B.Tech.

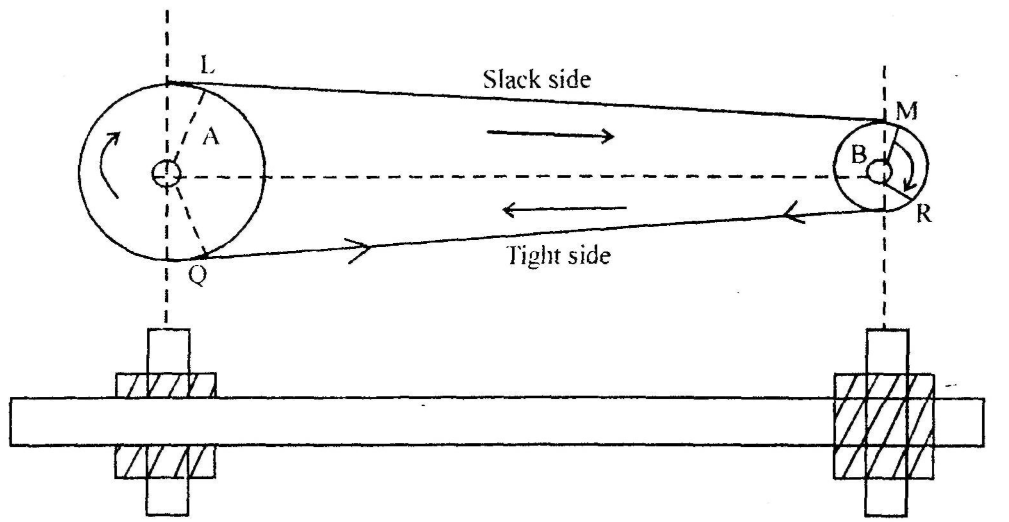
Second Semester Examination, 2009-2010

Basics of Mechanical Engineering (ME-101-F)

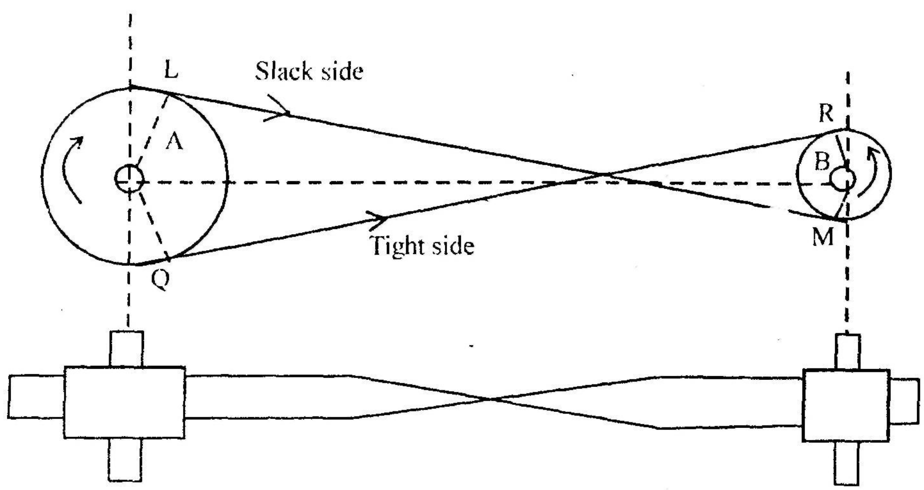
Q. 1. Explain belt drive.

Arts. Belt Drive : The power from one pulley to another, may be transmitted by any one of the following two types of belts drive :

(i) Open Belt Drive : In open belt drive, the two wheels move in the same direction as shown in fig.



(ii) Cross Belt Drive : In cross belt drive, the wheels move in the opposite directions as shown in fig.



Q.l.(vi) What is Poison's ratio?

Ans. Poison's Ratio: The ratio of lateral strain to **the** longitudinal strain is a constant for a given material, when the material is stressed with in the elastic limit. This ratio is called Poisson's ratio and it is generally denoted by μ.

$$\mu = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

Q. l.(vii) Explain four advantages of NC machine.

Ans. Advantages of NC Machines:

(i) The part program tape and tape reader are used only once to enter the program into computer memory.

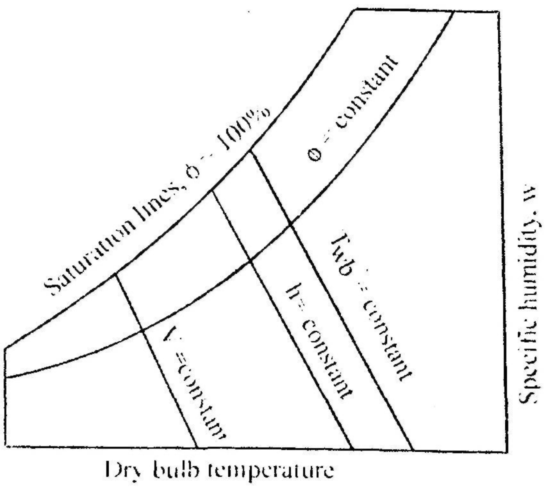
(ii) This result in improved reliability.

