LECTURE NOTES

ON

THEORY OF MACHINE

4TH SEMESTER,

DEPT OF MECHANICAL ENGG.,

GOVERNMENT POLYTECHNIC

NAYAGARH

PREPARED BY:

Mr GOVIND CHANDRA BARIK, PTGF

Machine

(i) Machine is anything that produces human effect.
(ii) It is the combination of various no. of kinematic links pairs which have relative motion better them.
(iii) A machine resives some energy & convert it into some useful work. A machine is anything that is use to do some usefull work by resiving some work.

Machine	Structure
(i) parts of the machine having relative motion between them.	(i) parts of the structure don't having any motion bet. them.
(ii) parts are known as kinematic link.	(ii) parts are also known as link.
(iii) parts are always in motion.	

Rigid body

(i) The body which doesn't deform by applying force. this known as rigid body.
(ii) In actual & in partical there is no rigid body.

Resistant body

(i) The body which deform by applying force is known as resistant body.
(ii) If the deformation is negligible then it will be used for precision work.

Kinematic link

(i) The parts of the machine which have relative motion they are known as kinematic pairs

Types of link

① Rigid link
② Flexible link
③ Fluid link

① **Rigid link**

When there is no relative motion between the links is known rigid body

② **Flexible link**

When there are some relative motion between the link then it is known as flexible link.

③ **Fluid link**

When a link comes contact with a fluid having some relative motion between them is called fluid link

Kinematic pair

When the motion is restricted to a different ...

They are 3 types

(i) completly constraind motion
(ii) in completly "
(iii) successfully "

Types of kinematic pair

1. Sliding pair - lower pair
2. Rolling "
3. Turning pair
4. Screw pair
5. Spherical pair

According to the point of contact

1. Lower pair (surface contact)
2. Higher pair (point line contact)

Lower pair

1. When the two element of a kinematic pair have a surface contact between them then it is known as lower pair.
2. Ex: Cam & follower.

According to the connection:-

1. Self closed
2. Force closed

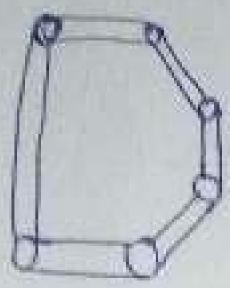
1. Self closed

When the element are connected mechanically to obtain the definite relative motion is known as self closed kinematic pair.

2. Forced closed

When the elements are not connected mechanically then it is known as forced closed.

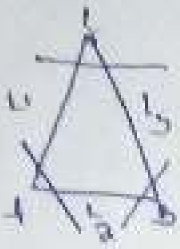
Kinematic chain



LHS < RHS (unconstrained kinematic chain)

LHS = RHS (constrained kinematic chain)

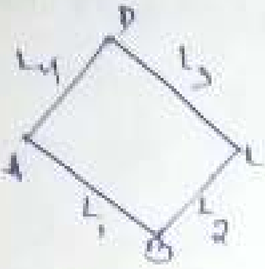
LHS > RHS (locked chain)



link = 3
joint = 3
pair = 3

$l = 2p - 4$
$3 = 2 \cdot 3 - 4$
$\Rightarrow 3 = 2$
$3 > 2$
LHS > RHS

$j = \frac{3}{2} l - 2$
$3 = \frac{3}{2} \times 3 - 2$
$3 = 4.5 - 2$
$3 = 2.5$
$3 > 2.5$
LHS > R.HS.



L = 4
J = 4
P = 4

$l = 2p - 4$
$\Rightarrow 4 = 2 \times 4 - 4$
$\Rightarrow 4 = 8 - 4$
$\Rightarrow 4 = 4$ L.H.S = R.H.S

Compound kinematic chain

A chain having more than 4 links is known as compound kinematic chain.

Types of joint

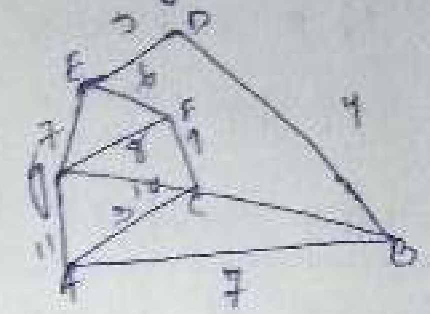
(1) Binary joint
(2) Quarternary joint
(3) Terminary joint

Binary joint

When 2 links are joint at the same connection the joint is known as binary joint.

(2) Quaternary joint

i) when 4 links are joint at the same connection the joint is called quaternary joint.



(3) Ternary joint

when 3 links are joint at the same connection the joint is known as ternary joint.

p = 9
L = 6
J = 5

L = 2P - 4
6 = 2×9 - 4
6 = 14
6 < 14

J = 3/2 L - 2
7 = 3/2 × 6 - 2
7 = 7

Mechanism

i) when one of the links of a kinematic chain is fixed when it is known as mechanism.

ii) when a mechanism is used to do some definite work it is called as machine.

ex : engine, indicator, type-writter

iii) A mechanism with links is known as simple mechanism.

iv) A mechanisme with more then 4 link called compound mechanism.

Degree of Freedom

(i) The maximum no. of independent movement of the links of a kinematic chain mechanism is known as degree of freedom.

Grublers criteria for plane Mechanism

(i) It applies to mechanism with only single degree of freedom.

$n = 0, n = 1$

$1 = 3(l-1) - 2J - 0$

$1 = 3l - 3 - 2j$

$= \boxed{3l - 2J - 4 = 0}$

Inversion

The process of obtain various of mechanism by fixed varies link of a kinematic chain by inversion.

Types of kinematic chain

Four bar chain of quadratic chain

(ii) single slider crank chain

(iii) double slider crank chain

Inversions of Single Slider Chain

Slider crank chain: This is a kinematic chain having four links. It has one sliding pair and three turning pairs. Link 2 has rotary motion and is called crank. Link 3 has got combined rotary and reciprocating motion and is called connecting rod. Link 4 has reciprocating motion and is called slider. Link 1 is frame (fixed). This mechanism is used to convert rotary motion to reciprocating and vice versa.

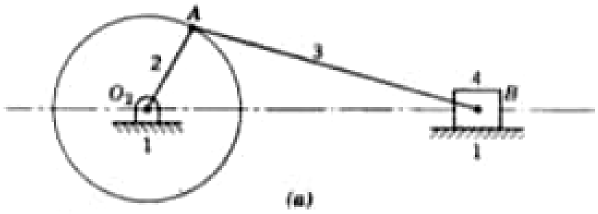
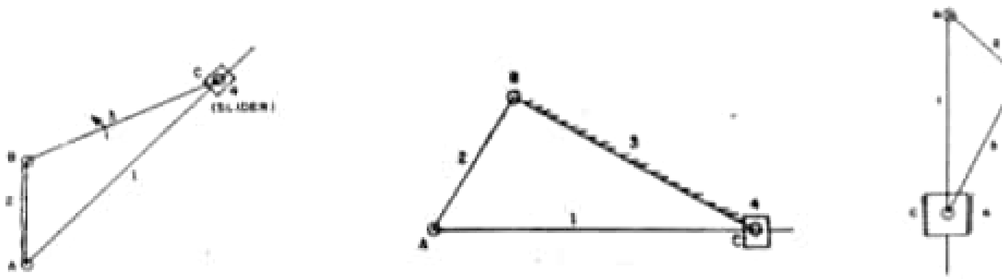


Fig1.27

Inversions of slider crank chain

Inversions of slider crank mechanism is obtained by fixing links 2, 3 and 4.



