engine lathe has got all the basic parts, e.g. bed, head stock and tail stock. But the head stock is much more robust in construction and it contains additional mechanisms for driving the lathe spindle at multiple speeds. Unlike the speed lathe, the engine lathe can feed the cutting tool both in cross and longitudinal direction w.r.to lathe axis with the help of carriage, feed rod and lead screw. It is more versatile.

   Engine lathes are classified according to the various designs of the head stock and methods of transmitting power to the machine. A lathe that receives its power from an over-head line shaft is a belt-driven lathe and is equipped with a speed-cone and one or more back gears to get a wide range of spindle speeds. A lathe that receives its power from an individual motor integral with the machine is called a motor driven lathe. A geared-head lathe gets its power from a constant speed motor, and all speed changes are obtained by shifting various gears located in the head stock. It has no cone pulley.

3) The bench lathe: This is a small lathe usually mounted on a bench. It has all the parts of the engine lathe, its only difference being in the size. This is used for small and precision work.

4) The tool room lathe: A tool room lathe having features similar to an engine lathe, is much more accurately built and has a wide range of spindle speeds. This is equipped, besides other things, with a chuck, taper turning attachment, draw in collet attachment, thread chasing dial, relieving attachment, steady and follower rest, pump for cooling etc. This lathe is mainly used for precision work on tools, dies,

gauges and in machining work where accuracy is needed. The machine is costlier than an engine lathe of the same size.

The Capstan and Turret lathe: The distinguishing feature of this type of lathe is that the tail stock of the engine lathe is replaced by a hexagonal turret, on the face of which multiple tools may be fitted and fed into the work in proper sequence. The advantage is that several different types of operations can be done on a work piece without resetting of work or tools, and a number of identical parts can be produced in the minimum time.

6) Special purpose lathe: As the name implies, they are used for special purposes and for jobs which cannot be accommodated or conveniently machined on a standard lathe. The wheel lathe is made for turning the tread on locomotive wheels. The gap bed lathe, in which a section of the bed adjacent to the head stock is removable is used to swing extra-large diameter work pieces.

The T-lathe is intended for machining the rotors for jet engines. The axis of the lathe bed is at right angles to the axis of the head stock spindle in the form of a 'T'. The duplicating lathe is one for duplicating the shape of a flat or round template on to the work piece. Mechanical, air and hydraulic devices are all used to coordinate the movements of the tool to reproduce accurately the shape of the template.

7) Automatic lathe: These are high speed, heavy duty, mass production lathes with complete automatic control. Once the tools are set and the machine is started, it performs automatically all the operations to finish the job. The changing of tools, speeds and feeds are also done automatically. After the job is complete, the machine will continue to repeat the cycle producing identical parts even without the attention of the operator. An operator who has to look after 5 or 6 automatic lathes at a time will look after general maintenance of the machine and cutting tool , load up a bar stock and remove finished jobs from time to time.

(Description of 7 lathes – 7M)

b) Explain thread cutting operation in lathe with neat sketch.

A)

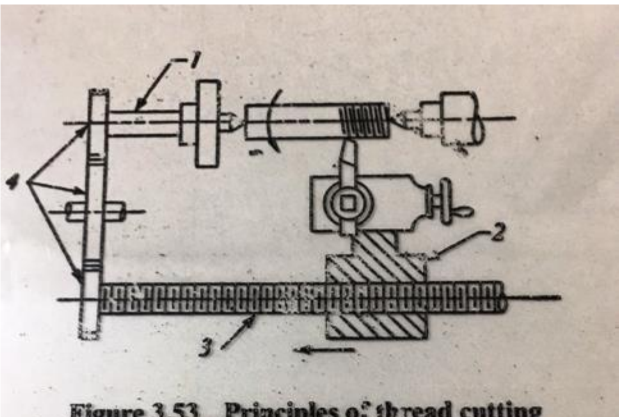


Figure 3.53 Principles of thread cutting
Headstock spindle, 2. Carriage, 3. Leadscrew, 4. Change gear

Thread Cutting:

Thread cutting is one of the most important operations performed on a lathe. The principle of thread cutting is to produce a helical groove on a cylindrical surface by feeding the tool longitudinally, when the job is revolved between centres or by a chuck. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the w/p.

The lead screw of the lathe through which the saddle receives its traversing motion, has a definite pitch. A definite ratio between the longitudinal feed and rotation of the head stock spindle should therefore be found out, so that the relative speeds of rotation of the work and the lead screw will result in the cutting of a screw of the desired pitch.

This is affected by change gears arranged between the spindle and the lead screw or by a change gear mechanism in feed box used in a modern lathe where it provides a wide range of feed and the speed ratio can be easily and quickly changed.

Calculation of change gears:

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{\text{Pitch of the thread to be cut}}{\text{Pitch of the lead screw}}$$

For multi start threads,

$$\frac{\text{Driver teeth}}{\text{Driven teeth}} = \frac{\text{Lead of the thread to be cut}}{\text{Pitch of the lead screw}}$$

Where, Lead of the thread = No. of starts x pitch of the thread

(Sketch – 1M, Explanation – 6M)

UNIT – II

4 a) Explain the Radial drilling machine with neat sketch.

A)

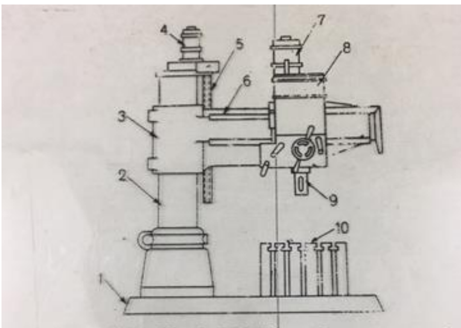


Figure 5.3 Radial drilling machine

1. Base, 2. column, 3. Radial arm, 4. Motor for elevating the arm, 5. Elevating screw, 6. Guide ways, 7. Motor for driving the drill spindle, 8. Drill head, 9. Drill spindle, 10. Table

Radial drilling machine: The radial drilling machine is intended for drilling medium to large and heavy work pieces. The m/c 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 to 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 clamped at any desired position.

These three movements in a radial drilling m/c , when combined together permit the drill to be located at any desired point and on a large w/p for drilling the hole. When several holes are to be drilled on a large w/p, the position of the arm and the 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 work is very large it may be placed on the floor or in a pit.

Plain radial drilling machine: In a plain radial drilling m/c provisions are made for vertical adjustment of the arm, horizontal movement of the drill head along the arm, and circular movement of the arm about the vertical column.

Semi-universal Radial Drilling machine: In this m/c, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. This permits drilling a hole at an angle other than the vertical position.

Universal Radial Drilling machine: In this type of m/c, in addition to the above four movements, the arm holding the drill head may be rotated on a horizontal axis. All these five movements in a universal drilling m/c enables it to drill on a w/p at any angle.

(Fig – 2M, Explanation = 5M)

b) Explain quick return mechanism in shaper with neat sketch.