(iii) Tape reader is commonly considered the least reliable component of a conventional NC system.

(iv) Local storage of more than one part program.

Q. l.(ix) Why wc use Psycheometric charts?

Ans. Psycheometric Charts : The state of atmospheric air at a specified pressure is completer specified by two independent intensive properties. The rest of the properties can be calculated easily from the previous relations. The sizing of a typical air-conditioning systems involves numerous such calculations, which .nay "eventualI) get on the nerves of even the most patient engineers. Therefore, there is clear motivation to computerize calculations or to do these calculations once and to present the data in the form of easily readable charts. Such charts are calledpsychromctric charts.



Q. 1. (x) What is the difference between spur and helical gear?

Ans. Spur Gears : In these gears the teeth are straight and parallel to the shaft axis. Spur gears are the most common type and their advantages are simplicity in design, economy of manufacture & maintenance and absence of end thrust on the bearing. They impose only radial loads on the bearings. These are usually known as slow speed gears but if noise is not a serious design problem, these can be used at almost any speed which can be handled by other types of gears. The most usual arrangement of spur gears is an external gear & pinion combination, but it centre distance is to be reduced, then internal gear and external pinion combustion is used.

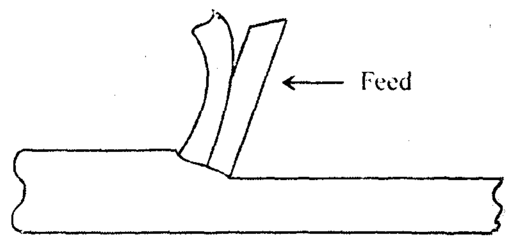
Helical Gear : In these gears, the teeth are inclined to the axis of the shafts and are in the form of helix. These gears are usually through of as high speed gears and they can take higher loads as compared to equal sized spur gears. The motion is smoother and quieter than the spur gears.

Section-A

Q. 2(a)Explain different types of chips in metaltutting?

Ans. The chips produced, whatever the cutting conditions may be along to one of the following three types :

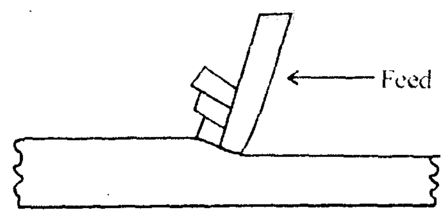
(i) Continuous Chip:



Continuous Chip

These chips are produced while machining more ductile materials. This type of chip is most desirable the continuous chip which is like a ribbon flows along the rake face. Production of continuous chips is possible because of metal. About 95% of the power extended for metal removal is used in the deformation taking place in the shear zone. The remaining power consumed 5% of the total, is expended in stored elastic energy or residual stresses in the workpiece and fraction.

(ii) Discontinuous Chip:



Discontinuous Chip

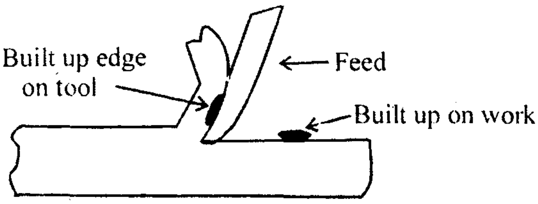
These chips are usually produced while cutting more brittle materials like grey cast-iron, bronze & hard brass. In this type the chip produced in the form of discontinuous segments gets ruptured periodically Discontinuous chips are likely to be produced under the following conditions :

(i) Lower cutting speeds

(ii) Small rake angles

iii) Higher depths of cut.

(iii) Built-up Chips:



Built up Chips

When machining ductile materials, conditions of high local temperature and extreme pressure in the machining cutting zone and also high friction in the tool-chip interface may cause the work material to adhere or weld to the cutting edge to the tool forming the built up edge (BUE). This causes the finished surface to be rough.

That way BUE is not harmful while rough machining.

* In general low cutting speed, high feed & small angle are conductive to BUE formation.

* Presence of BUE increases power consumption.

Q. 2. *(b)* DefjneI, II and III law of Thermodynamics.

Ans. Ist Law of Thermodynamics: The energy balance relations already given are intuitive in nature and are easy to use when the magnitudes and directions of heat and work transfers are known. However, when performing a general analytical study for solving a problem that involves an unknown heat or work interaction, we need to assume a direction for the heat or work interactions. In such cases, it is common practice to use the classical thermodynamics sign convention & to assume heat to be transferred into the system in the amount of Q & work to be done by the system in the amount of w and then to solve the problem. The ene'rgy balance equation in case of closed system becomes

$$Q_{net\,in} - W_{net\,out} = \Delta E_{system} \text{ or } Q - W = \Delta E \,.$$