(a) crank fixed (b) connecting rod fixed (c) slider fixed

Fig.1.28

Quick return motion mechanisms.

Quick return mechanisms are used in machine tools such as shapers and power driven saws for the purpose of giving the reciprocating cutting tool a slow cutting stroke and a quick return stroke with a constant angular velocity of the driving crank.

Whitworth quick return motion mechanism–Inversion of slider crank mechanism.
This mechanism is mostly used in shaping and slotting machines. In this mechanism, the link *CD* (link 2) forming the turning pair is fixed, as shown in Fig. The link 2 corresponds to a crank in a reciprocating steam engine. The driving crank *CA* (link 3) rotates at a uniform angular speed. The slider (link 4) attached to the crank pin at *A* slides along the slotted bar *PA* (link 1) which oscillates at a pivoted point *D*. The connecting rod *PR* carries the ram at *R* to which a cutting tool is fixed. The motion of the tool is constrained along the line *RD* produced, *i.e.* along a line passing through *D* and perpendicular to *CD*.

FRICTION

① screw Friction

Screw is a fastning that have thread which have made by cutting a countinues helical grew on a cylindri-cal surface.

(ii) EX :- V - thread, square thread etc.

Types of thread

(i) External
(ii) Internal

→ If the threads are cut on the outer surface of and on cylindrical surface is known as external thread.

EX : Bolt.

Internal

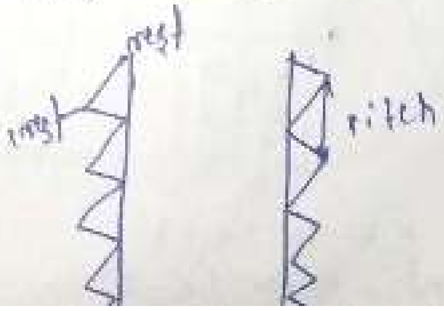
(i) The threads are cut on the internal surface then it is called internal thread.

(ii) Nut

Various terms use in screw friction

① Helix
It is the curve test by a particle while describing a circular path.

2- Pitch
It is the distance from one point of a screw to the adjacent next point



(3) Lead

The axial distance travel by a screw one turn (5) is known as lead.

(4) Depth of thread

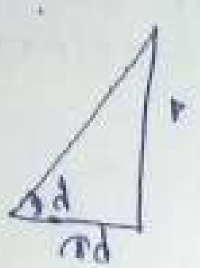
The distance between crest & root is called D.o.t.

(5) Single thread screw

If the lead of the screw is equal to it's pitch it is known as single thread screw.

