Hall Ticket Number:

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

November, 2019 **Mechanical Engineering**

Fifth Semester **Metal Cutting & Machine Tools**

Time: Three Hours **Maximum:** 60 Marks

Answer Question No.1 compulsorily. (1X12 = 12 Marks)

Answer ONE question from each unit. (4X12=48 Marks)

1. Answer all questions (1X12=12 Marks)
   a) State the specifications of the lathe.
   b) List out some of the lathe operations.
   c) Importance of half nut mechanism
   d) Difference between drilling and boring
   e) What is dressing?
   f) Define quick return mechanism
   g) Difference between lapping and honing
   h) Purpose of indexing
   i) Difference between up milling and down milling
   j) What is cutting ratio?
   k) Why tools fail during cutting
   l) Economics of machining

UNIT I

2. a) Sketch and explain the back gear drive mechanism of a lathe. 6M
   b) Describe the classifications of a lathe. 6M

(OR)

3. a) What are various accessories used in lathe? Explain any two of them. 6M
   b) Explain the primary and auxiliary motions in machine tools. 6M

UNIT II

4. a) Explain the basic parts of radial drilling machine with neat sketch. 6M
   b) Distinguish between shaper and planer 6M

(OR)

5. a) Write about quick return mechanism of a planer with the help of a sketch. 6M
   b) Describe clearly the specifications of a grinding wheel 6M

UNIT III

6. List various types of milling machines and explain with neat sketch the horizontal milling machine. 12M

(OR)

7. a) Explain clearly the honing operation with neat sketch. 6M
   b) Index 31 divisions using differential Indexing. 6M

UNIT IV

8. In orthogonal cutting if the feed is 1.25 mm/rev and chip thickness after cutting is 2 mm determine chip thickness ratio and shear angle. The tool bit has a rake angle of 10^0. If the shear strength is 6000 kg/cm^2, width of cut is 10 mm, cutting speed is 30 mpm, coefficient of friction is 0.9, determine:(i) Shearing force(ii) Friction angle(iii) Cutting force, and (iv) Horse power at the cutting tool. 12M

(OR)

9. a) Derive an equation for Shear angle in terms of chip thickness ratio and rake angle.(6M) 6M
   b) What are the major types of tool materials? Explain. 6M

III/IV B.Tech. (Regular) Degree Examination
November 2019, Vth Semester, Mechanical Engg.
Sub: Metal cutting & Machine Tools (14ME504/ME314)

Scheme of Evaluation

1) Bits — 1x12 = 12 M

a) State the specifications of the lathe

Ans: 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 carriage
5) The maximum bar diameter
6) Spindle nose dia; Centre Morse taper No., No. and range of spindle speeds and feeds, Power input etc.

b) List out some of the lathe operations.

Ans: 1) Straight turning 2) Taper turning 3) Thread cutting 4) Facing 5) Knurling 6) Chamfering 7) Drilling, Reaming & Boring 8) Parting-off etc.

c) Importance of half nut mechanism.

Ans: The rotation of the lead screw is used to traverse the tool along the work to Produce screw thread. The half nut mechanism makes the carriage to engage or disengage with the lead Screw. It comprises a pair of half nuts capable of moving in or out of mesh with the lead screw.

d) Difference between drilling and boring

Ans: Drilling is the operation, which originates the hole, where as Boring enlarges the existing hole. Drilled hole is rough and slightly oversize. Boring Produces good finish and accurate size

e) what is dressing?

Ans: Dressing removes loading and breaks away the glazed surface on the grinding wheel so that sharp abrasive particles are again presented to the work. In precision grinding diamond dressers are used to remove clogged chips and glazed surface from wheel face by slowly feeding the dresser against revolving wheel.

f) Define quick return mechanism.

Ans: In a standard shaper, metal is removed in the forward cutting stroke, while the return stroke goes idle and no metal is removed. To reduce the total machining time it is necessary to reduce the time taken by the return stroke. Thus the shaper mechanism is designed such that, the ram holding the tool moves relatively at a slower speed during forward cutting stroke, whereas during return stroke it can allow the ram to move at a faster rate to reduce the idle return time. This mechanism is known as quick return mechanism. In shaper this is obtained by using crank and slotted link mechanism.

g) Difference between lapping and honing.