A) The motion or power is transmitted to the bull gear 14 through a pinion 1 which receives its motion from an electric motor through a gear box. Speed of the bull gear may be changed by different combination of gearing or by shifting the belt on a step cone pulley. Bull gear 14 is a large gear mounted within the column. Bolted to the centre of the bull gear is a radial slide 16 which carries a sliding block 10 into which the crank pin 11 is fitted.

Rotation of the bull gear will cause the crank pin 11 to revolve at a uniform speed. Sliding block 12 which is mounted upon the crank pin 11 is fitted within the slotted link 9. The slotted link 9 which is also known as the rocker arm is pivoted at 15 at its bottom end attached to the frame of the column. The upper end of the rocker arm is forked and connected to the ram block 8 by a pin.

As the bull gear rotates causing the crank pin to rotate, the sliding block 12 fastened to the crank pin 11 will rotate on the crank pin circle, and at the same time will move up and down the slot in the slotted link 9 giving it a rocking movement which is communicated to the ram. Thus the rotary motion of the bull gear is converted to reciprocating motion of the ram.

The principle of quick return motion is shown in the above fig. When the link is in the position PM, the ram will be at the extreme backward position of its stroke, and when it is at PN, the extreme forward position of the ram will have been reached. PM and PN are shown tangent to the crank pin circle. The forward cutting stroke, therefore, takes place when the crank rotates through the angle C_1KC_2 and the return stroke takes place when the crank rotates through the angle C_2LC_1. It is evident that the angle C_1KC_2 made by the forward or cutting stroke is greater than the angle C_2LC_1 described by the return stroke.

The angular velocity of the crank pin being constant the return stroke is, therefore, completed within a shorter time for which it is known as quick return motion. The ratio between the cutting time and return time may be determined from the formula,

$$\frac{\text{Cutting time}}{\text{Return time}} = \frac{\text{Angle } C_1KC_2}{\text{Angle } C_2LC_1}$$

Cutting time to return time ratio usually varies between 2:1 to 3:2. The only disadvantage lies with this mechanism is that the cutting speed and return speed is not constant throughout the stroke. It is minimum when the rocker arm is at the two extremities and the speed is maximum when the rocker arm is vertical.

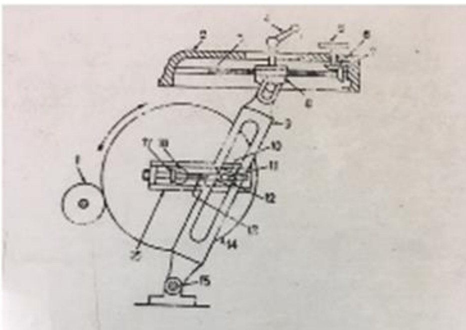


Figure 7.5 Crank and slotted link mechanism
1. Driving pinion, 2. Ram, 3. Screwed shaft, 4. Clamping lever, 5. Handwheel for position of stroke adjustment, 6,7. Bevel gears, 8. Ram block, 9. Slotted link or rocker arm, 10. Bull gear sliding block, 11. Crank pin, 12. Rocker arm sliding block, 13. Lead screw, 14. Bull gear, 15. Rocker arm pivot, 16. Bull gear slide, 17,18. Bevel gears.

(Fig – 1M, Explanation – 6M)

5 a) Explain the constructional details of Planing machine with neat sketch.

A) <u>Standard or double housing planer:</u>

This type of planer is most widely used. A double housing planer has a long heavy base on which a table reciprocates on accurate guide ways. Two vertical housings or uprights are mounted near the middle of the base, one on each side of the bed. To ensure rigidity of the structure, these two housings are connected at the top by a cast iron member. The vertical faces of the two housings are accurately machined So that the horizontal crossrail carrying two tool heads may slide upon it.

The tool heads which hold the tools are mounted upon the crossrail. These tools may be fed either by hand or by power in crosswise or vertical direction. In addition to these tool heads, there are two other tool heads which are mounted upon the vertical face of the housing. They can also be moved either in vertical or horizontal direction to apply feed. The planer table may be driven either by mechanical or hydraulic devices.

The setting up of a large number of identical work pieces on a planing m/c table takes quite a long time. to have a continuous production one of the table is used for setting up the work, while the other reciprocates past the cutting tool finishing the work. When the work on the second table is finished, it is stopped and finished jobs are removed. Fresh jobs are now set up on this table while the first table holding the jobs now reciprocates past the tool. When a heavy and large job has to be machined, both the tables are clamped together and are given reciprocating movement under the tool.

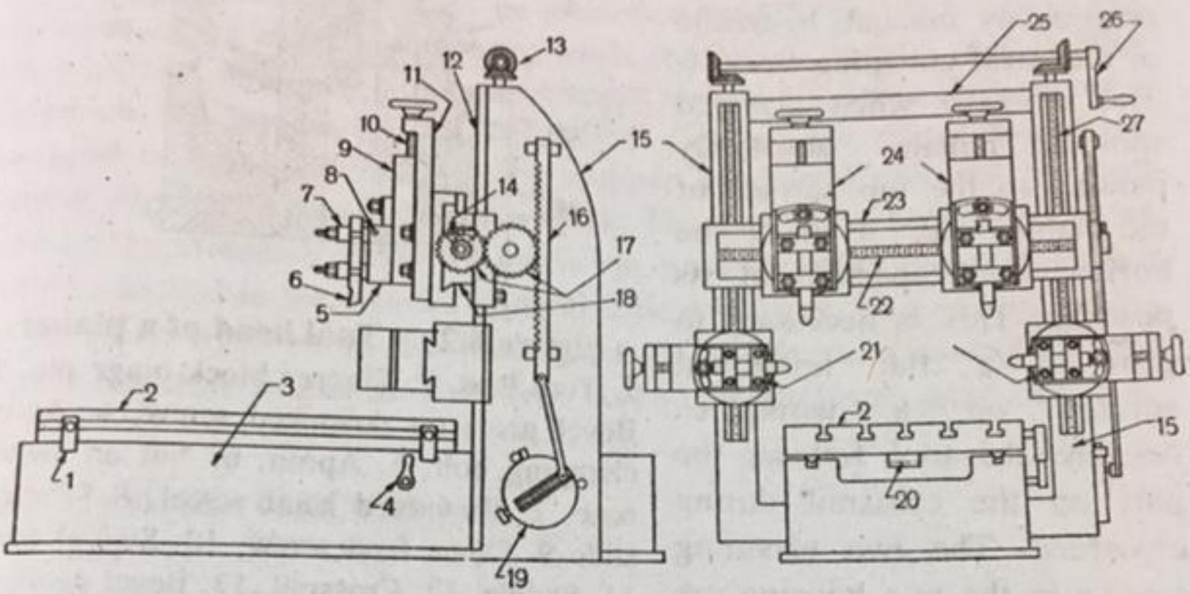


Figure 8.1 Standard double housing planer

1. Trip dog, 2. Table, 3. Bed, 4. Reversing lever, 5. Clapper box, 6. Tool, 7. Tool Post, 8. Hinge pin, 9. Vertical slide, 10. Downfeed screw, 11. Slide, 12. Guideways on column face, 13. Feed screw for elevating crossrail, 14. Pawl, 15. Column o housing, 16. Rack, 17. Feed gears, 18. Saddle, 19. Feed disc, 20. Table rack, 21 Slide toolhead, 22. Feed screw, 23. Crossrail, 24. Vertical toolheads, 25 Crossmember, 26. Crossrail, elevating handle, 27. Cross elevating screw.