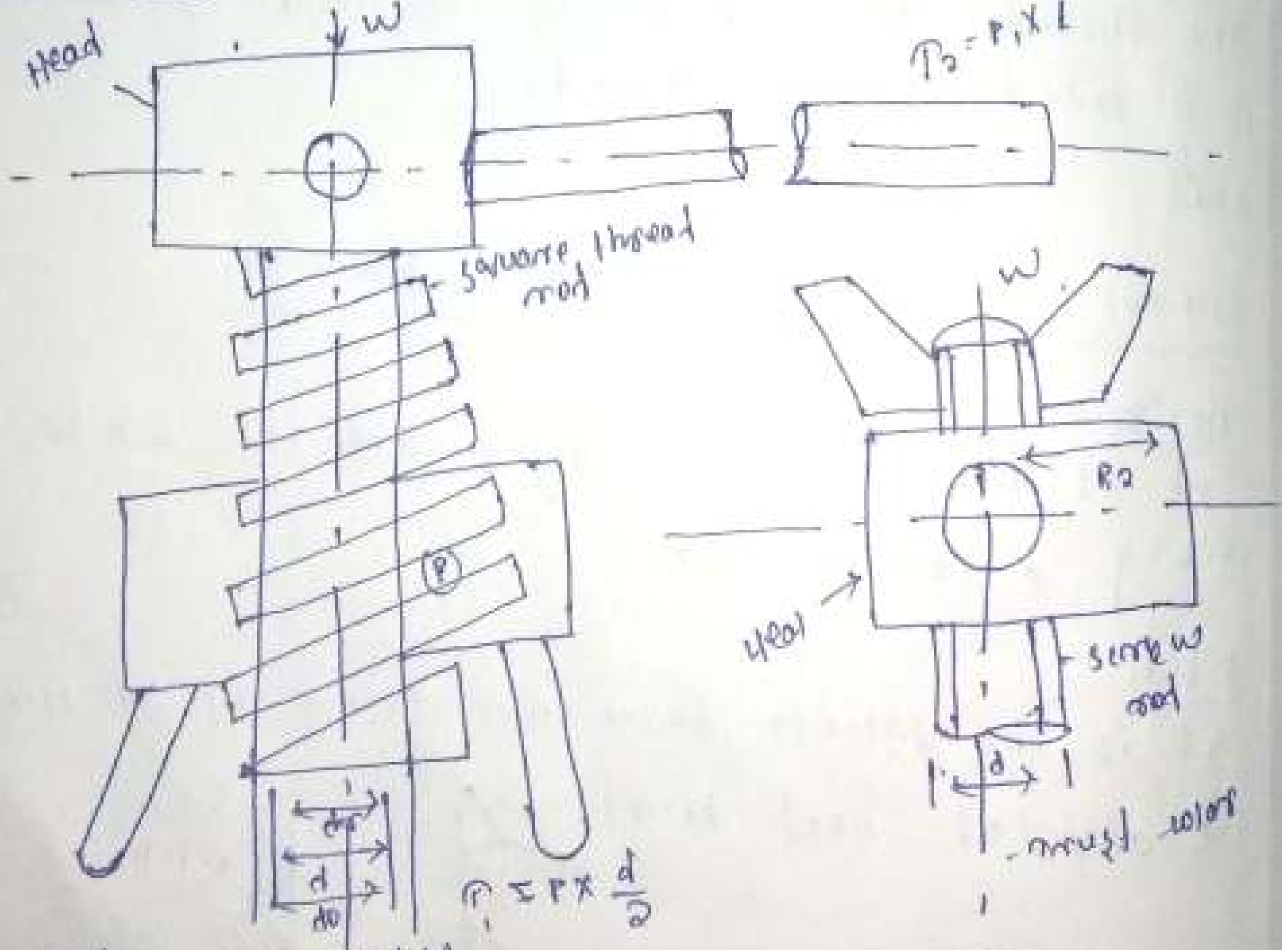
(6) Helix Angel

It is the slope of the thread the horizontal



pitch $\tan\alpha = \frac{p}{\pi d}$

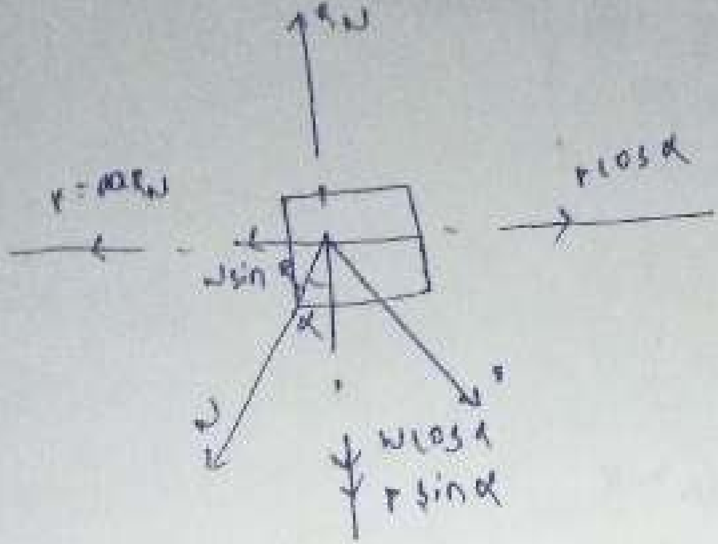
Screw Jack

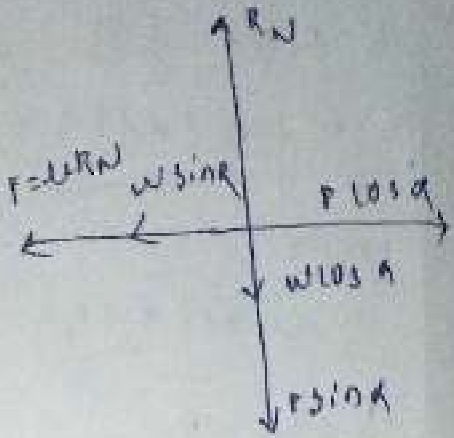


upward = $W \tan(\alpha + \phi)$

downward = $W \tan(\alpha - \phi)$

Free body diagram





$\Sigma V = 0$

$R_N - W\cos\alpha - P\sin\alpha = 0$

$R_N = W\cos\alpha + P\sin\alpha \rightarrow (i)$

$\Sigma H = 0$

$P\cos\alpha - F - W\sin\alpha = 0$

$P\cos\alpha = F + W\sin\alpha$

$\Rightarrow P\cos\alpha = \mu \cdot R_N + W\sin\alpha \rightarrow (ii)$

Put the value of R_N in eq (ii)

$P\cos\alpha = \mu \cdot (W\cos\alpha + P\sin\alpha) + W\sin\alpha$

$\Rightarrow P\cos\alpha = \mu W\cos\alpha + \mu P\sin\alpha + W\sin\alpha$

$\Rightarrow P\cos\alpha - \mu P\sin\alpha = \mu W\cos\alpha + W\sin\alpha$

$\Rightarrow P(\cos\alpha - \mu\sin\alpha) = W(\mu\cos\alpha + \sin\alpha)$

$\Rightarrow P = \dfrac{W(\mu\cos\alpha + \sin\alpha)}{(\cos\alpha - \mu\sin\alpha)}$

$\Rightarrow P = \dfrac{W\left(\cos\alpha \times \frac{\sin\phi}{\cos\phi} + \sin\alpha\right)}{\cos\alpha - \frac{\sin\phi}{\cos\phi} \times \sin\alpha}$

$\Rightarrow P = \dfrac{\dfrac{W(\cos\alpha \times \sin\phi) + (\sin\alpha \times \cos\phi)}{\cos\phi}}{\dfrac{(\cos\alpha \times \cos\phi) - (\sin\alpha \times \sin\phi)}{\cos\phi}}$

$\Rightarrow P = \dfrac{W\sin(\alpha + \phi)}{\cos(\alpha + \phi)}$

$\Rightarrow \boxed{P = W\tan(\alpha + \phi)}$

$T_1 = P \times \frac{d}{2} \rightarrow (1)$ $\quad P_1 = \frac{Pd}{2l} \rightarrow (5)$ — Torque

$T_2 = P_1 \times l \rightarrow (2)$ $\quad T_1 = T_2 \rightarrow (4)$

$T_1 = W \tan(\alpha + \phi) \times \frac{d}{2} \rightarrow (3)$

Collar

$T_3 = \mu_1 W \left(\frac{R_1 + R_2}{2}\right)$

$T_3 = \mu_1 W R$

$T_0 = T_1 + T_3 = P \times \frac{d}{2} + \mu_1 W R$

$= W \tan(\alpha + \phi) + \mu_1 W R$

$= W \{\tan(\alpha + \phi) + \mu_1 R\}$

Mechanical Advantages

$M.A = \frac{W}{P_1} = \frac{W}{\frac{Pd}{2l}} = \frac{W 2l}{Pd} = \frac{2Wl}{W \tan(\alpha + \phi) \times d} = \boxed{\frac{2l}{\tan(\alpha+\phi) \times d}}$

$V.R = \frac{\text{Distance moved by the effort}}{\text{Distance moved by the load}}$

$= \frac{2\pi l}{\text{pitch}} = \boxed{\frac{2\pi l}{\tan\alpha \times \pi d}}$

$\eta = \frac{\frac{2l}{\tan(\alpha+\phi) \times d}}{\frac{2\pi l}{\tan\alpha \times \pi d}} = \frac{2l}{\tan(\alpha+\phi) \times d} \times \frac{\tan\alpha \times \pi d}{2\pi l}$

$= \boxed{\frac{\tan\alpha}{\tan(\alpha+\phi)}}$

(1) An electric motor driven power screw moves a nut in a horizontal plane against a force of 75 kN at a speed of 300 mm per minute. The square have single thread of 6 mm pitch on a measure diameter of 40 mm. The coefficient of friction screw thread is 0.1. Estimate the power of motor

given

$W = 75 kN = 75 \times 10^3 N$

pitch = 6mm

$d_0 = 40 mm$

$\mu = 0.1$

$v = 300 mm/min$

$d_m = d_0 - \frac{p}{2}$

$\tan\alpha = \frac{p}{\pi d} = \frac{6}{\pi \times 37}$

$\Rightarrow \tan\alpha = 0.0516$

second $P = W \tan(\alpha + \phi)$

$W \times \left(\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha \times \tan\phi} \right)$

$= 75 \times 10^3 \times \left[\frac{0.0516 + 0.1}{1 - (0.0516 \times 0.1)} \right]$

$= 11428.97$

$= 11.428 \times 10^3 N$

power = torque × angular velocity

$P = T \times \omega$

$= 211.45 Nm \times 5.24 rad/s$

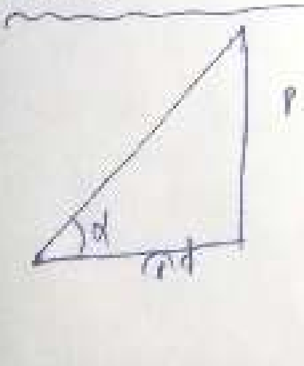
$= 1108 W = 1.108 kW$

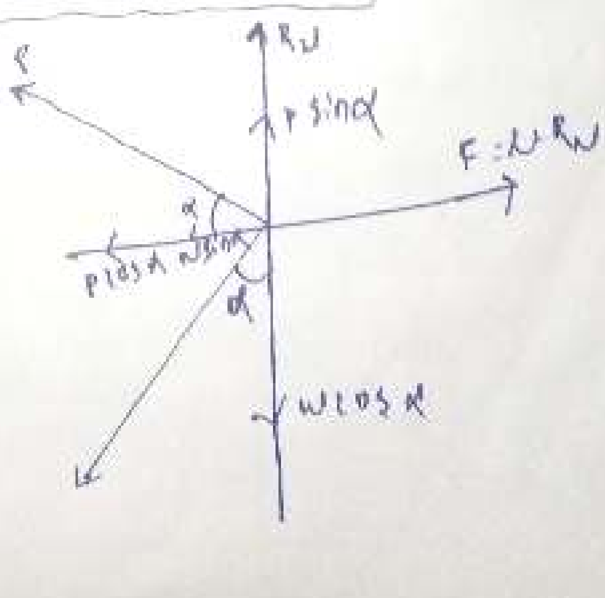
$T = P \times \frac{d}{2}$

$= 11.428 \times 10^3 \times \frac{37}{2} = 211.45 N.m$

$N = \frac{v}{p} = \frac{\text{speed of nut}}{\text{pitch}} = \frac{300}{6} = 50$