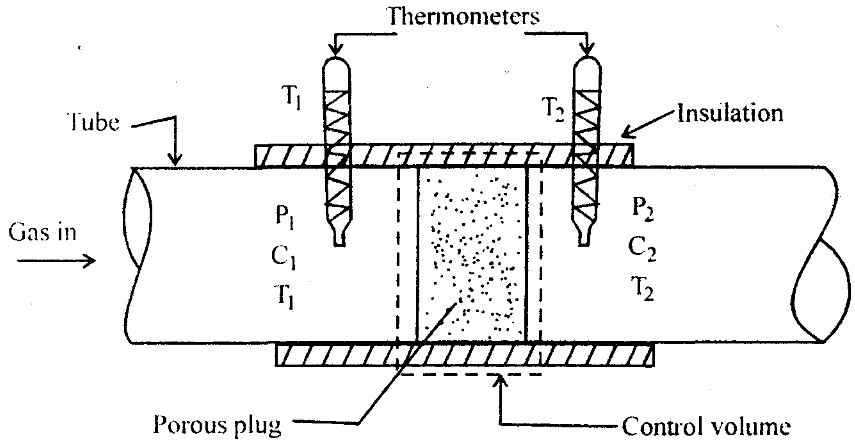
IInd Law of Thermodynamics: The clausius statement does not imply that a cyclic device that transfers heat from a cold medium to a warmer one is impossible to contract. In fact this is precisely what a common **house** hold refrigerator does. It simply states that a refrigerator can't operate unless the compressor is driven by an external power source, such as an electric motor. This way, the net effect on the surroundings involves **the** consumption of some energy in the form of work, in addition to the transfer of heat from a colder body to **a** warmer one. That is it leaves a trace in the surroundings. Therefore, **a** house **hold** refrigerator is in **complete** compliance with the clausius statement of the second law.

IIIrd Law of Thermodynamics : The molecules of a substance in solid phase, continually oscillate, creating an uncertainty about their position. These oscillations, however fade as the temperature is described and the molecules supposely become motion less at absolute zero. This represents the state of a pure crystalline substance at absolute zero temperature is zero since there is no uncertainity about the state of the molecules as that instant. This statement is known as third law of thermodynamics. The third law of thermodynamics provides an absolute reference point is called absolute entropy and is extremely useful in the thermodynamic analysis of chemical reactions.

Q.3.(a) What is throttling calorimeter?

Ans. Throttling process involves the passage of a higher pressure fluid through a narrow constriction. The effect is the reduction in pressure and increase in volume. This process is adiabatic as no heat flows from and to the system, but it is not reversible. It is not an isentropic process. The entropy of the fluid actually increases.

Such a process occur in a flow through a porous plug, a partially closed valve and a very narrow orifice. The porous plug is shown in fig.



In this system,

$$Q = 0 \quad (\because \text{ system is isolated})$$

$$W = 0 \quad (\because \text{ three is no work interaction})$$

Applying the energy equation to the system

$$h_1 = h_2$$

This shows that enthalpy remains constant during adiabatic throttling process.

The throttling process is commonly used for the following purposes :

(i) For determining the condition of steam.

(ii) For controlling the speed of turbine.

(iii) Used in refrigeration plant for reducing the pressure of the refrigerant before entry into the evaporator.

Throttling process frequently encountered in practice was investigated by John & Thompson in their famous porous plug experiment. A system of gas at pressure P_1 and temperature. T_1 is forced continuously through a porous plug in a tube from which it energies at a lower pressure P_2 and temperature T_2. The whole apparatus is thermally insulated.

In this process : $h_1 = h_2$

Whether the temperature and internal energy change in a throttling process depends on whether the fluid behaves as an ideal gas or not. Since the enthalpy of an ideal gas is a function of temperature alone, it follows that

$$T_1 = T_2 \text{ for (throttling process) ideal gas}$$

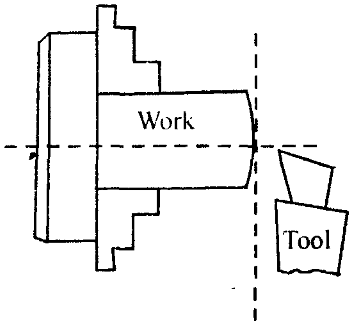
$$u_1 = u_2$$

Q. 3.(b) Explain 5 operations of lathe machine.

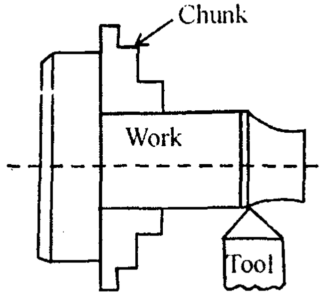
Arts. Operations of Lathe Machine:

(i) Facing : This operation is **almost** essential **for all works. In this operation, as shown in fig., the** workpiece is held **in** the **chuck and the facing tool is fed from the centre of the workpiece towards the outer** surface or from the outer surface **to the centre, with the help of a cross-slide.**

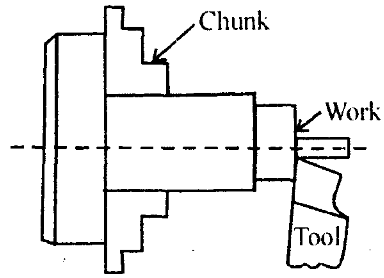
(ii) Plane Turning: **It** is an operation of removing excess amount of material from the surface the surface of the cylinder workpiece. In this operation, shown in fig., the work is held either in the chuck or between centres & the longitudinal feed is given to the tool either by hand or power.