Ans: Lapping is an abrading process that is used to produce geometrically true surfaces, correct minor surface imperfections, improve dimensional accuracy or provide very close fit between two contact surfaces. Very thin layers of metal is removed (0.005 to 0.01mm) in lapping, hence it can't correct substantial errors in form and size of surfaces.

Honing is grinding or a abrading process mostly for finishing round holes by means of bonded abrasive stones called hones. Honing is a cutting operation and can remove upto 3mm stock, but normally confined to less than 0.25mm. So honing is primarily used to correct some out of roundness, taper, tool marks and axial distortion.

h) Purpose of indexing.

Ans. Indexing is the operation of dividing the periphery of a work piece into any number of equal parts. In cutting spur gear equal spacing of teeth on the gear blank is performed by indexing.

The indexing operations can also be used for producing hexagonal and square headed bolts, cutting splines on shafts, fluting drills taps and reamers, all requiring the periphery of work piece to be divided equally and accurately. Indexing is accomplished by using an attachment known as dividing head or Index head. (3)

i) Difference between up milling and down milling.

Ans: The up milling also called as 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 also called as climb milling is the process of removing metal by a cutter which is rotated in the same direction of travel of the work piece.

j) what is cutting ratio?

Ans. Cutting ratio or chip thickness ratio is the ratio between the uncut chip thickness to the chip thickness. i.e. $r = \frac{t}{t_c}$.

Its value is always less than 1.

k) Why tools fail during cutting.

Ans: During metal cutting, tool is subjected to three distinct factors: forces, temperature and sliding action due to relative motion between tool and work piece. These factors cause tool wear due to its continued use. In metal cutting 99% of the energy spent is converted into heat. When ferrous and high strength materials are machined, the temperature rises with the cutting speed and the tool strength decreases, leading to a faster wear and failure.

l) Economics of machining.

Ans. While considering economics of metal cutting, the basic consideration should be to produce a satisfactory part at the best possible cost. At low cutting speeds, tools last long and tooling cost is low. But the MRR is low and hence the cutting cost and the total cost are high.

on the other hand, at high cutting speeds, the MRR will be high giving low cutting cost, but the tool life will be shorter giving the high tooling cost, making the total cost high. At some intermediate cutting speed, the total cost is at the minimum. ④

UNIT - I

2) a) Sketch and explain the back gear drive mechanism of a lathe.

Ans. The back gear is an additional feature of a belt driven lathe and this is used to obtain wide range of spindle speeds. When the backgear is engaged, the spindle speed reduces considerably.

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 engagement with the gears A and D by partly rotating the shaft by means of the 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. On using back gears, the power is transmitted from the cone pulley and the gear A to the back gear B and C from C to the gear D, and from the gear D to the spindle. Of the gear B is three times as large as A, it will revolve one-third as fast as B. Gears B and C being both fastened to the quill will revolve at equal speed. Of D is three times as large as C, it will revolve one-third as fast, with the result that D will revolve one-third of one-third, i.e one-ninth as fast as A or cone pulley. For a particular speed of the cone pulley, the gear D or the spindle will rotate at a speed:

$$n_D = n_A \times \frac{Z_A}{Z_B} \times \frac{Z_C}{Z_D}$$

where, Z_A, Z_B, Z_C and Z_D are the numbers of teeth on gears A, B, C and D, and n_D and n_A are the speeds of the spindle and the speed of the cone pulley, respectively.

A lathe with four steps on the cone pulley and with back gears would thus have eight spindle speeds - 4 direct and 4 indirect, the latter being slower.

Sketch - 1M
Explaination - 5M

b) Describe the classification of a lathe.

Ans: 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 or All geared drive.
3) Bench lathe
4) Tool room lathe
5) Capstan and Turret lathe
6) Special lathe
   a) wheel lathe
   b) Gap bed lathe
   c) T- Lathe
   d) Duplicating or copy lathe
7) Automatic lathe

(Explaination of any 6 types of lathe – 6M)

3) a) What are various accessories used in lathe? Explain any two of them.

Ans: Lathe accessories are used for holding and supporting the work.

Various accessories used on lathe are:

1) Centres
2) Catch plates and carriers
3) Chucks, collets
4) Face plate
5) Angle plate
6) Mandrels
7) Rests

(Explaination of any two of the above – 3×2 = 6M)

b) Explain the primary and auxiliary motions in machine tools.