Torque required to lower the load





$\Sigma V = 0$

$R_N + W\cos\alpha + P\sin\alpha$

$\Rightarrow R_N = W\cos\alpha + W\sin\alpha$

$\Sigma H = 0$

$F - P\cos\alpha - W\sin\alpha = 0$

$P\cos\alpha = \mu \cdot R_N - W\sin\alpha \rightarrow (1)$

Putting the value of R_N in eq (1)

$P\cos\alpha = \mu \cdot R_N - W\sin\alpha$

$P\cos\alpha = \mu \cdot (W\cos\alpha - P\sin\alpha) - W\sin\alpha$

$\Rightarrow P\cos\alpha = \mu W\cos\alpha - \mu P\sin\alpha - W\sin\alpha$

$\Rightarrow P(\cos\alpha + \mu P\sin\alpha = \mu W\cos\alpha - W\sin\alpha$

$\Rightarrow P(\cos\alpha + \mu\sin\alpha) = W(\mu\cos\alpha - \sin\alpha)$

$\Rightarrow P = \dfrac{W(\mu\cos\alpha - \sin\alpha)}{(\cos\alpha + \mu\sin\alpha)}$

$\Rightarrow P = \dfrac{W(\cos\alpha \times \frac{\sin\phi}{\cos\phi} - \sin\alpha)}{\cos\alpha + \frac{\sin\phi}{\cos\phi} \times \sin\alpha)}$

$\Rightarrow P = \dfrac{W(\frac{\cos\alpha \times \sin\phi}{\cos\phi} - \sin\alpha)}{(\cos\alpha + \frac{\sin\phi - \sin\alpha}{\cos\phi})}$

$\Rightarrow P = \dfrac{W(\frac{\sin\phi \times \cos\alpha - \sin\alpha \times \cos\phi)}{\cos\phi}}{\frac{\cos\alpha \cdot \cos\alpha + \sin\phi - \ldots}{\cos\phi}}$

$P \Rightarrow W \dfrac{\sin(\phi - \alpha)}{\cos(\phi - \alpha)}$

$P = W\tan(\phi - \alpha)$

when $\phi > \alpha$

Bearing

- Bearing provides an effective means of supporting rota-ting shaft while reducing friction.
- Bearings are mechanical assembly that consist of rolling eliments & usually inner & outer races which are use for rotating linear shaft applications.

(ii) There are various types of bearing

(i) Ball bearing
(ii) Roller bearing
(iii) Linear Bearing
(iv) Plane bearing

(ii) Ball bearing have spherical rolling eliments & are use for lower load application while roller bearing use sylindrical rolling eliments for heavyer load carrying load carrying required ments.

(iv) Linear bearing are use for linear moment along shaft & may also have rotational capability.

Ball Bearing

(i) Ball bearing are mechanical assembly that consists of rolling sphorical eliments that are captures betwee circular inner & outer races. They provides a mean of supporting rotating shaft & minimising friction between shaft & stationary machine members.

(ii) Ball bearing are also known as rolling eliment bearing or anti friction bearing.

Advantage

(i) use to support high speed shaft.
(ii) large range of standardise forms.
(iii) can handel radial & axial load with specific configuration.

Roller bearing

(i) Roller bearing are mechanical assembly that consists of cylindrical or tapper rolling element usually captured between inner & outer races.
(ii) They provide a mean of supporting rotating shaft & minimising friction between shaft & stationary machine members.
(iii) They are used primarily in machinary with rotating shaft that required the support of heavyer load than ball bearing provides.
(iv) They are mostly preferred for.
(v) They are mostly preferd than ball bearing.
(v) High load capacity than ball bearing.
(vi) can with stand high axial load.

Friction in pivot & colar bearing

(i) The rotating shaft are frequently subjected two axial thrusts. The bearing surface such as pivot & colar bearing are used to take the axial thrusts of the rotating shaft.

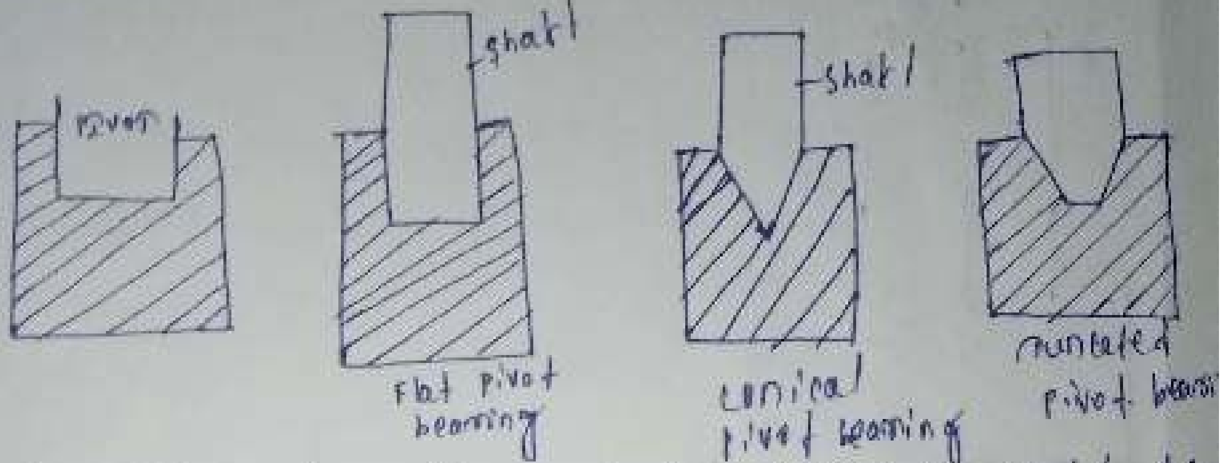
EX: The propeller of ships. The shaft of turbine etc.

(ii) The bearing surface placed at the end of shaft to take the axial thrust are known as pivot

Types of bearing

Pivot
- Flat pivot
- Conical
- Truncated

Collar
- Single flat collar bearing
- Multiple flat collar bearing



In a new bearing the contact between the shaft & bearing may be good over the whole surface. In other may be good over the whole surface. In other words we can say that the pressure over the rubbing surface is uniformly distributed.

But when the bearing becomes old all part of the rubbing surface will not move with the same velocity because the velocity of rubbing surface increases with the distance from the axis of bearing. Hence the continuous wear is generated through out the bearing surface.

So the torque generated in the shaft & bearing can be found out considering uniform pressure & uniform wear.