(Facing)



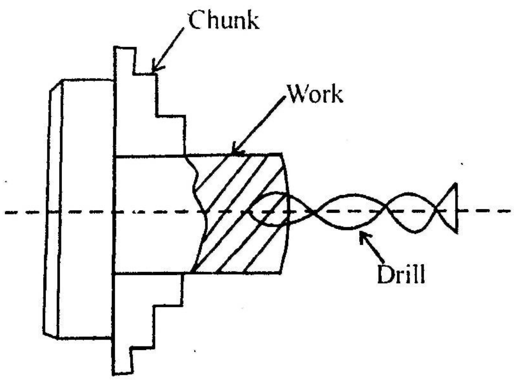
(Plain turning)



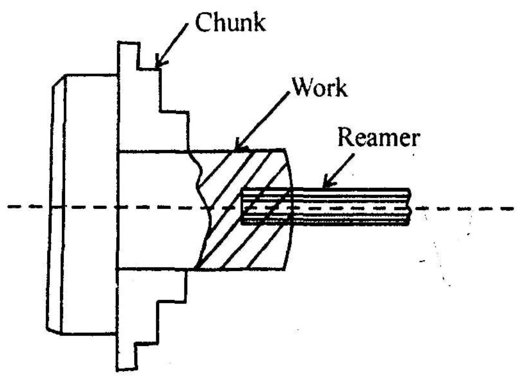
(Step turning)

(iii) Step Turning: It is an operation of producing various steps of different diameters of in the workpiece as shown in fig. This operation is carried out in the similar way as plain turning.

(iv) **Drilling** : It is an operation of making a hole in a workpiece with the help of a drill. In this case as shown in fig., the workpiece, by rotating the tail stock hand wheel. The drill is fed normally, into the rotating workpiece, by rotating the tail stock hand wheel.



(Drilling)



(Reaming)

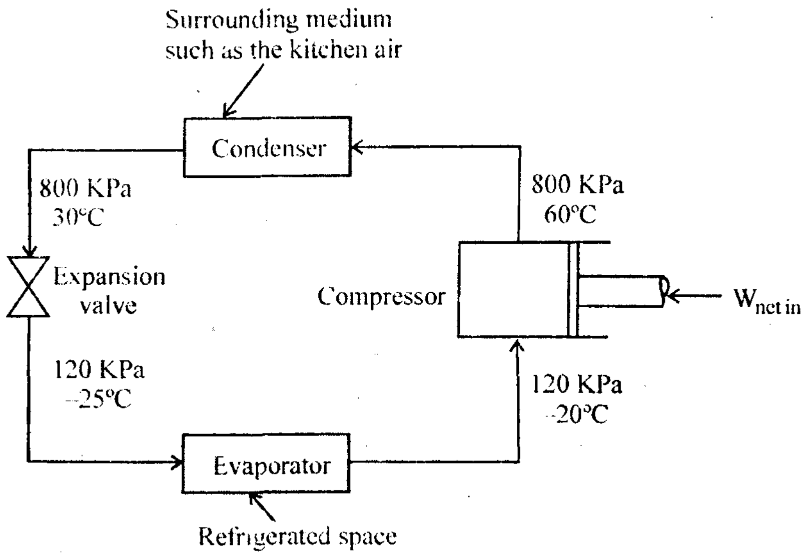
(v) **Reaming** : It is an operation of finishing the previously drilled hole. In the operation as shown in fig., a reamer is held in the tailstock and it is fed into the hole in the similar way as for drilling.

Section-B

Q. 4. (a) **Explain simple refrigeration vapour compression cycle.**

Ans. The most commonly used refrigeration cycle is the vapour-compression refrigeration cycle which involves four main components : a compressor, a condenser, an expansion value and an evaporator as shown in fig.

The refrigerant enters the compressor as a vapour and is compressed to the condenser pressure. It leaves the compressor at a relatively high temperature and cool and down and condenses as it flows through the coils of the condenser by rejecting heat to the surrounding medium. If then enters a capillary tube where its pressure and temperature drops drastically due to the throttling effect. The low temperature refrigerant then enters the evaporator, where it, evaporates the absorbing heat from the refrigerated space. The cycle is completed as the refrigerant leaves the evaporator & recenters the compressor.



In a house hold refrigerator, the freezer compartment where heat is absorbed by the refrigerant serves as an evaporator and the coils usually behind the refrigerator where heat is dissipated to the kitchen air serve as the condenser.

Q.4.(b) Define human comfort.

Ans. Human beings have an inherent weakness-they want to feel comfortable. They wan't to live in an environment that is neither hot nor cold, neither humid nor dry. However, comforts does not quite come easily since the desire of the human body and weather usually are not quite compatible. Achieving comfort requires a constant struggle against the factors that cause discomfort such as high for low struggle against the such as high or low temperatures and high or low humidity. As engineers, it is our duty to help the people feel comfortable.