(Sketch – 2M, Explanation of parts – 5M)

b) Describe briefly about selection and specification of grinding wheel.

A) <u>Selection of grinding wheels:</u>

In selection of grinding wheels there are four constant factors and four variables to be considered.

Constant factors	Variable factors
1) Material to be ground	1) Wheel speed
2) Amount of stock to be removed	2) Work speed
3) Area of contact	3) Condition of the m/c
4) Type of grinding m/c	4) Personal factor

<u>1)The material to be ground:</u> This influences the selection of abrasive, grain size, grade, structure and bond.

Al_2O_3 abrasive is recommended for materials of high tensile strength and SiC for low tensile strength.
Fine grain is used for hard and brittle materials and coarse grain for soft and ductile materials.
Hard wheel is used for soft materials and soft wheel for hard materials.
Generally, close(dense) spacing for is required for hard and brittle materials and wide(open) for soft and ductile.
The class of work usually dictates the bond to be used. Majority of wheels are manufactured with vitrified bonds. They are sensitive against shock and blow, however they endure high temperature. Rubber, shellac and resinoid bonds are tough and elastic, they are suitable for thin discs and sharp profiles. The resinoid bond is suitable for high temperatures.

<u>2)Amount of stock to be removed:</u> This involves accuracy and finish. Coarse grain is used for fast cutting and fine grain for fine finish. Wide spacing for rapid removal and close for fine finish. Resinoid, rubber and shellac bond for high finish.

<u>3)Area of contact:</u> Area of contact influences the selection of grit size, grade and structure. Fine grain, close grain spacing and hard wheels are useful where the area of contact(between wheel and w/p) involved is small(Ext.cyl.grinding) and
Coarse grain, open spacing and soft wheels are employed where a large area of contact is concerned(Int.cyl.grinding and End face grinding).

<u>4)Type of grinding machine:</u> Type of grinding m/c determines to an extent the grade of the wheel. Heavy, rigidly constructed machines take softer wheels than the lighter more flexible types.

<u>5) Wheel speed:</u> The wheel speed influences the selection of grade and bond. The higher the wheel speed with relation to work speed, the softer the wheel should be. Vitrified bond is usually specified for surface speeds up to 2000m/min.
and rubber, shellac and resinoid bonds for surface speeds over 2000m/min.

<u>6)Work speed:</u> The higher the work speed with relation to the wheel speed, the harder the wheel should be.

<u>7) Condition of the grinding machine:</u> The condition of the grinding m/c has a bearing on the grade of the wheel to be selected. Spindle loose in their bearings
or shaky foundations would necessitates the use of harder wheels than would be the case if the machine is in better operating condition.

<u>8)Personal factor:</u> The skill of workman is another variable factor which should be considered in selecting the wheel. It can vary the grinding costs considerably on the same work.

<u>Specification of grinding wheel:</u>

The Indian standard marking system for a grinding wheel has been prepared with a view to establish a uniform system of marking grinding wheels to designate their various characteristics. Bonded abrasives are marked with standardized system of letters and numbers indicating in sequence, the type of abrasive, grain size, grade, structure and bond type.

Each marking shall consists of six symbols, denoting the following in succession.

1) Abrasive type 2) Grain size 3) Grade 4) Structure 5) Bond type 6) manufacturer's record.

In addition Straight grinding wheels or disc wheels are specified by :
Outside diameter x Thickness x Inside diameter. For Ex: 200 x 13 x 32mm

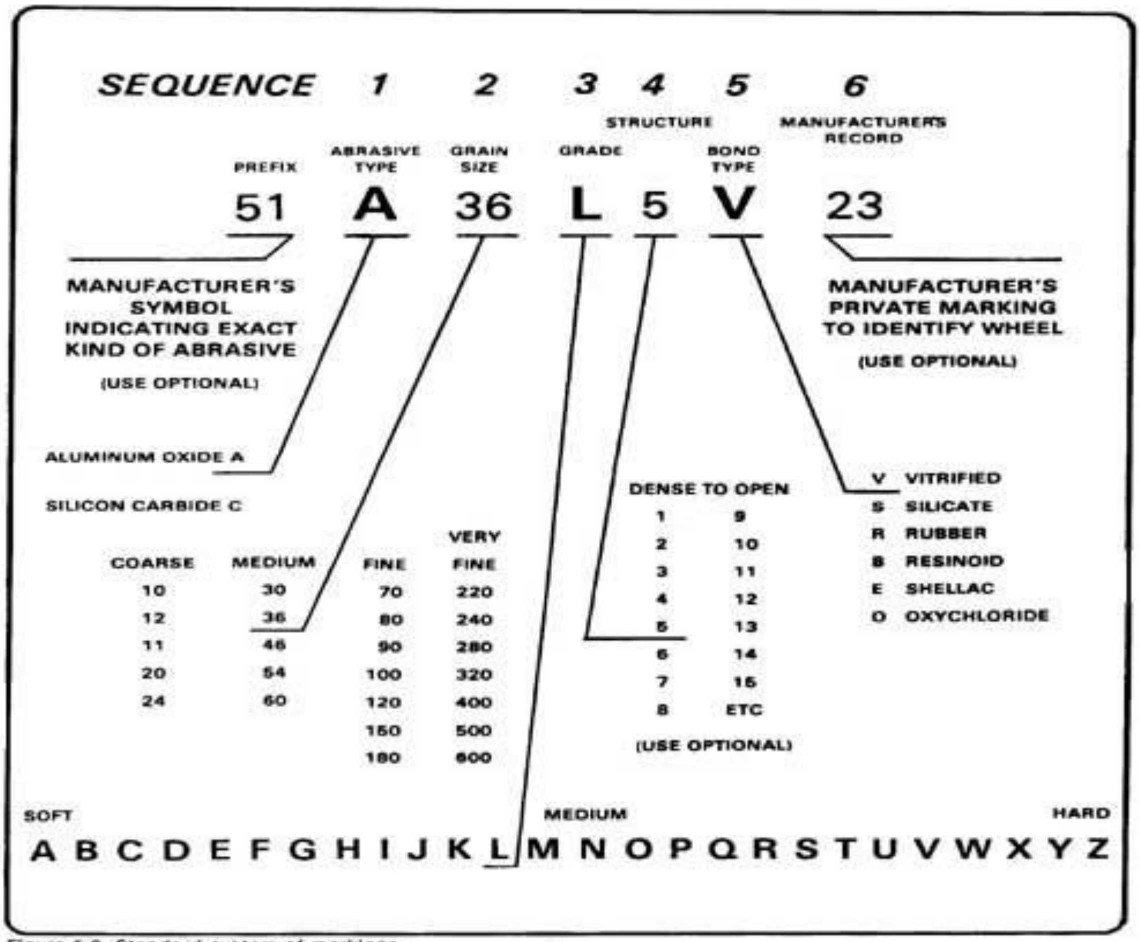


Figure 5-9. Standard system of markings.