Flat pivot bearing

p = Intensity of pressure per unit area of bearing surface

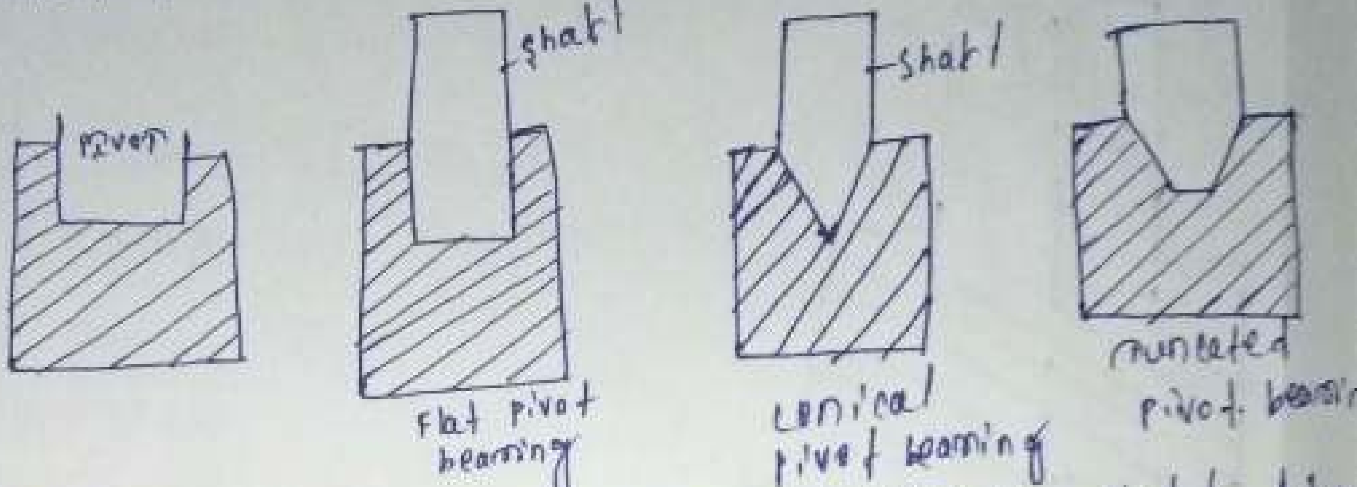
W = load

μ = coefficient of friction

r = radious of small strip

pivot
- Flat pivot
- conical
- truncated

collar
- single Flat collar bearing
- multiple flat colar bearing



In a new bearing the contact between the shaft & bearing may be good over the whole surface. In other may be good over the whole surface. In other words we can say that the pressure over the rubbing surface in uniformly distributed.

But when the bearing becomes old all parts of the rubbing surface will not move with the same velocity because the velocity of rubbing surface increases with the distance from the axis of bearing. Hence the continues wear is generated through out the bearing surface.

So the torque generated in the shaft & bearing can be found out considering uniform pressure & uniform wear.

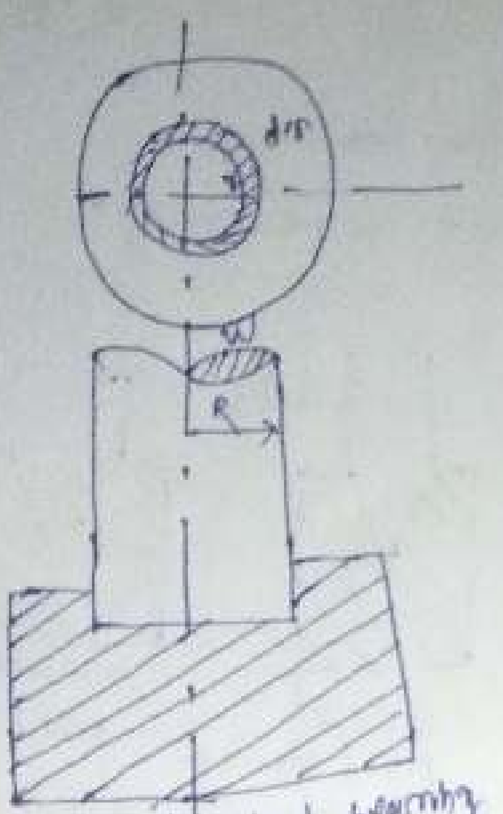
Flat pivot bearing

p = Intensity of pressure per unit area of bearing surface

W = load

u = coefficient of friction

r = radious of small strip



Flat pivot bearing

<u>considering uniform pressure</u>

$p = \frac{W}{A}$

$\Rightarrow p = \frac{W}{\pi R^2} \rightarrow (1)$

$a = 2\pi r\, dr$

$p = \frac{\delta W}{2\pi r\, dr} \Rightarrow \delta W = p \times 2\pi r\, dr \rightarrow (2)$

Frictional resistance generated on the ring

$F_r = \mu \times \delta W$

$= \mu \times p \times 2\pi r\, dr$

$= 2\pi \mu p r\, dr$

Frictional torque generated on the ring

$T_r = F_r \times r$

$= 2\pi\mu p r\, dr \times r$

$= 2\pi \mu p r^2\, dr$

Total friction torque generated on the bearing surface

$T = \int_0^R 2\pi \mu p r^2\, dr$

$T = \int_0^R 2\pi\mu p r^2 dr$

$= 2\pi\mu p \int_0^R r^2 dr$

$= 2\pi\mu p \left[\frac{R^3}{3}\right]_0^R$

$= 2\pi\mu p \frac{R^3}{3} = 2\pi\mu \times \frac{W}{\pi R^2} \times \frac{R^3}{3} \therefore \boxed{T = \frac{2}{3}\mu W R}$