Q. 5. (a) Derivean expression for specific speed **of turbine.**

From equation (i),

$$P = \eta_0 \times \frac{\rho \times g \times Q \times H}{1000} \qquad \text{...(ii)}$$

$$\propto g \times Q \times H \qquad (\because \ \rho \ \& \ \eta_0 \text{ are constants})$$

Let D = Diameter of actual turbine

N = Speed of actual turbine

u = Tangential velocity of the turbine

N_s = Specific speed of the turbine

V = Absolute velocity of water

The absolute velocity, tangential velocity & head on the turbine are related as,

$$u \times v \text{, where } v \propto \sqrt{H} \qquad \text{...(iii)}$$

$$\propto \sqrt{H}$$

But the tangential velocity u is given by

$$Q = \text{Area} \times \text{velocity}$$

Area $\propto B \times D$

$$\propto D^2$$

Velocity $\propto \sqrt{H}$

$$Q \propto D^2 \times \sqrt{H}$$

$$\propto \left(\frac{\sqrt{H}}{N}\right)^2 \times \sqrt{H}$$

$$\propto \frac{H^{3/2}}{N^2} \qquad \text{...(iv)}$$

Substituting the value of Q in equation (ii), we get

$$P \propto \frac{H^{3/2}}{N^2} \times H \propto \frac{H^{5/2}}{N^2}$$

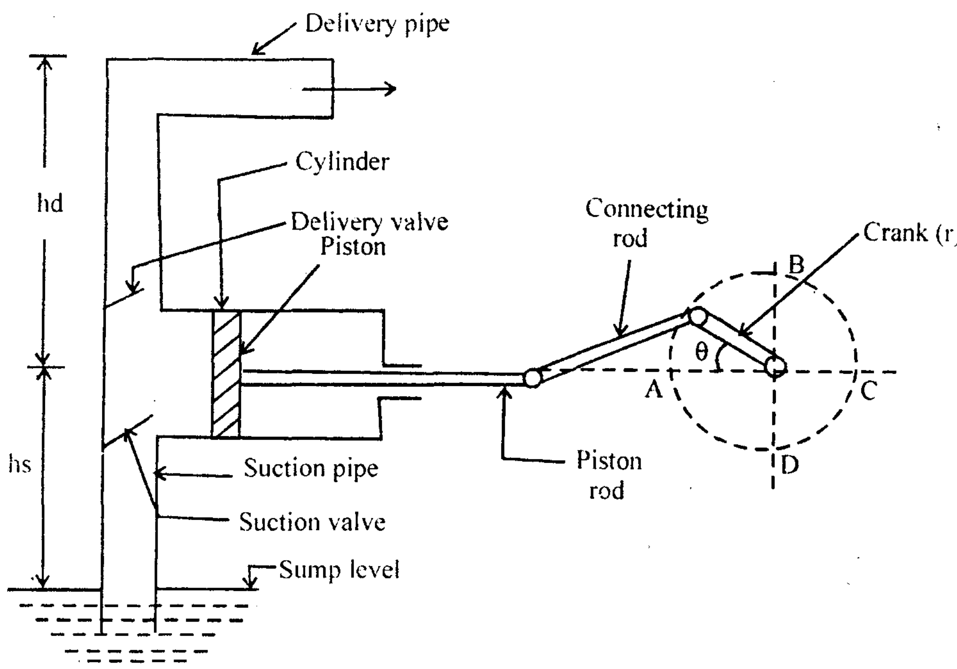
$$P = \frac{KH^{5/2}}{N^2}$$

Where K = Constant of proportionality

If P = 1, H = 1, the speed N = Specific speed N_s, substituting values in the above equation, we get

Q.5 (b)Explain reciprocating water pumps.

Ans. The following are the main parts of a reciprocating pump as shown in fig.



(i) A cylinder with a piston, piston rod, connecting rod & **a** crank.

(ii) Suction pipe (iii) Delivery pipe

(iv) Suction valve (v) Delivery valve

Working : Fig. shows a single acting reciprocating pump, which consists of a piston which moves forward and backward in a close fitting cylinder. The movement of a piston is obtained by connecting the piston rod to crank by means of a connecting rod. The crank is rotated by means of an electric motor. Suction & delivery pipes with suction valve and delivery valve are connected to the cylinder. The suction and delivery valve arc one way valves or non-return valves which allow the water to flow in one direction only. Suction vaive allows water from suction pipe to the cylinder which delivery valve allows water from cylinder to del ivery pipe only.

When crank starts rotating the piston moves to and from in the cylinder. When crank is at A., the piston is at the extreme left position in the cylinder. As a crank is rotating from A to C. (i.e., from $0 = 0$ to $\theta = 180°$) the piston is moving towards right in the cylinder. The movement of the piston towards right creates a partial vaccum in the cylinder. But on the surface of the liquid in the sump atmospheric pressure is acting, which is more than the pressure inside the cylinder. Thus, the liquid is forced in the suction pipe from the sump. This liquid opens the suction valve and enters the cylinder.