(selection of wheels- 4M, specification of wheels – 3M)

UNIT – III

6 a) Explain surface finishing operation Lapping with neat sketch.

A) Lapping: Lapping is an abrading process that is used to produce geometrically true surfaces, correct minor surface imperfections, improve dimensional accuracy or provide a very close fit between two contact surfaces. Very thin layers of metal (0.005 to 0.01mm) are removed in lapping and it is, therefore, evident that lapping is unable to correct substantial errors in the form and sizes of surfaces. It is however, low efficiency process and is used only when specified accuracy and surface finish cannot be obtained by other methods.

Abrasive powders such as emery, corundum, iron oxide, chromium oxide etc mixed with oil (usually kerosene) or special pastes with some carrier are used in lapping. Most lapping is done by means of laps that are rubbed against the work. The face of the lap becomes charged with abrasive particles. Charging a lap means to embed the abrasive grains into its surface. The lap is usually made of cast iron, brass, copper, lead, leather or cloth, which is soft enough to receive and retain abrasive grains.

Laps may be operated by hand or machine, the motion being rotary or reciprocating . Cylindrical work may be lapped by rotating the work in a lathe and reciprocating the lap over the work in an ever changing path. Small flat surfaces may be lapped by holding the work against a rotating disc or the work may be moved by hand in an irregular path over a stationary face plate lap. The vertical axis lapping machine laps flat or cylindrical surfaces between two opposed laps on vertical spindles. The abrasive belt lapping m/c laps bearings and cam surfaces by means of abrasive coated clothes. The abrasive particles are embedded in the lap or they may be carried through a slurry. Lapping is also done on curved surfaces, such as spherical objects and glass lenses, using specially shaped laps. Running-in of mating gears can be done by lapping. Tolerances on the order of ± 0.0004mm can be obtained with the use of fine abrasives from 400 to900 grit. Surface finish can be as smooth as 0.025 – 0.1 microns. Examples of lapped parts are Gudgeon pin, Valves, Valve seats, Piston rings, Hydraulic valve blocks and pistons etc.

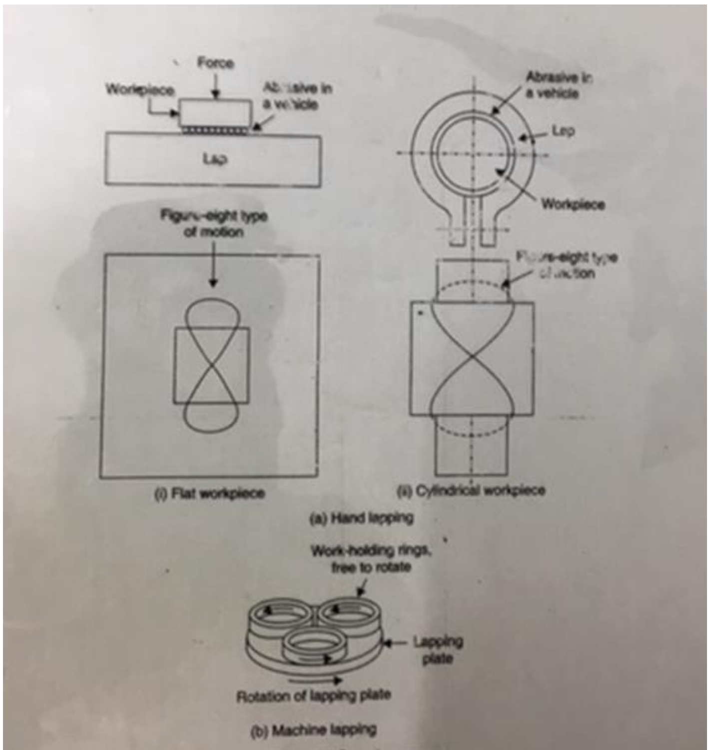


Fig. 9.137. Lapping process.

(Sketch – 1M, Explanation – 6M)

b) Explain the Column and knee type universal Milling machine with neat sketch.

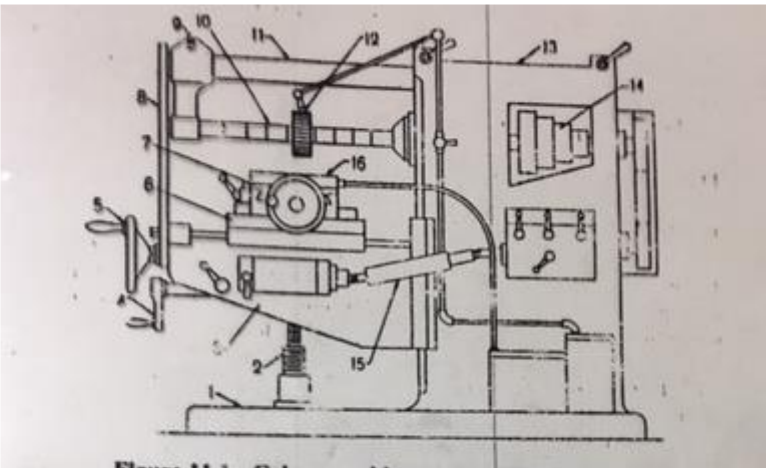


Figure 11.1 Column and knee type milling machine
1. Base, 2. Elevating screw, 3. Knee, 4. Knee elevating handle, 5. Crossfeed handle, 6. Saddle, Table, 8. Front brace, 9. Arbor support, 10. Conepulley, 15. Telescopic feed shaft.

<u>Base:</u> The base of the machine is made of grey cast iron machined on its top and bottom surface and serves as a foundation member for all the other parts which rest upon it. It carries the column at its one end. The base is made hollow and serves as a reservoir for cutting fluid.

<u>Column:</u> The column is the main supporting frame mounted vertically on the base. The column is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed. The front vertical face of the column is accurately machined and is provided with dovetail guide ways for supporting the knee. The top of the column is finished to hold an overarm that extends outward at the front of the machine.

Knee: The knee is a rigid grey iron casting that slides up and down on the vertical ways of the column face. The adjustment of height is effected by an elevating screw mounted on the base that also supports the knee. The knee houses the feed mechanism of the table, and different controls to operate it. The top face of the knee forms a slideway for the saddle to provide cross travel of the table.

Table: The table rests on ways on the saddle and travels longitudinally. The top of the table is accurately finished and T-slots are provided for clamping the work and other fixtures on it. A lead screw under the table engages a nut on the saddle to move the table horizontally by hand or power. The longitudinal movement of the table may be limited by fixing trip dogs on the side of the table. In universal milling machine, the table may also be swiveled horizontally. For this purpose the table is mounted on a circular base, which in turn is mounted on the saddle. The circular base is graduated in degrees.