when the shaft rotate at omega radian per second the power loss in friction

$P = \text{Torque} \times \omega$

$P = T \times \omega$

$= T \times \frac{2\pi N}{60}$ W

considering uniform wear

$p \times r = c$

$\Rightarrow p = \frac{c}{r} \rightarrow (1)$

$f_W = p 2\pi r dr$

$= \frac{c}{r} \times 2\pi r dr$

$\Rightarrow f_W = 2\pi c dr$

total load $W = \int_0^R 2\pi c\, dr$

$= 2\pi c \int_0^R dr$

$= 2\pi c R$

$\Rightarrow c = \frac{W}{2\pi R} \rightarrow (2)$

$F_r = 2\pi \mu p r dr$

$= 2\pi\mu \times \frac{c}{r} \times r \times dr$

$= \boxed{2\pi\mu c dr}$

$F_t = 2\pi\mu c\, dr \times r$

$= \boxed{2\pi\mu c r dr}$

Total torque $T = \int_0^R 2\pi \mu c r \, dr$

$= 2\pi\mu c \int_0^R r \, dr$

$= 2\pi\mu c \times \left[\frac{r^2}{2}\right]_0^R$

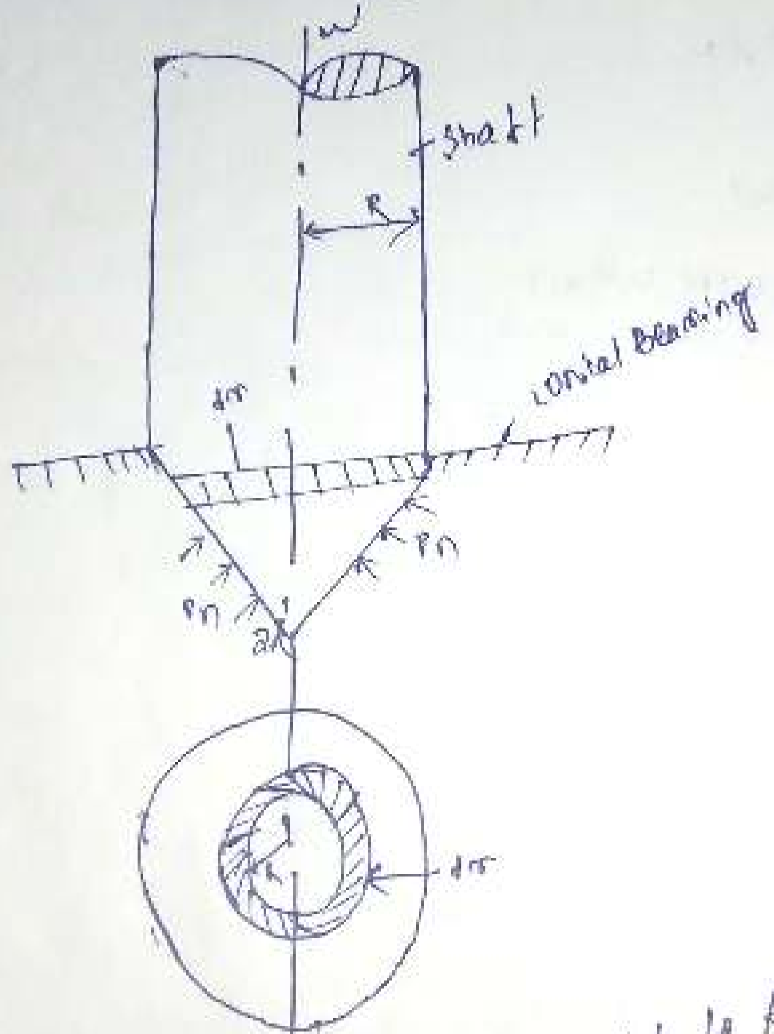
$= 2\pi\mu c \times \frac{R^2}{2}$

$= 2\pi \times \mu \times \frac{W}{2\pi R} \times \frac{R^2}{2}$

$= \boxed{\frac{1}{2}\mu W R}$

$P = T \times \omega = T \times \frac{2\pi N}{60}$

<u>Conical pivot bearing</u>



P_n = Intensity of pressure normal to the cone.

r = radious strip

R = Radious of shaft

W = load applied on the shaft

dr = thickness of strip

α = semi angel of the cone

μ = coefficient of friction between shaft & bearing

$a = 2\pi r \times dl$

$= 2\pi r\, dr \operatorname{cosec} \alpha$ ($\because dl = dr \operatorname{cosec} \alpha$)

$\delta W = P_n \times a$

$= P_n \times 2\pi r\, dr \operatorname{cosec} \alpha$

Total vertical load acting on the ring δW = vertical component of δW_n

$= \delta W_n \cdot \sin \alpha$

$= P_n \times 2\pi r\, dr \operatorname{cosec} \alpha \times \sin \alpha$

$= P_n\, 2\pi r\, dr$

Total vertical load $\int_0^R P_n 2\pi r\, dr$

$= P_n 2\pi \int_0^R r\, dr$

$= P_n 2\pi \frac{R^2}{2}$

$$\boxed{W = P_n \pi R^2}$$

$$\Rightarrow \boxed{P_n = \frac{W}{\pi R^2}}$$

Frictional resistance

$F_r = \mu \times \delta W$

$F_r = \mu \times P_n 2\pi r\, dr$

$T = F_r \times r = \mu \times P_n 2\pi dr \times r = 2\pi \mu P_n r^2 dr$

Total torque $T = \int_0^R 2\pi \mu P_n r^2 dr \operatorname{cosec} \alpha$

$= 2\pi \mu P_n \operatorname{cosec} \alpha \int_0^R r^2 dr$

$= 2\pi \mu P_n \operatorname{cosec} \alpha \times \frac{R^3}{3}$

$= 2\pi \mu \times \frac{W}{\pi R^2} \times \operatorname{cosec} \alpha \times \frac{R^3}{3}$

$= \frac{2}{3} \mu W R \operatorname{cosec} \alpha$

$T = \frac{2}{3} \mu W l$

$P = T \times \omega = \boxed{\frac{2\pi N T}{60}}$

Single Flat collar bearing

$A = \pi(r_1^2 - r_2^2)$

$p = \frac{W}{A} = \frac{W}{\pi(r_1^2 - r_2^2)}$

$\Rightarrow W = p\pi(r_1^2 - r_2^2) \rightarrow (i)$

$T_r = 2\pi\mu p r^2 dr$

$T = \int_{r_2}^{r_1} 2\pi\mu p r^2 dr$

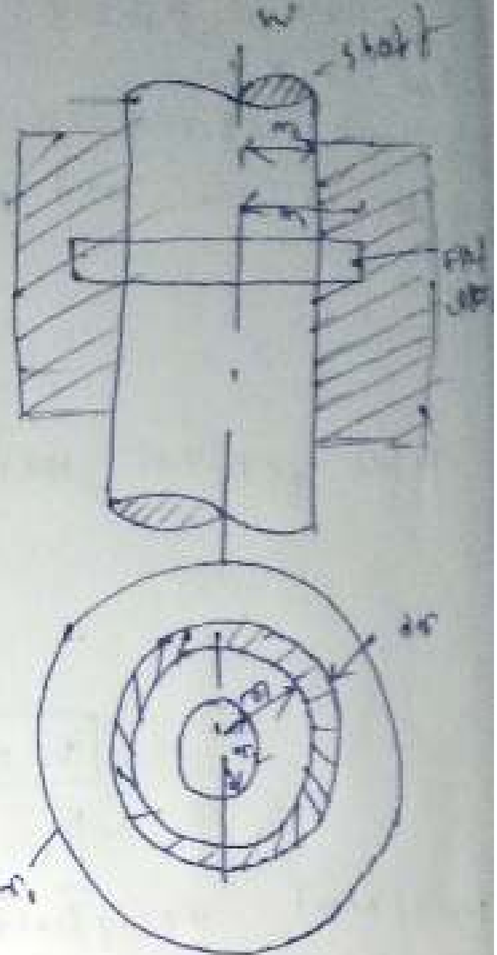
$= 2\pi\mu p \int_{r_2}^{r_1} r^2 dr$

$= 2\pi\mu p \left(\frac{r^3}{3}\right)_{r_2}^{r_1}$

$= 2\pi\mu p \, \frac{r_1^3 - r_2^3}{3}$

$= 2\pi\mu \times \frac{W}{\pi(r_1^2 - r_2^2)} \times \frac{r_1^3 - r_2^3}{3}$

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



Uniform wear

$p_r \times r = C \Rightarrow p_r = \frac{C}{r} \rightarrow (i)$

$\delta W = p_r \times 2\pi r \, dr = \frac{C}{r} \times 2\pi r \, dr$

$= 2\pi C \, dr$

$= \int_{r_2}^{r_1} 2\pi C \, dr = 2\pi C \int_{r_2}^{r_1} dr = 2\pi C(r_1 - r_2)$

$\Rightarrow C = \frac{W}{2\pi(r_1 - r_2)} \rightarrow (ii)$

$dT = 2\pi\mu c r dr$

$T = \int_{r_2}^{r_1} 2\pi\mu c r dr$

$= 2\pi\mu c \int_{r_2}^{r_1} r dr = 2\pi\mu c \left[\frac{r^2}{2}\right]_{r_2}^{r_1}$

$= 2\pi\mu c \left(\frac{r_1^2 - r_2^2}{2}\right)$

$= 2\pi\mu \times \frac{W}{2\pi(r_1 - r_2)} \times \frac{(r_1 + r_2)(r_1 - r_2)}{2}$

Multiple collar bearing $\boxed{p = \frac{W}{n\pi (r_1^2 - r_2^2)}}$

(Q) A shaft has a number of collars integral with the ... The external diameter is 400 mm & shaft diameter 250 mm. If the intensity of pressure is 0.35 N/mm² & co-efficient of friction is 0.05. Explained:

(1) Power absorbed in the shaft runs 105 rpm carrying a load 150 kN.

(2) No. of collar.