Ans: 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 workpiece. The relative movement between the w/p and the cutting edge can be obtained either by the motion of the w/p, the cutting tool or by a combination of the motion of the w/p and cutting tool both. These motions which are essential to impart required shape to the w/p are known as working motions. Working motions are further classified into two types.

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.

For ex: on a lathe m/c, drive motion is the rotary motion of w/p. Feed motion is the translatory motion of cutting tool.

Besides the working motions, a m/c 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 fulfil their assigned function. Examples of auxiliary motions in m/c tools are clamping and unclamping of w/p, idle travel of 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 m/c tools the working motions are powered by an external source of energy. The auxiliary motions may be carried out manually or may also be power operated depending upon the degree of automation of the M/c tool.

(Explaination of Primary motions – 3 M
auxiliary motions – 3 M)

UNIT – II

4) a) Explain the basic parts of radial drilling m/c with neat sketch.

Ans: Different parts of a radial drilling m/c are:

1) Base 2) column 3) Radial arm 4) Drill head
5) Spindle speed and feed mechanism.

Base: The base of a radial drilling m/c is a large rectangular casting that is finished on its top to support a column on its one end and to hold the work table at the other end.

Column: The column is a cylindrical casting that is mounted vertically at one end of the base. It supports the radial arm which may slide up or down on its face. An electric motor is mounted on the top of the column which imparts vertical adjustment of the arm by rotating a screw passing through a nut attached to the arm.

Radial arm: The radial arm that is mounted on the column extends horizontally over the base. It is a massive casting with its front vertical face accurately machined to provide guide ways on which the drill head may be made to slide. The arm may be swung round the column.

Drill head: The drill head is mounted on the radial arm drives the drill spindle. It encloses all the mechanism for driving the drill at multiple speed and at different feed. All the mechanisms and controls are housed within a small drill head which may be made to slide on the guide ways of the arm for adjusting the position of drill spindle with respect to the work. After the spindle has been properly adjusted in position the drill head is clamped on the radial arm.

Spindle drive and feed mechanism: An electric motor is fitted directly on the drill head and through gear box multiple speed and feed of the spindle can be obtained.

Sketch – 2M
Explaination of Parts – 4M

b) Distinguish between Shaper and Planer.

Ans: Shaper and Planer are both reciprocating machine tools but they differ very much in construction, operation and use.

1) In a Planer the work is mounted on the table which reciprocates while the tool is held rigidly 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 provides the feed.

2) In a Planer, the tool is rigidly supported, when the work moves on precision ways and maximum accuracy on the machined surface is assured.
In a shaper due to overhanging of the ram during the cutting stroke and m/c being not robust, the accuracy of machining is less.

3) Planers are machines capable of holding big and heavy jobs (9)
Shapers are intended for small jobs.

4) High rate of power consumption and overall rigidity in a planer enables to take deep cuts and apply heavy feed to rough finish a job quickly. A planer can consume up to 150 HP, whereas a shaper 15 to 20 HP.

5) Multiple tooling with double or four tool heads in a planer makes it possible to machine more than one surface together thus reducing cutting time.

6) Cutting and return speeds of a planer are almost uniform throughout the stroke.
But in a crank driven shaper the speed varies throughout the length of stroke.

7) On a planer work setting requires much skill and takes long time, whereas in a shaper work may be clamped easily and quickly.

8) Planers are heavier, larger and costlier machines compare to shapers.

9) On modern planers wide range of cutting and return speeds are available and they may be changed independently.

10) A large number of jobs of identical shapes can be machined in one setting on a planer table. Usually one w/p is machined at a time on shaper.

Above 10 Points — 6M

5) a) Write about quick return mechanism of planer with a neat sketch.

Ans. A planer which is a reciprocating m/c tool, material is removed only during forward cutting stroke of the table and no material is removed during its return stroke. It is better to reduce the time taken by the return stroke which is an idle stroke by increasing the speed of the table for which it is known as the quick return motion.