Overhanging arm: The overhanging arm that is mounted on the top of the column extends beyond the column face and serves as a bearing support for the other end of the arbor. The arm is adjustable so that the bearing support may be provided nearest to the cutter. More than one bearing support may be provided for the arbor.

Front brace: The front brace is an extra support that is fitted between the knee and the overarm to ensure further rigidity to the arbor and the knee. The front brace is slotted to allow for the adjustment of the height of the knee relative to the overarm.

Spindle: The spindle of the machine is located in the upper part of the column and receives power from the motor through belts, gears, clutches and transmit it to the arbor. The front end of the spindle just projects from the column face and is provided with a tapered hole into which various cutting tools and arbors may be fitted. The accuracy in metal machining by the cutter depends primarily on the accuracy, strength and rigidity of the spindle.

Universal milling machine: A universal milling machine can be distinguished from a plain milling machine in that the table of a universal milling machine is mounted on a circular swiveling base which has degree graduations, and the table can be swiveled to any angle up to 45^0 on either side of the normal position. The table can be swiveled in a horizontal plane about a vertical axis and set at an angle other than right angle to the spindle.

Thus in a milling machine, in addition to three movements of a plain milling machine, the table may have a fourth movement, when it is fed at an angle to the milling cutter. This additional feature enables it to perform helical milling operation which cannot be done on a plain milling m/c. The capacity of a universal milling m/c is considerably increased by the use of special attachments such as dividing head or index head, vertical milling attachment, rotary table attachment, slotting attachment etc.

(Fig – 2M, Explanation – 5M)

7 a) Describe various Milling operations with neat sketch.

A) The following are the different operations performed on a milling machine.

1) Plain milling 2) Face milling 3) Side milling 4) Straddle milling 5) Angular milling 6) Gang milling

7) Form milling 8) End milling 9) Saw milling 10) Milling key ways, grooves and slots 11) Gear cutting

12) Helical or spiral milling 13) Cam milling 14) Thread milling.

Plain milling:

The plain milling is the operation of production of a plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter. The operation is also called slab milling. To perform the operation, the work and the cutter are secured properly on the machine. The depth of cut is adjusted by rotating the vertical feed screw of the table and the machine is started after selecting proper speed and feed.

Face milling:

The face milling operation is performed by a face milling cutter rotated about an axis perpendicular to the work surface. The operation is carried on a plain milling m/c and the cutter is mounted on a stub arbor to produce a flat surface. The depth of cut is adjusted by rotating the cross feed screw of the table.

Side milling:

The side milling is the operation of production of a flat vertical surface on the side of a work piece by using side milling cutter. The depth of cut is adjusted by rotating the vertical feed screw of the table.

Straddle milling:

The straddle milling is the operation of production of flat vertical surfaces on both sides of a work piece by using two side milling cutters mounted on the same arbor. The distance between the two cutters is correctly adjusted by using suitable spacing collars. The straddle milling is very commonly used to produce square or hexagonal surfaces.

Form milling:

The form milling is the operation of production of irregular contours by using form cutter. The irregular contour may be convex, concave, or any other shape. After machining, the formed surface is checked by a template gauge. The cutting speed for form milling is 20% to 30% less than that of the plain milling.

End milling:

The end milling is the operation of production of a flat surface which may be vertical, horizontal or at an angle with reference to the table surface. The cutter used is an end mill. The end milling cutters are also used for production of slots, grooves or key ways. A vertical milling machine is most suitable for end milling operation.

Saw milling:

The saw milling is the operation of production of a narrow slots or grooves on a work piece by using a saw milling cutter. The saw milling can also be performed for complete parting-off operation. The cutter and w/p are set in a manner so that the cutter is directly placed over one of the T-slots of the table.

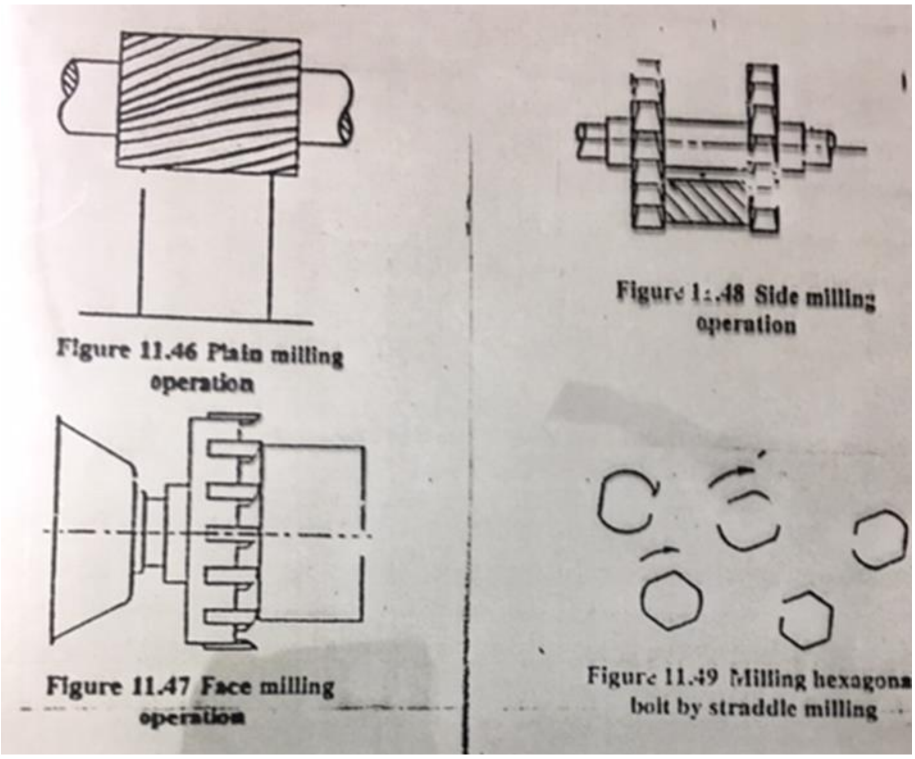
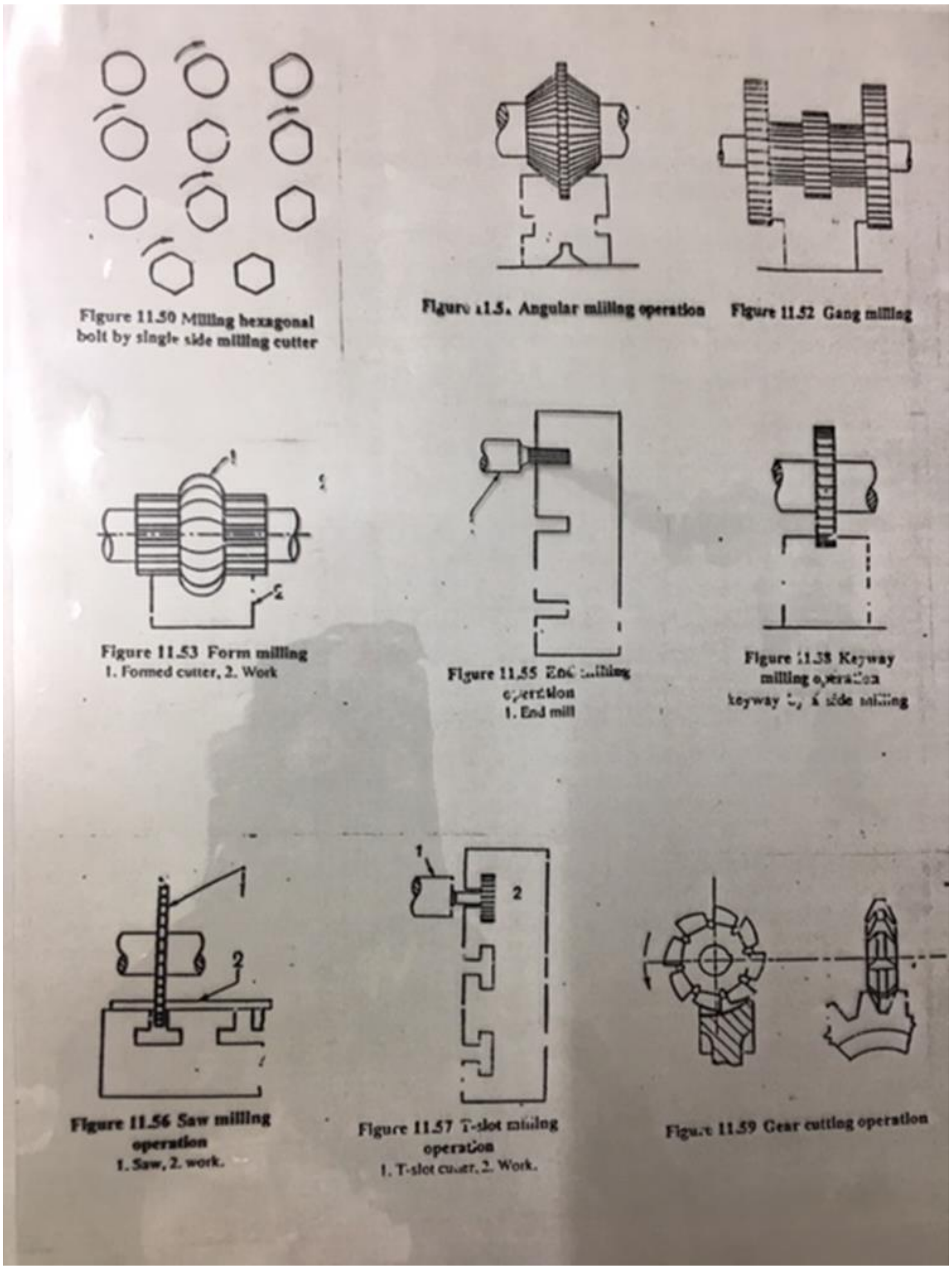