When crank is rotating from C to A (i.e., from $\theta = 180°$ to $\theta = 360°$), the piston from its extreme right piston starts moving towards left in the cylinder. The movement of the piston towards left increases the pressure of the liquid inside the cylinder more than atmospheric pressure. Hence, suction valve closes and delivery valves open the liquid is forced into the delivery pipe and is raised to a required height.

Section-C

Q.6.(a) Explain with neat diagram, multiple clutch.

Ans. Multiple Disc Clutch : A multiple disc clutch, as shown in fig., may be used when a large torque is to be transmitted. The inside discs are fastened to the driven shaft to permit axial motion. The outside discs are held by bolts and are fastened to the housing which is keyed to the driving shaft. The multiple disc clutches are extensively used in motor cars, machine tools etc.

Let n_1 = Number of discs on the driving shafts

n_2 = Number of discs on the driven shafts

$\therefore$ No. of pairs of contact surfaces

$$n = n_1 + n_2 = 1$$

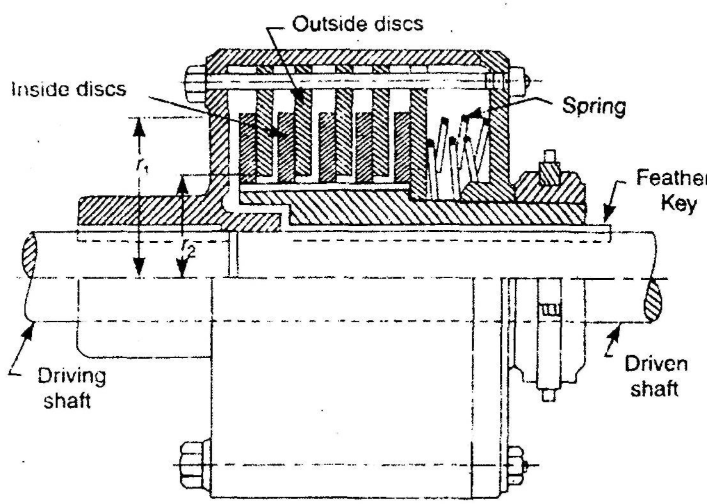
and total fractional torque acting on the fraction surfaces or on the clutch,

$$T = n.\mu.\omega.R$$

Where, R = Mean radius of the friction surfaces

$$= \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right]$$

$$= \frac{r_1 + r_2}{2}$$



(Multiple Disc Clutch)

Q.6.(b)Define **different types of gear.**

Ans. The gears or toothed wheels may be classified as follows:

I According to the position of axes of the shafts: The axes of the two shafts between which the motion is to be transmitted, may be

(a) Parallel,

(b) Intersecting, and

(c) Non-intersecting and non-parallel.

The two parallel and co-planar shafts connected by the gears is shown in fig. These gears are called spur gears and the arrangement is known as spur gearing. These gears have teeth parallel to the axis of the wheel as shown in fig. Another name given to the spur gearing is helical gearing, in which the teeth are inclined to the axis. The single and double helical gears connecting parallel shafts are shown in fig. (a) and (b) respectively. The double helical gears are known as herringbone gears. A pair of spur gears are kinematically equivalent to a pair of cylindrical discs, keyed to parallel shafts and having a line contact.

The two non-parallel or intersecting, but coplanar shafts connected by gears is shown in fig. (c). These gears are called bevel gears and the arrangement is known as bevel gearing. The bevel gears, like spur gears, may also have their teeth inclined to the face of the bevel, in which case they are known as helical bevel gears.

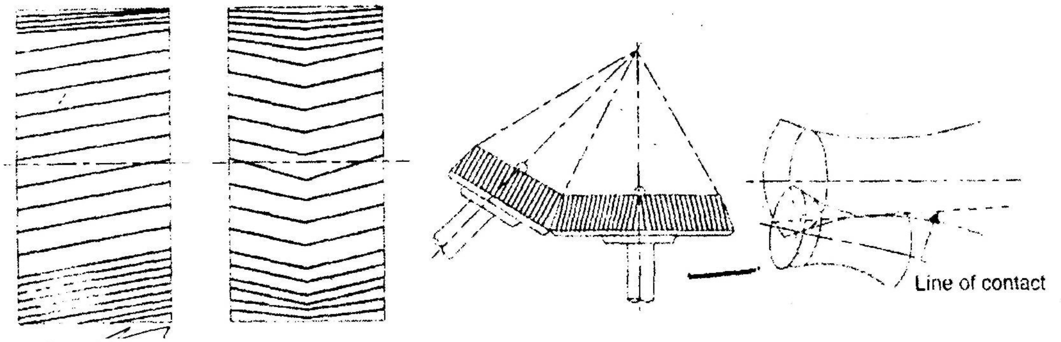
The two non-intersecting and non-parallel i.e. non-coplanar shaft connected by gears is shown in fig. 12.2 *(d).* These gears are called skew bevel gears or spiral gears and the arrangement is known as skew bevel gearing or spiral gearing. This type of gearing also have a line contact, the rotation of which about the axes generates the two pilch surfaces known as hyperboloids.