In a belt driven planer, the main driving motor mounted on the top member drives a counter shaft through a V-belt. The counter shaft at its extreme, carries two driving pulleys, one for open belt and the other for cross belt. The main driving shaft is provided below the bed. One end of it passes through the housing and carries a pinion, which meshes with a rack fitted on the underside of the table. The other end of this shaft carries two pairs of pulleys - each pair consisting of a fast pulley and a loose pulley. One of these pairs is connected to one of the driving pulleys by means of an open belt and the other to the second driving pulley by means of a cross belt.

One set of the above pulleys is used for the forward motion of the table and the other set for return motion. The cross belt will be used for forward motion and the open belt for return motion. The driving pulley on the counter shaft for cross belt is smaller than the pair of fast and loose pulleys for the same. The driving pulley on the counter shaft for open belt is bigger than the pair of fast and loose pulleys for the same. Consequently, for same speed or number of revolutions of the counter shaft, the main driving shaft will run faster when connected by open belt than when cross belt is used. Therefore that the return stroke will be faster than the forward stroke. Trip dogs mounted on the side of the table, operates the belt shifter, to get change in direction of rotation of main shaft alternately from open and cross belt drive for changing the direction of movement of table.

Sketch - 1M
Explanation - 5M

b) Describe clearly the specifications of a grinding wheel.

Ans. The Indian Standard marking system for grinding wheels 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 band type.

Ex: W A46K5V17

Prefix
W
↓
Mfr's symbol indicating exact kind of abrasive (optional)

Abrasive
A
↓
A = Al. oxide
C = SiC
D = Diamond

Grain size
46

Coarse	Medium	Fine	Very fine
10	30	80	220
12	36	100	240
14	46	120	280
16	54	150	320
20	60	180	400
24			500
			600

Grade
K

Soft: A B C D E F G H
Medium: I J K L M N O P
Hard: Q R S T U V W X Y Z

Structure
5

Dense	Open
1	9
2	10
3	11
4	12
5	13
6	14
7	15
8	16
	Etc

Band type
V
V - Vitrified
B - Resinoid
R - Rubber
E - Shellac
S - Silicate

Suffix
17
↓
Mfr's record (optional)

The grain or grit number indicates the size of the abrasive grains used in making a wheel. Grain size is indicated by a number indicating the number of meshes per linear inch of the seive through which the grains pass when they are graded after crushing.

The grade refers to the hardness with which the band holds the abrasive grains in place. It refers to the band strength in the wheel. A band from which the abrasive grains can easily be dislodged is called soft, whereas one which holds the grains more securely is called hard. 'A' dinoting the softest and 'z' the hardest grade.

Structure in wheel refers to the Porosity. The Primary Purpose of structure is to Provide chip clearance and it may be open or dense. In addition straight or disc grinding wheels are specified by outside diameter x Thickness x Internal diameter of wheel.

Explaination — 6M

UNIT-III

6) List various types of milling machines and explain with neat sketch the horizontal milling machine.

Ans: Types of milling machines according to general design features are

1) Column and knee type
   a) Hand milling m/c
   b) Plain milling m/c
   c) universal milling m/c
   d) omniversal "
   e) Vertical "
2) Manufacturing or fixed bed type
   a) Simplex milling m/c
   b) Duplex "
   c) Triplex "
3) Planer type
4) Special type
   a) Rotary table milling m/c
   b) Drum milling m/c
   c) Planetary "
   d) Pantograph, Profiling & tracer controlled milling m/c.

Plain or horizontal milling m/c: The milling m/c table may be fed by hand or power against a rotating cutter mounted on a horizontal arbor. A plain milling m/c, having horizontal spindle, is also called as horizontal milling m/c. In horizontal milling m/c, the table may be fed in a longitudinal, cross and vertical directions. The feed is longitudinal, when the table is moved at right angle to the spindle, it is cross when the table is moved parallel to the spindle and the feed is vertical when the table is adjusted in the vertical plane.

The main parts of a column and knee type horizontal milling machine are : 1) Base 2) column 3) knee 4) saddle 5) Table 6) spindle 7) spindle 8) overhanging arm 9) front brace 10) Arbor etc.

Sketch – 2M
Types of milling m/cs – 4M
Explanation of parts – 6M

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7)a) Explain clearly the honing operation with neat sketch.