Figure 11.46 Plain milling operation

Figure 11.48 Side milling operation

Figure 11.47 Face milling operation

Figure 11.49 Milling hexagona bolt by straddle milling



(Sketch – 1M, Explanation of any three operations- 6M)

b) What are the various types of Indexing methods? Explain any two methods.

A) <u>Indexing methods:</u>

There are different methods of indexing. The choice of any method depends upon the number of divisions required and the type of dividing head used.

Different methods of indexing are:

1) Direct or Rapid indexing 2) Plain or Simple indexing 3) Compound indexing 4) Differential indexing 5) Angular indexing

<u>Direct indexing:</u> Direct indexing or rapid indexing is used when a large number of identical work pieces are indexed by very small number of divisions. When using a universal head, the worm and worm wheel are first disengaged. The required number of divisions on the work is obtained by means of the rapid index plate generally fitted to the front end of the spindle nose. The plate has 24 equally spaced holes, into any one of which a spring loaded pin is pushed to lock the spindle with the frame. While indexing the pin is first taken out and the spindle is rotated by the hand and after the required position is reached, it is again locked by the pin.

When the plate is turned through the required part of the revolution, the spindle and work are also turned through the same part of the revolution. With rapid index plate having 24 holes it is possible to divide the work into 2, 3, 4, 6, 8, 12, 24 parts which are all factors of 24.

To find index movement, divide the total number of holes in the direct index plate by the number of divisions required on the work.

No. of holes to be moved = 24/N

Where N = No. of divisions required

To machine a hexagonal bolt head, No. of holes to be moved = 24/6 = 4

After machining one face of the bolt head, the index plate has to be moved by 4 holes for 5 number of times to machine the remaining faces of the bolt head.

<u>Simple indexing:</u> The simple indexing is more accurate and suitable for numbers beyond the range of rapid indexing. Here the dividing head spindle is moved by turning the index crank. As the shaft carrying the crank has a single threaded worm which meshes with a worm gear having 40 teeth. 40 turns of crank are necessary to rotate the index head spindle through one revolution. To facilitate indexing to fraction of a turn, index plates are used.

Index plates made by Brown & Sharp Manufacturing company are:

Plate no.1 = 15, 16, 17, 18, 19, 20 hole circles

Plate no.2 = 21, 23, 27, 29, 31, 33

Plate no.3 = 37, 39, 41, 43, 47, 49

With the three index plates supplied, simple indexing can be used for all divisions up to 50, even numbers up to 100, except 96 and many others.

To find index crank movement, divide 40 by the number of divisions required on the work.

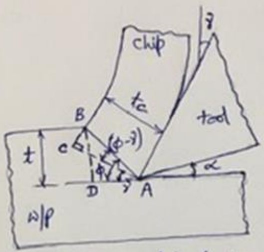
Index crank movement = 40/N

where, N = No. of divisions required on the work

(Types of indexing methods – 1M, Explanation of any two methods – 6M)

UNIT – IV

8 a) Derive the expression for stress and strain in the chip.



In a simplified model of two-dimensional (orthogonal) cutting operation, the cutting tool is completely defined by the rake angle 'γ' and the clearance angle 'α'. In addition the following assumptions are made.