Noted:

(a) When equal bevel gears (having equal teeth) connect two shafts whose axes are mutually perpendicular, then the bevel gears are known as mitres.

(b) A hyperboloid is the solid formed by revolving a straight line about an axis (not in the same plane), such that every point on the line remains at a constant distance from the axis.

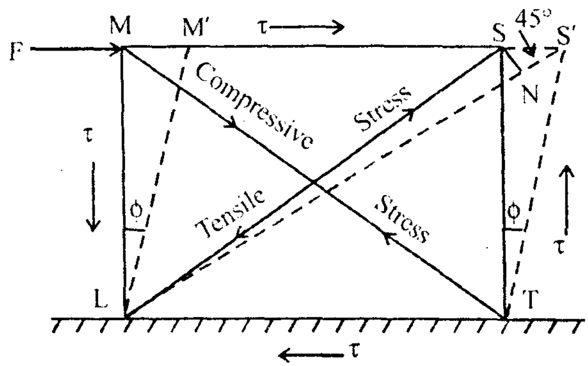
(c) The worm gearing is essentially a form of spiral gearing in which the shafts are usually at right angles.



Q.7.Explain elastic constants and their relationship.

Ans. Relations exist between the elastic constants for any specific material and these relations hold good for all materials within the elastic range. The relations result from the fact that the application of any particular type of stress necessarily produces other types of stress at other places in the material. Further, each of the stresses produces its corresponding strain and all the strains produced must be consistent.

Relation Between E and C : LMST is a solid cube subjected to a shearing force F. Let *x* be the shear stress produced in the faces MS and LT due to this shear force. The complementary shear stress consequently produced in the faces ML and ST is also x . Due to the shearing load, the cube, is distorted to LM'S'T, and as such, the edge M moves to M', S to S' and the diagonal LS to L'S.



$$\text{Shear strain} = \phi = \frac{SS'}{ST}$$

Also, shear strain $= \dfrac{\tau}{C}$

$$\therefore \quad \frac{SS'}{ST} = \frac{\tau}{C} \quad \text{...(i)}$$

On the diagonal LS', draw a perpendicular SN from S.

Now diagonal strain $= \dfrac{NS'}{LN} = \dfrac{NS'}{LS}$ ...(ii)

$$NS' = SS' \cos 45° = \frac{SS'}{\sqrt{2}}$$

[$\angle LS'T$ is assumed to be equal to $\angle LST$ since SS' is very small.]

And, $LS = ST \times \sqrt{2}$

Putting the value of LS in (ii), we get

Diagonal strain $= \frac{SS'}{\sqrt{2}ST \times \sqrt{2}} = \frac{SS'}{2ST}$

But, $\frac{SS'}{ST} = \frac{\tau}{C}$

∴ Diagonal strain $= \frac{\tau}{2C} = \frac{\sigma_n}{2C}$ ...(iii)

Where σ_n is the normal stress due to shear stress τ. The net strain in the direction of diagonal LS

$$= \frac{\sigma_n}{E} + \frac{\sigma_n}{mE}$$

[Since the diagonals LS and MT have normal tensile and compressive stress σ_n, respectively.]

$$= \frac{\sigma_n}{E}\left[1 + \frac{1}{m}\right] \quad ..(iv)$$

Comparing equations (iii) and (iv), we get

$$\frac{\sigma_n}{2C} = \frac{\sigma_n}{E}\left[1 + \frac{1}{m}\right]$$

i.e., $E = 2C\left[1 + \frac{1}{m}\right]$ ...(v)

Relation Between E and K : If the solid cube in question is subjected to σ_n (normal compressive stress) on all the faces, the direct strain in each axis $= \frac{\sigma_n}{E}$ (compressive) and lateral strain in other axis $= \frac{\sigma_n}{mE}$ (tensile).

∴ Net compressive strain in each axis

$$= \frac{\sigma_n}{E} - \frac{\sigma_n}{mE} - \frac{\sigma_n}{mE} = \frac{\sigma_n}{E}\left[1 - \frac{2}{m}\right]$$

Volumetric strain (e_v) in this case will be,

$$e_v = 3 \times \text{linear strain} = 3 \times \frac{\sigma_n}{E}\left[1 - \frac{2}{m}\right]$$

But, $e_v = \frac{\sigma_n}{K}$

∴ $\frac{\sigma_n}{K} = \frac{2\sigma_n}{E}\left[1 - \frac{2}{m}\right]$ or $E = 3K\left[1 - \frac{2}{m}\right]$ ...(vi)

The relation between E, C and K can be established by eliminating m from the equations (v) and (vi) as follows :

From equation (v),

$$m = \frac{2C}{E-2C}$$

$$E = 3K\left[1 - \frac{2}{2C/(E-2C)}\right]$$

Or, $$E = 3K\left[1 - \frac{E-2C}{C}\right]$$

Or $$\frac{E}{3K} = \frac{C-E+2C}{C} = \frac{3C-E}{C}$$

Or $$\frac{E}{3K} + \frac{E}{C} = 3$$

Or, $$EC + 3KE = 9KC$$

Or $$E(3K+C) = 9KC$$

Or, $$E = \frac{9KC}{3K+C} \quad ...(vii).$$

Section-D

Q. 8. Explain INC machine in detail.

Ans. The evolution of numerical control technology has been closely related to and dependent on the development of computer technology. In Chapter 8 we examined the use of computers in NC part programming. As a practical matter, it would not be possible to carry out the part programming function for many part designs without computer-assisted part programming. In addition, the computer is being used to refine and improve the NC part programming procedure through such technologies as interactive graphics and voice programming.