Given

$d_1 = 400 mm$, $r_1 = \frac{d_1}{2} = \frac{400}{2} = 200 mm$

Shaft $d_2 = 250 mm$, $r_2 = \frac{d_2}{2} = \frac{250}{2} = 125 mm$

$p = 0.35 N/mm^2$

$W = 150 kN$

$\mu = 0.05$

$T = \frac{2}{3}\mu W \frac{r_1^3 - r_2^3}{r_1^2 - r_2^3}$

$= \frac{2}{3} \times 0.05 \times 150 \times 10^3 \times \frac{(200)^3 - (125)^3}{(200)^2 - (125)^2}$

$= 1240 \times 10^3$ N.mm

$= 1240$ N.m

$P = \frac{2\pi NT}{60} = \frac{2\pi \times 105 \times 1240}{60} = 13640$ W $= 13.64$ kW

$P = \frac{W}{\pi \pi (r_1^2 - r_2^2)} = \frac{150 \times 10^3}{0.3 \times \pi \times (200^2 - 125^2)} = 5.6 = 6$ [Ans]

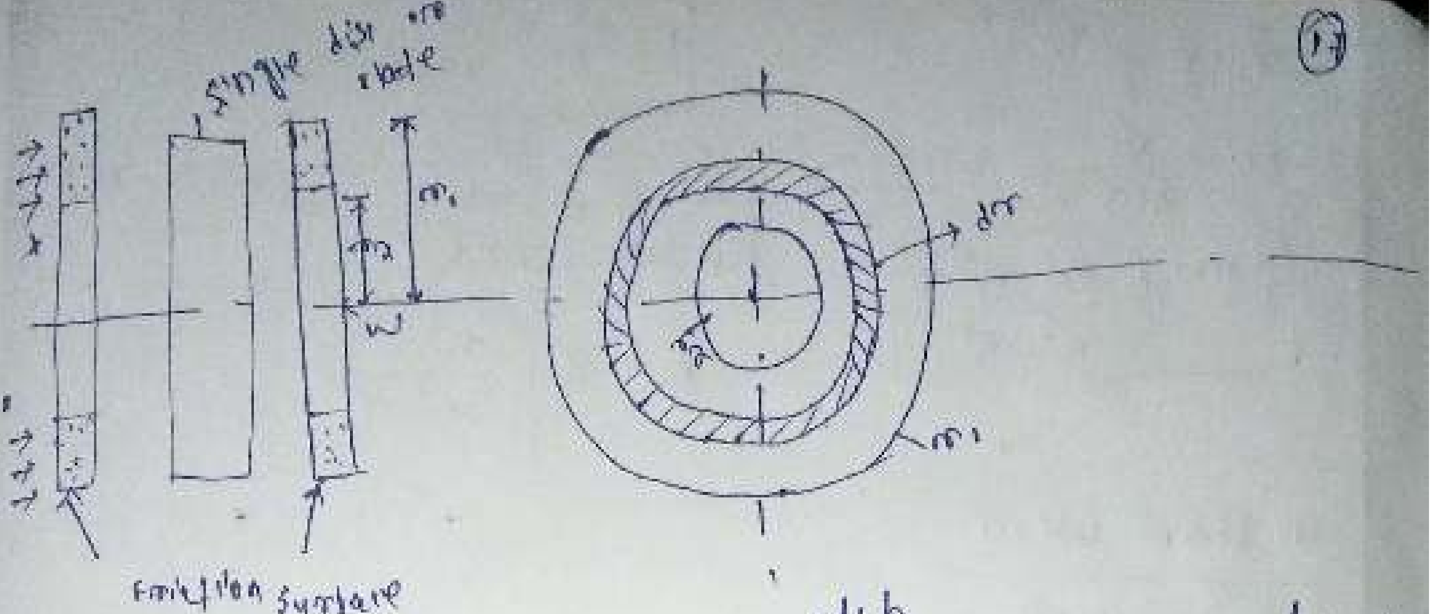
Friction clutch

(1) It is use in the transmission of power of shaft machine which must be started stoped frequently. It is also use to deliver power to the machines that is partially or fully loaded.

(2) Friction clause is use to connect to engine to driven shaft. In operating such a clutch care should be taken so that the friction surface engage smoothly bring the driven shaft upto proper speed.

(3) Main types of clutch.

1. Disk or plate clutches (single disk or multiple)
2. cone clutch
3. centrifugal clutch



T = torque transmitted by the clutch

p = Intensity of pressure with which the contact surface are held together

r_1 = external radious

r_2 = internal radious

μ = co efficient of friction

→ Area of the strip $= 2\pi r\,dr$ → (i)

→ Load applied on the strip $\delta W = p \times 2\pi r\,dr$ → (ii)

→ Frictional resistance created on the strip.

$F_r = \mu \delta W = \mu \times p \times 2\pi r\,dr$ → (iii)

→ Frictional torque applied on the strip

$T_r = F_r \times r = \mu p\, 2\pi r\, dr \times r = 2\pi \mu p r^2 dr$ → (iv)

Total torque applied on the friction surface

$$T = \int_{r_2}^{r_1} 2\pi \mu p r^2 dr$$

$$= 2\pi \mu p \int_{r_2}^{r_1} r^2 dr$$

$= 2\pi \mu c \left[\frac{r^3}{3} \right]_{r_2}^{r_1}$

$= 2\pi\mu \times \frac{W}{\pi(r_1^2 - r_2^2)} \times \frac{r_1^3 - r_2^3}{3}$

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

$P = \frac{W}{A} = \frac{W}{\pi(r_1^2 - r_2^2)}$

If R is mean radius total torque $= \mu W R$

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

Uniform wear

$P_r \times r = $ const.

$\Rightarrow P_r = \frac{c}{r} \rightarrow$ (i)

Area of strip $= 2\pi r\, dr$

load applied $\delta W = P_r \times 2\pi r\, dr$

$= \frac{c}{r} \times 2\pi r \times dr = 2\pi c\, dr$

Total load $W = \int_{r_2}^{r_1} 2\pi c\, dr = 2\pi c \int_{r_2}^{r_1} dr$

$= 2\pi c\,(r_1 - r_2)$

$\Rightarrow W = 2\pi c\,(r_1 - r_2)$

$\Rightarrow c = \frac{W}{2\pi(r_1 - r_2)} \rightarrow$ (ii)

$F_r = \mu \times \delta W$

$= 2\pi\mu c\, dr$

$T_r = F_r \times r = 2\pi\mu c\, dr \times r$

$= 2\pi\mu c\, r\, dr \rightarrow$ (iii)

Total torque generated on the friction surface

$T = \int_{r_2}^{r_1} 2\pi\mu c\, r\, dr = 2\pi\mu c \int_{r_2}^{r_1} r\, dr$

$= 2\pi\mu c \left[\frac{r^2}{2} \right]_{r_2}^{r_1}$

$$= \frac{2\pi \mu \times W}{2\pi(r_1 - r_2)} \times \frac{r_1^2 - r_2^2}{2}$$

$$= \frac{1}{2}\mu W \frac{(r_1 + r_2)(r_1 - r_2)}{(r_1 - r_2)}$$

$$= \boxed{\frac{1}{2}\mu W (r_1 + r_2)}$$

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

Frictional Break

(i) It is a device by means of which artificial frictional resistance is applied to a moving machine member in order to decrease or stop motion of machine.

(ii) In this process the break absorbes either kinematic energy of moving member or potential energy given of by objects being lowers by hoists.

(iii) The energy absorbes by breaks is dissipated in the form of heat.

(iv) This heat is dissipated in the surrounding air or water, which is circulated through the passage.

(v) The capacity of a break depends upon the following factors:

(i) The unit pressure between the braking surface.

(ii) coefficient of pressure.

(iii) peripheral velocity of the break drum.

(iv) The projected area of friction surface

(v) Ability of capacity of break to dissipate heat equivalent to the energy being absorbed.

Types of frictional break

(1) Hydraulic break : Ex : pumps or hydrodynamic break & fluid agitator.

(2) Electric break :- Generator & Eddy current breaks.