1) The tool is perfectly sharp and contacts the chip on its rake face.
2) The Primary deformation takes place in a very thin zone adjacent to shear plane.
3) There is no side flow of chip. i.e. the Plain strain condition is Present.
4) The width of the chip is same in both cases i.e. cut and uncut.
5) orthogonal cutting, where Principal cutting edge angle = 90° and inclination angle = 0°.

t = uncut chip thickness

t_c = chip thickness

γ = rake angle, ϕ = shear angle, AB = shear Plane

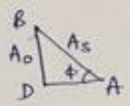
cutting ratio

Shear stress and Shear strain in metal cutting:

Let F_s = Shear force acting along shear Plane

A_s = Area of shear Plane

A_o = c/s area of uncut chip = bt

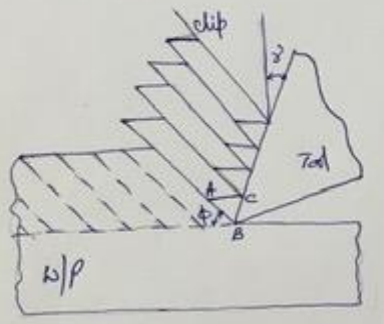


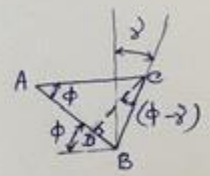
$$\sin\phi = \frac{A_o}{A_s} = \frac{bt}{A_s}$$

$$A_s = \frac{bt}{\sin\phi}$$

τ_s = shear stress of the material on to shear Plane

$$\tau_s = \frac{F_s}{A_s} = \frac{F_s \sin\phi}{bt}$$





$\angle ABC = 90 - \phi + \gamma$

$\angle BCD = 90 - (90 - \phi + \gamma)$

$= (\phi - \gamma)$

The shearing Process in metal cutting can be represented by a simple model as shown above.

The shearing Process is similar to the displacement of a stack of cards, with each card sliding slightly over the adjacent card.

From this model, the shear strain that the material is undergoing can be determined.

$$\text{Shear strain 's'} = \frac{AB}{CD} = \frac{AD+BD}{CD} = \frac{AD}{CD} + \frac{BD}{CD}$$

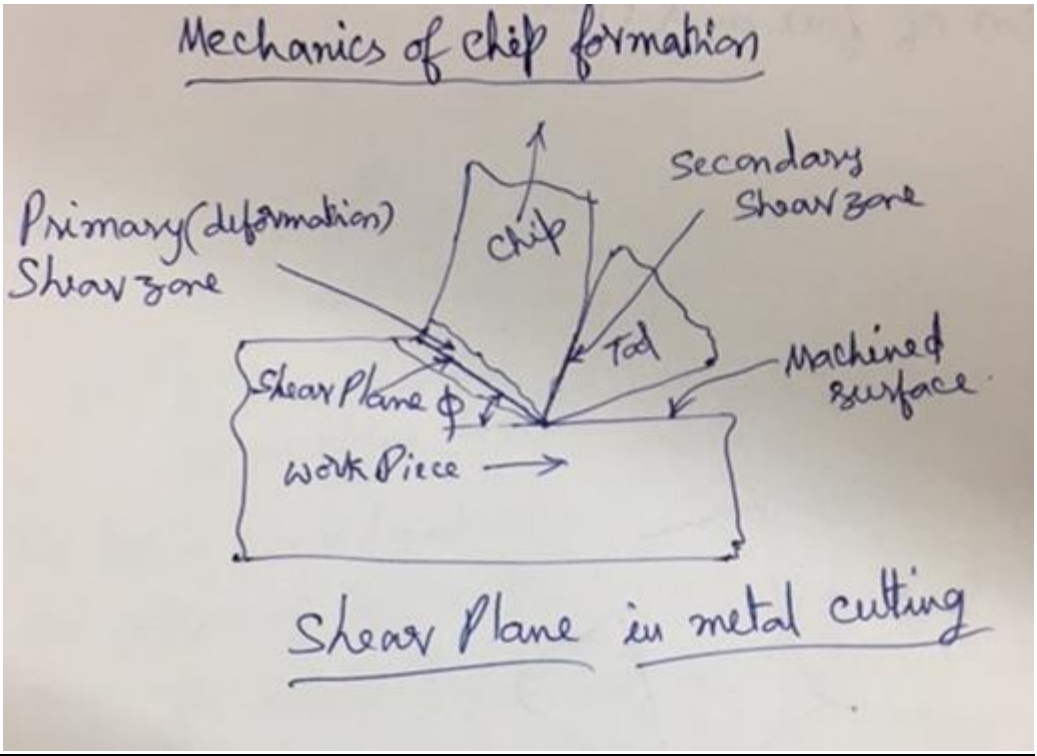
$$s = \cot\phi + \tan(\phi - \gamma)$$

Thus large shear strains are associated with low shear angles.

(Expressions for stress – 3M, strain – 4M)

b) Explain the mechanics of chip formation with neat sketch.

A)



Mechanics of chip formation:

The tool is considered stationary and the work piece moves to the right. The metal in front of the cutting edge of the tool is severely compressed. The uncut layer deforms into chip after it goes through a severe deformation in the primary shear zone. As a result of plastic deformation the thickness of chip is greater than that of the uncut layer. A distinctive zone of separation between the chip and the work piece where the deformation gradually increases towards the cutting edge is called shear zone or primary deformation zone. However in case of higher cutting speeds the width of the shear zone is very small and is only about 1 to 10 microns and can be idealized as a plane. The plane where the shear occurs is known as the shear plane and its inclination with the machined surface is called the shear angle ø.

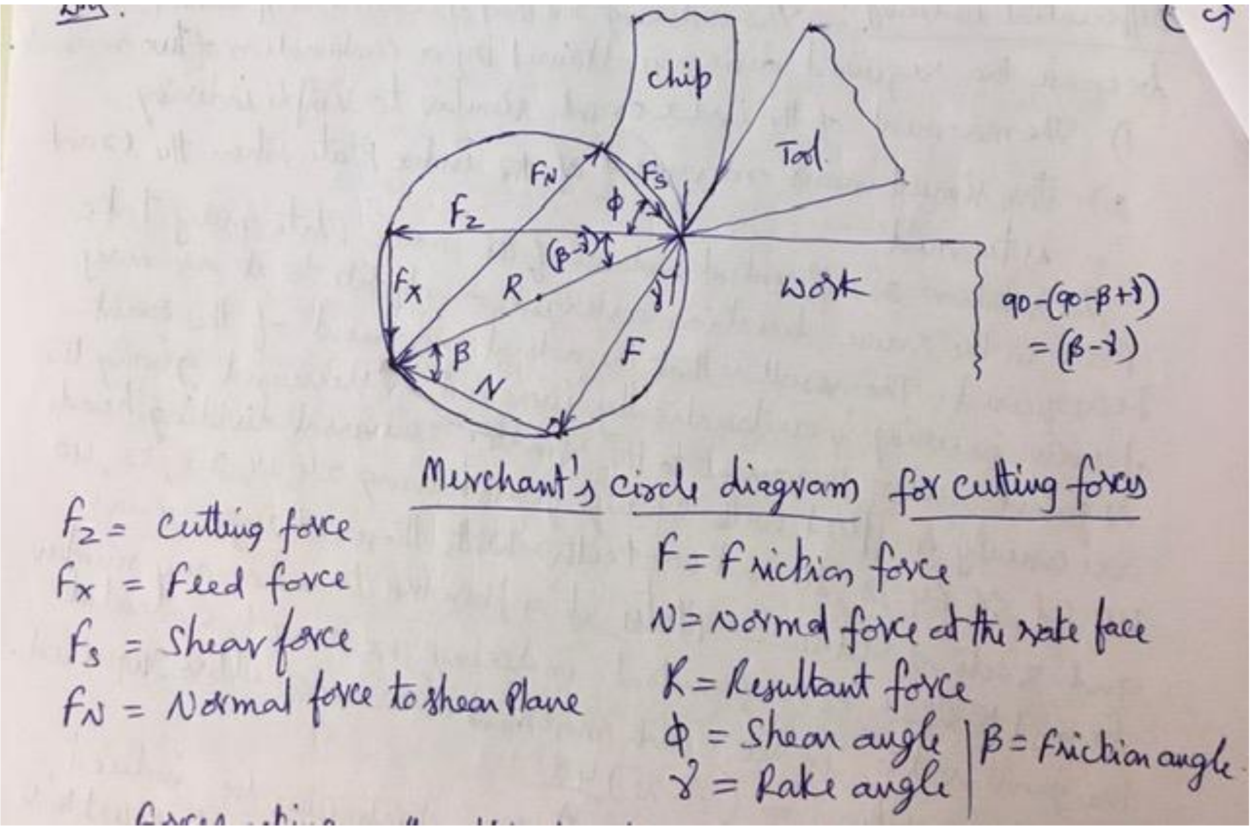
To deform the metal in this manner, the forces that must be transmitted to the chip across the interface between the chip and the tool are sufficient to deform the lower layers of the chip as it slides along the tool face.