Ans: Honing is a grinding or an abrading process mostly for finishing round holes by means of bonded abrasive stones called hones. Honing is a cutting operation usually the metal removed is less than 0.25 mm. So honing is primarily used to correct some out of roundness, taper, tool marks and axial distortion. Honing stones are made from Al_2O_3 or SiC bonded abrasives often impregnated with sulphur, resin or wax to improve cutting action and lengthen tool life. Material honed range from plastics, silver, Al, Brass, cast Iron to hard steel and cemented carbides. Honing stones are mounted on a mandrel that rotates in the hole, applying a radial force with a reciprocating axial motion, thus producing a cross-hatched pattern. The stones can be adjusted radially for different hole sizes. The surface finish can be controlled by the type and size of abrasive used, the speed of rotation and the pressure applied.

A cutting fluid is used to remove chips and to keep temperatures low. If not done properly, honing can produce holes that are not straight and cylindrical but with shapes that are bell mouthed, wavy and tapered. In honing a floating action between the work and tool prevails and any pressure exerted by the tool may be transmitted equally to all sides. There are two types of honing machines horizontal and vertical. A honing m/c rotates and reciprocates the hone inside the holes being finished. The two motions produce round and straight holes that have a very fine surface finish of random scratches. Vertical honing machines are most commonly used. Horizontal honing machines are often used for gun barrels, hydraulic cylinder bores. This process is used for finishing crank shaft journals, automobile cylinder liners etc.

Peripheral speed of hone = 25-50 m/min

Reciprocation speed = 12-25 m/min

Abrasive grit size = 220-600

Surface finish produced 'Ra' = 0.1 to 0.6 μm.

Sketch - 1M

Explanation - 5M

b) Index 31 divisions using differential indexing.

Ans:

Let A = The selected number which can be indexed by simple indexing and the number is approximately equal to 'N'.

N = The required no. of divisions to be indexed

N = 31

Assume A = 32, a number almost equal to 31 and can be indexed by simple indexing.

1) Gear ratio $= (A-N)\frac{40}{A}$

$= (32-31)\frac{40}{32} = 1 \times \frac{40}{32} = \frac{40}{32}$

Driver gear teeth $= 40$

Driven gear teeth $= 32$

Gears with no. of teeth available are: 24, 24, 28, 32, 40, 44, 48, 56, 64, 72, 86 and 100.

2) Index crank movement $= \frac{40}{A} = \frac{40}{32} = \frac{20}{16}$

$= 1\frac{4}{16}$

For complete indexing, the index crank has to be moved by 1 complete turn and 4 holes in 16 hole circle of the index plate (Pl. No-1) for 30 times.

3) As (A-N) is positive and gear ratio is simple, only one idler gear is used.

Gear ratio	— 3M
ICM	— 2M
Idler	— 1M

UNIT-IV

8) In orthogonal cutting if feed is 1.25 mm/rev and chip thickness after cutting is 2 mm, determine chip thickness ratio and shear angle. The tool bit has a rake angle of 10°. If the shear strength is 6000 kg/cm² width of cut is 10 mm, cutting speed is 30 m/min, coefficient of friction is 0.9, determine i) Shear force ii) Friction angle iii) cutting force, and iv) Horse power at the cutting tool. (12M)

Sol: Given that,

feed, $f = 1.25\,mm/rev$

Chip thickness, $t_c = 2\,mm$

Rake angle, $\gamma = 10^\circ$

Shear strength, $\tau_s = 6000\,kg/cm^2$

width of cut, $b = 10\,mm$

cutting speed, $V = 30\,m/min$

Coefficient of friction $\mu = 0.9$

$r, \phi = ?$

$F_s, \beta, F_c, P = ?$

In orthogonal cutting, we know,

uncut chip thickness 't' $= f = 1.25\,mm = 0.125\,cm$.

$t_c = 2\,mm = 0.2\,cm$.