Use of the digital computer has also permitted substantial improvements to be made in the controls for NC In this chapter we discuss three NC-related control topics :

(i) Computer numerical control (CNC)

(ii) Direct numerical control (DNC)

(iii) Adaptive control

Computer NC involves the replacement of the conventional hard-wired NC controller unit by a small computer (minicomputer or microcomputer). The small computer is used to perform some or all of the basic ,NC functions by programs stored in its read/write memory. One of the distinguishing features of CNC is that one computer is used to control one machine tool. This contrasts with the second type of computer control, direct numerical control. DNC involves the use of a larger computer to control a number of separate NC machine tools.

The third control topic, adaptive control, does not require a digital computer for implementation. Adaptive control machining denotes a control system that measures one or more process variables (such as cutting force, temperature, horse-power, etc.) and manipulates feed and/or speed in order to compensate for undesirable changes in the process variables. Its objective is to optimize the machining process, something that NC alone is unable to accomplish. Many of the initial adaptive control projects relied on analog controls rather • ' .'n digital computers. Today, these systems employ microprocessor technology to implement the adaptive con'!ol strategy.

Eiefore describing the three types of control systems, it is appropriate to examine some of the problems related to the use of conventional numerical control which have influenced ihe change over to computer control.

Q. 9. Define manufacturing system and compare NC and CNC machines.

Ans. The hardware technology in NC controls has changed dramatically over the years. At least seven generations of controller hardware can be identified.

(i) Vacuum tubes (circa 1952)
(ii) Electromechanical relays (circa 1955)
(iii) Discrete semiconductors (circa 1960)
(iv) Integrated circuits (circa 1965)
(v) Direct numerical control (circa 1968)
(vi) Computer numerical control (circa 1970)
(vii) Microprocessors and microcomputers (circa 1975)

The initial NC prototype machine built in the MIT Servomechanism Laboratories used vacuum tubes for the controller hardware. These components were so large that the control unit consumed more space than the machine tool. But that was the state of the technology in controls at that time. By the time the first NCmachines were soid to the commercial market several years later, electromechanical relays were substituted for the vacuum tubes. The problem with these relay-based con-advantages of CNC, very few conventional hard-wired NC systems are soid in the United States.

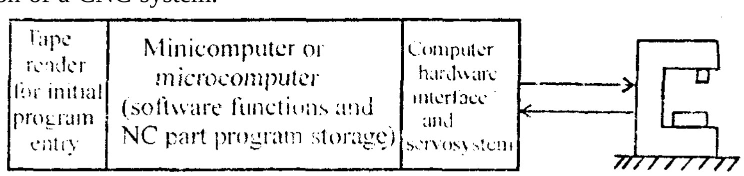
Advances in computer technology have continued to provide smaller and smaller digital control devices which have greater speed and capacity at lower cost. This has permitted the machine tool builders to design the CNC control panel as an integral part of the machine tool rather than as a separate stand-alone cabinet. This reduces floor space requirements for the machine. The VLSI (very large scale integrated) circuits used in these controllers are advantageous to the machine tool designer and to the machine user. Fewer components in the controller means it is easier and less expensive for the machine tool builder to fabricate. Fewer circuit boards, which are readily replaced, reduce the burden on the user for maintenance and repair.

Now. that we have traced the evolution of NC controls from the original vacuum-tube controller at MIT to the modem microcomputer-based controls, we will next examine the technology of CNC and DNC in more detail.

Computer Numerical Control (CNC): Computer numerical control is an NC system that utilizes a dedi cated, stored pro-gram computer to perform some or all of the basic numerical control functions. Because of the trend toward downsizing in computers, most of the CNC systems sold today use a microcomputer-based controller unit. Over the years, minicomputers have also been used in CNC controls.

The external appearance of a CNC machine is very similar to that of a conventional NC machine. Part programs are initially entered in a similar manner.

Punched tape readers are still the common device to input the part program into the system. However, with conventional numerical control, the punched tape is cycled through the reader for every workpiece in the batch. With CNC. the program is entered once and then stored in the computer memory. Thus the tape reader is used only for the original loading of the part program and data. Compared to regular NC. CNC offers additional flexibility and computational capability. New system options can be incorporated into the CNC controller simply by reprogramming the unit. Because of this reprogramming capacity, both in terms of part programs and system control options, CNC is often referred to by the term' 'soft-wired" NC. fig. illustrates the general configuration of a CNC system.



General Configuration of Computes Numerical Control (CNC) System