Hence this is known as the secondary deformation zone. The process of formation of chips may be represented as the process of successive slip through shear of the sections of layers being cut. The tool side of the chip surface is shiny or burnished, which is caused by rubbing of the chip as it moves up the tool face.

(Sketch – 1M, Explanation = 6M)

9 a) Draw the Merchant's circle diagram and derive expressions for various forces acting in the machining.

A)



Merchant's circle diagram for cutting forces

F_z = cutting force
F_x = feed force
F_s = Shear force
F_N = Normal force to shear Plane
F = Friction force
N = Normal force at the rake face
R = Resultant force
ϕ = Shear angle | β = Friction angle
γ = Rake angle

Forces in metal cutting:

The force system in the general case of conventional turning Process is shown in fig. The resultant cutting force 'R' may be resolved into three components. 'F_x' known as the thrust force or feed force acting in a horizontal Plane, but in a direction opposite to the feed. 'F_y' called radial force acting in the direction Perpendicular to the machined surface and 'F_z' the tangential force or cutting force acting in the direction of the Primary cutting motion. The largest in magnitude is the vertical force 'F_z'. In plain turning, $F_x = 0.3$ to $0.6 F_z$ and $F_y = 0.2$ to $0.4 F_z$. In case of orthogonal cutting where inclination angle $i = 0$ and PCEA 'ϕ_1' $= 90°$, the force system is reduced to 2D system.

Merchant's theory of cutting forces:

The forces acting on the chip in orthogonal cutting are shown in fig.

F_s = force which acts along the shear Plane is the resistance to the shear of the metal in forming the chip

F_N = Force normal to the shear Plane. This is backing up force on the chip Provided by the W/P.

F = frictional resistance of the tool acting downwards against the motion of the chip.

N = force acting on the chip normal to the rake face of the tool and is Provided by the tool.

Forces acting on the chip in which forces F_s and F_N may be replaced by their resultant R, and so the forces F and N by their resultant R'.

These resultant forces R and R' are equal in magnitude, opposite in direction and collinear. Therefore the chip is in mechanical equilibrium by the action of two equal and opposite forces R which the work piece exerts up on the chip and R' which the tool exerts upon the chip.

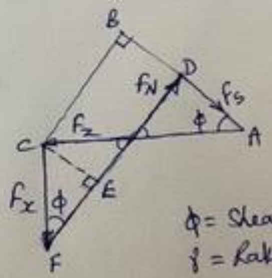
All these forces can be represented with the help of a circle known as the "Merchant force circle". In the circle diagram, two force triangles have been combined and R and R' together have been replaced by 'R'. Since the forces F_s and F_N are at right angles to each other, their intersection lies on a circle with diameter 'R'. The forces F and N may be placed in the diagram as shown, to form the circle diagram. Now the force R can be resolved in to two component forces. F_z the cutting force of the tool on the w/p and F_x the feed force. In the fig. 'β' is the angle of friction.

In $\triangle$le ABC,

$AB = AC\cos\phi = F_z\cos\phi$

In $\triangle$le CEF,

$CE = CF\sin\phi = F_x\sin\phi$



ϕ = Shear angle
γ = Rake angle.

$\therefore$ Shear force $F_s = AB - BD$
$= AB - CE$

$$\therefore \quad F_s = F_z\cos\phi - F_x\sin\phi$$

$BC = AC\sin\phi = F_z\sin\phi$

$BC = ED = F_z\sin\phi$

$EF = CF\cos\phi = F_x\cos\phi$

$\therefore$ Normal force $F_N = ED + EF$

$$F_N = F_z\sin\phi + F_x\cos\phi$$

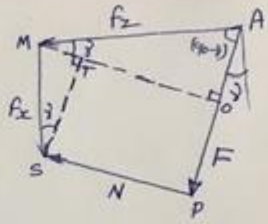
In Δle AMO,

$AO = AM \sin\gamma = F_z \sin\gamma$

In Δle MTS,

$TS = MS \cos\gamma = F_x \cos\gamma$

$TS = OP = F_x \cos\gamma$



Frictional resistance at the rake surface, $F = AO + OP$

$F = F_z \sin\gamma + F_x \cos\gamma$

$MO = AM \cos\gamma = F_z \cos\gamma$

$MT = MS \sin\gamma = F_x \sin\gamma$

$\therefore$ Normal force on the rake surface $N = MO - MT$

$N = F_z \cos\gamma - F_x \sin\gamma$

(Diagram – 2M, Derivations – 5M)

b) What are the functions and requirements of cutting fluids? Explain briefly.

A) In any metal cutting operation lot of heat is generated due to plastic deformation of metal, friction at the rake face of the tool between the tool and the chip and also between the work piece and flank of the tool. This increases the temperature of both the work piece and the tool point, resulting decrease in hardness and hence life of the tool. The machined surface will also be rough and the possibility of BUE increases. So the use of a cutting fluid during a machining operation is very essential. Its application at the work piece-tool interface produces the following affects.

1) Cooling down of the chip-tool work zone by carrying away some of the generated heat.

2) Reducing the coefficient of friction at the chip-tool interface due to lubricating action.

3) Reducing the thermal distortion caused by the temperature gradient generated during machining.

4) Washing away the chips and cleaning the machining zone.

5) Protecting the finished surface from corrosion.

Requirements of a cutting fluid:

1) It should have a large specific heat and thermal conductivity

2) It should have a low viscosity and small molecular size (to help rapid penetration to the tool-chip interface)

3) It should contain a suitable reactive constituent (for forming a low strength compound after reacting with work material)

4) It should be nonpoisonous and noncorrosive.

5) It should be inexpensive and easily available.

(Functions – 4M, Requirements – 3M)

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