1) Chip thickness ratio $r = \frac{t}{t_c} = \frac{0.125}{0.2} = \underline{\underline{0.625}}$

2) $\tan\phi = \frac{r\cos\gamma}{1 - r\sin\gamma} = \frac{0.625\cos 10^\circ}{1 - 0.625\sin 10^\circ} = \frac{0.6155}{0.89147}$

$\tan\phi = 0.69043$

Shear angle 'ϕ' $= \tan^{-1}(0.69043) = \underline{\underline{34.62^\circ}}$

3) $\tau_s = \frac{F_s}{A_s} = \frac{F_s}{bt/\sin\phi} = \frac{F_s \cdot \sin\phi}{bt}$

$b = 10\,mm = 1\,cm$

Shear force, $F_s = \frac{\tau_s \cdot bt}{\sin\phi} = \frac{6000 \times 1 \times 0.125}{\sin 34.62^\circ} = \frac{750}{0.56813}$

$F_s = \underline{\underline{1320\,kg}}$

4) $\mu = \tan\beta$

$\tan\beta = 0.9$

Friction angle 'β' $= \tan^{-1}(0.9) = \underline{\underline{42^\circ}}$

5) we know,

$$F_s = R\cos(\phi+\beta-\gamma)$$

$$F_c = R\cos(\beta-\gamma)$$

$$R = \frac{F_c}{\cos(\beta-\gamma)}$$

$$\therefore F_s = \frac{F_c\cos(\phi+\beta-\gamma)}{\cos(\beta-\gamma)}$$

$\therefore$ cutting force, $F_c = \dfrac{F_s\cos(\beta-\gamma)}{\cos(\phi+\beta-\gamma)}$

$$F_c = \frac{1320\cdot\cos(42^\circ-10^\circ)}{\cos(34.62^\circ+42^\circ-10^\circ)} = \frac{1320\cdot\cos 32^\circ}{\cos 66.62^\circ}$$

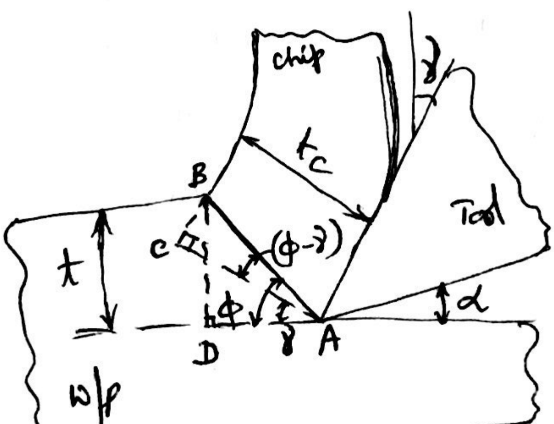
$$F_c = \frac{1119.42}{0.39682} = \underline{\underline{2821\ kg}}$$

6) HP at the cutting tool 'P' $= \dfrac{F_c\cdot V}{4500} = \dfrac{2821\times 30}{4500} = \underline{\underline{18.81\,HP}}$

calculation of $\gamma, \phi, F_s, \beta, F_c, P$ — 2M each (2×6=12M)

9) a) Derive an equation for shear angle in terms of chip thickness ratio and rake angle.

Ans:



In a simplified model of two-dimensional 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. 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 $= 90^\circ$ and inclination angle $= 0^\circ$.

Let t = uncut chip thickness

t_c = Chip thickness

γ = Rake angle

ϕ = Shear angle.

AB = Shear plane

r = Chip thickness ratio or cutting ratio

$$r = \frac{t}{t_c}$$

From fig, $t = BD = AB\sin\phi$

$$t_c = AC = AB\cos(\phi-\gamma)$$

$$r = \frac{t}{t_c} = \frac{AB\sin\phi}{AB\cos(\phi-\gamma)} = \frac{\sin\phi}{\cos(\phi-\gamma)}$$

$$\frac{\cos(\phi-\gamma)}{\sin\phi} = \frac{1}{r}$$

$$\frac{\cos\phi\cos\gamma}{\sin\phi} + \frac{\sin\phi\sin\gamma}{\sin\phi} = \frac{1}{r}$$

$$\cot\phi \cos\gamma + \sin\gamma = \frac{1}{r}$$

$$\cot\phi \cos\gamma = \frac{1}{r} - \sin\gamma = \frac{1 - r\sin\gamma}{r}$$

$$\cot\phi = \frac{1 - r\sin\gamma}{r\cos\gamma}$$

$$\tan\phi = \frac{r\cos\gamma}{1 - r\sin\gamma}$$

Figure – 1M
Derivation – 5M

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b) What are the major types of tool materials? Explain.

Ans: 1) High Speed Steel: HSS is the general purpose matl. for low and medium cutting speeds owing to its superior hardness and wear resistance. It retains hardness up to about 600–700°C. Three general types of HSS are 1) Tungsten HSS 2) Molybdenum HSS 3) Cobalt HSS.

Tungsten in HSS provides hot hardness and form stability. Molybdenum or Vanadium maintain keenness of the cutting edge while the addition of cobalt improves hot hardness and makes the tool more wear resistant.

Tungsten HSS: 18% W – 4% Cr – 1% V (18-4-1 HSS) and 0.7% C

Molybdenum HSS: 6% Mo – 6% W – 4% Cr – 2% V

Cobalt HSS: 20% W – 4% Cr – 2% V and 12% Cobalt

HSS is used to make drills, reamers, taps, milling cutters, tool bits etc.

2) Stellite: Stellite is a trade name of non-ferrous cast alloy composed of Co, Cr and W.

The composition is 38-53% Cobalt, 30-33% chromium 10-20% tungsten and 1-3% carbon. It can be operated at speeds 50-100% higher than HSS and withstand cutting temp. in the range of 900°c. They are used for cutting rubber, plastics, CI and bronzes etc. It become obsolete after inventing Cemented carbides.

3) Cemented Carbides: The carbides of tungsten, Titanium tantalum and Niobium with some percentage of cobalt are sintered by a special method known as Powder metallurgy. Such carbides are called sintered or Cemented carbides. These carbides have high hot hardness (of about 1000°c), high wear resistance, high modulus of elasticity, low thermal expansion and high thermal conductivity. ISO specifies 3 basic grades for cemented carbides according to use.

Symbol	Composition	work matl.	Designation
P	WC + TiC	Car carbon steels and other steels	P01, P10, P20, P30, P40, P50
M	WC + TiC + TaC	For all types of matls especially difficult to cut matls.	M10, M20, M30, M40
K	WC	cast Iron, Non-ferrous matls; non-metallic matls.	K01, K10, K20, K30, K40 K50

other tool matls. are : Ceramics, Cermets, Diamond, cubic Boron Nitride (CBN) etc

Explaination of any 3 tool matls — 3 X 2 = 6M

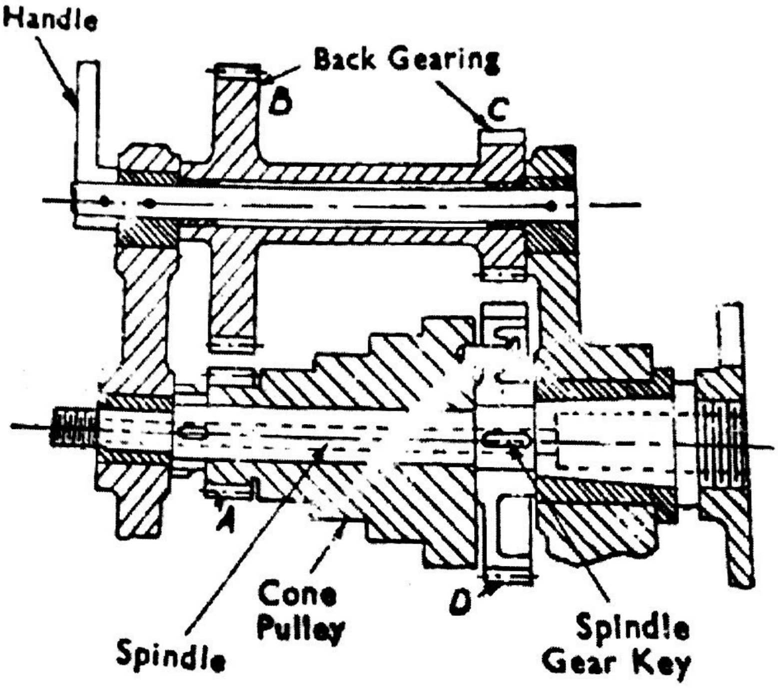

Figure 3.7 Backgeared headstock

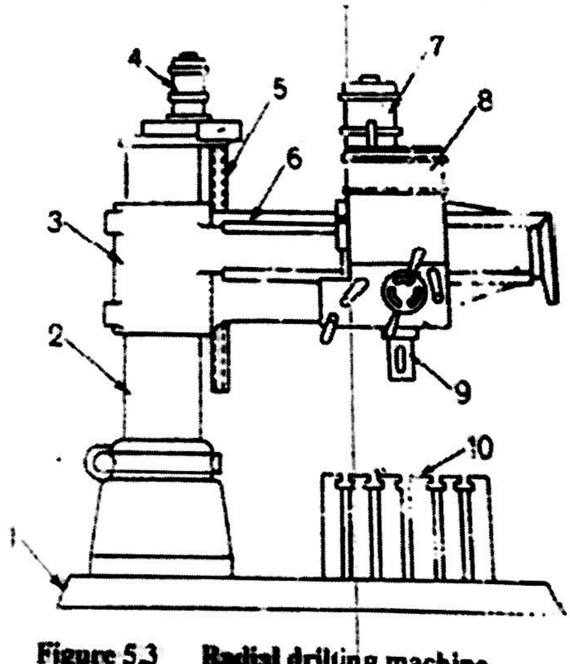

Figure 5.3 Radial drilling machine

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

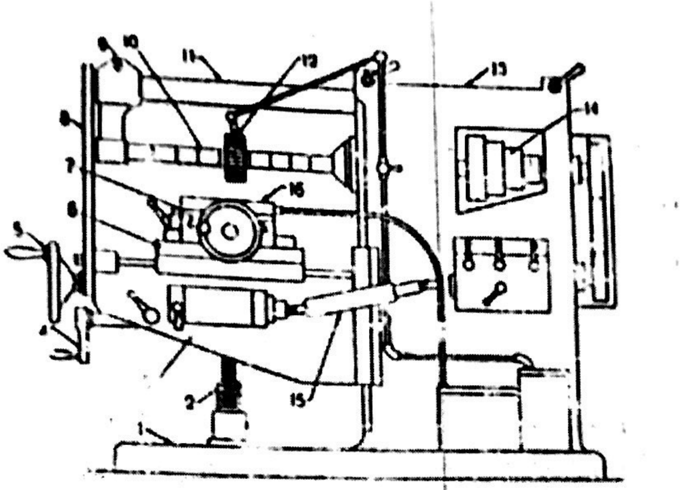

Figure 11.1 Column and knee type milling machine

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.

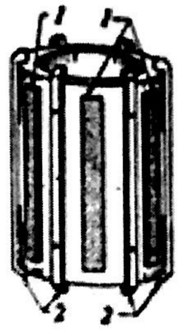

Figure 16.1 Honing tool-head for holes

1. Stones, 2. Guides

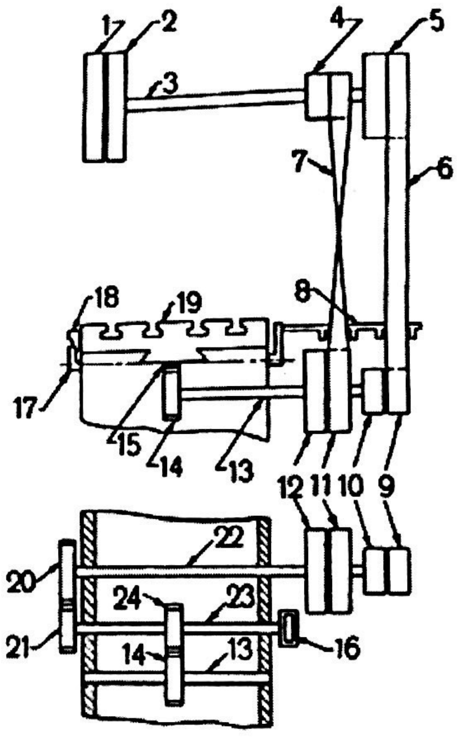

Figure 8.3 Quick return mechanism of a planer by open and crossbelt

1. Loose pulley, 2. Fast pulley, 3. Countershaft, 4, 5. Pulleys on shaft, 3, 6. Open belt, 7. Cross belt 8. Belt shifter, 9. Loose pulley, 10. Fast pulley, 11. Fast pulley, 12. Loose pulley, 13. Bull gear shaft, 14. Bullgear, 15. Rack, 16. Feed disc, 17. Belt shifter lever, 18. Trip dog, 19. Table, 20, 21. Change gears, 22. Shaft, for pulleys, 9, 10, 11 and 12, 23. Intermediate shaft, 24. Intermediate gear.