(3) Mechanical break :- Ex : Bikes, car, automobile etc.

* The hydraulic & electric breaks can't bring the member to rest & are mostly use where large amount of energy are to be transfered. while the break is retarding the road. such as in vibratory dynameter, highway truck electric locomotives.

* These breaks are also use for retarding or controlling the speed for down wheel travel.

Mech

(i) The mechanical break according to the direction of acting force may be divided into the following two groups.

(1) Radial break

(i) In these break the force acting on the break drum is radial direction.

(ii) The radial break may be sub divided into external break internal break.

(iii) According to friction element these break may be block or shoe break & band breaks.

(2) Axial break

(i) In these breaks the force acting on the break drum is in axial direction.

(ii) The axial break may be disk break & cone break. The function of break is similar to clutches.

single block or shoe break

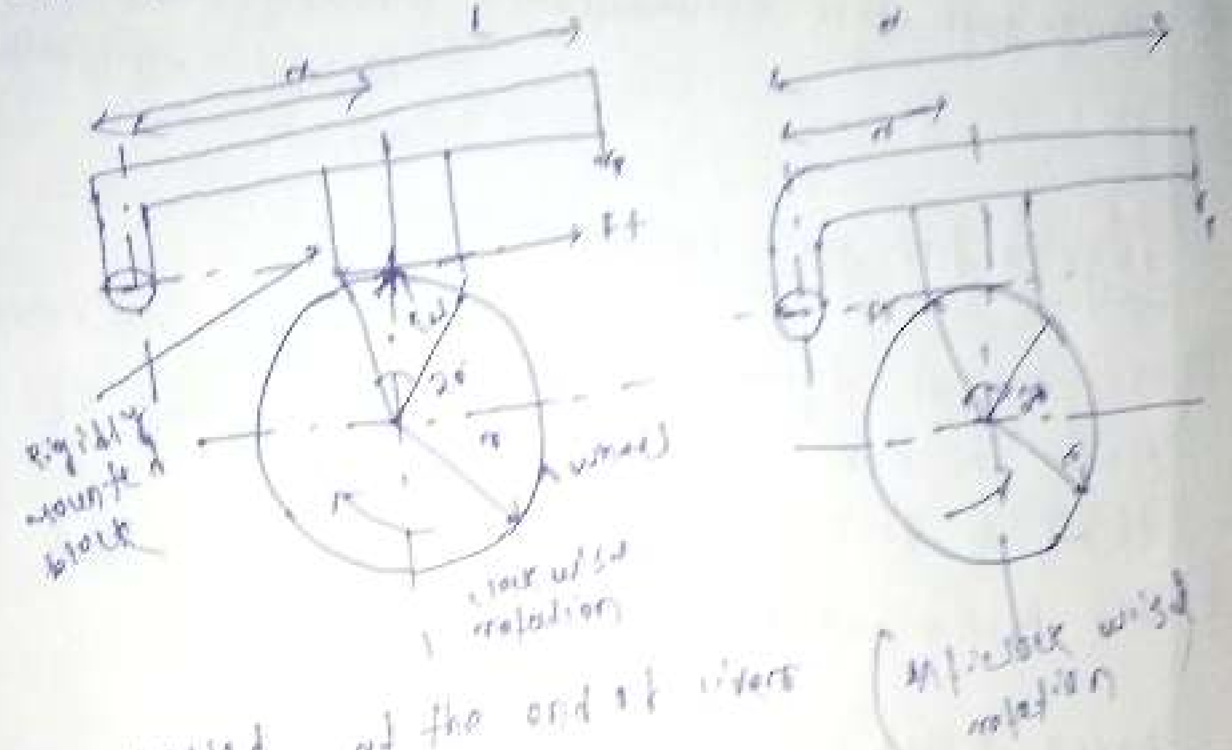
(i) It consists of a block or shoe which is pressed against the rim of a

wheel.

(ii) The block is made of a softer material than the rim of the wheel. This type of break is commonly used on railway train wheel.

(iii) The friction between the block & wheel causing a tangential braking force to act on the wheel, which reduces the rotation of wheel.

(iv) The block is pressed against the wheel by a force applied to one end of lever to which the block is rigidly fixed.



P = force applied at the end of lever

$F_T = \mu \times R_N$

$F_t = F_T \times r = \mu \cdot R_N \cdot r$

$F_t = \mu \times \frac{P \times l}{a} \times r$

Dynamometers

(i) It is a device which is used to measure the frictional resistance. By knowing frictional resistance we can determine the torque transmitted & the power of the engine.

(ii) Dynamometers can be use to measure force, torque or power.

Types of Dynamometer

(1) Absorption dynamometer :- (i) Prony break (ii) Rope break (iii) Hydraulic dynamometer

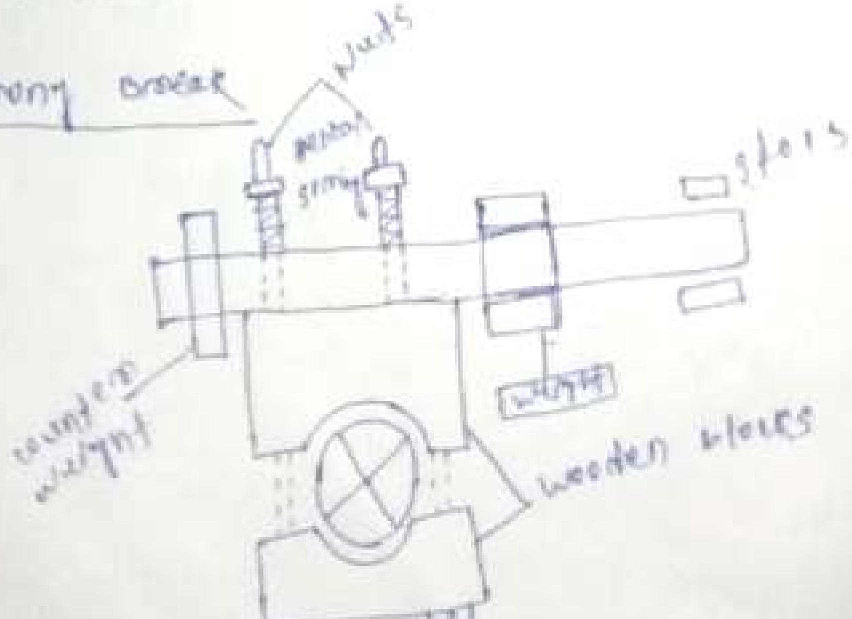
(2) Transmission type dynamometer :- (i) Break transmission dynamometer (ii) Epicyclic dynamometer (iii) Torsion

Absorption type dynamometer

(i) This type of dynamometers are used to measure the power absorve by friction & output of the engine to which they are coupled.

(ii) The power absorved is usually desipated as heat.

Prony break



(i) It is one of the simplest dynamometers for measuring break power.

(ii) It is use to stop the engine using a break on the fly wheel & measure the weight which an arm attached to break which support as it tries to rotate with the fly wheel.

(iii) The prony break consists of a wooden block & counter weight, helical spring, stops

(iv) It works on principle of converting power into heat by dry fixed.

(v) Spring loads bolts are provided to increase friction by fixing the wooden block.

(vi) The hole of the power absorved is converted into heat & hence this type of dynamometer must be cooled.

(vii) Break power $= \frac{2\pi N T}{60}$ & Torque $= \frac{\text{weight apply (w)}}{\text{distance (l)}}$

Rope break dynamometer

(i) It is also use for measuring break power of engine.

(ii) It consists of some turns of row cone around the rotating drum attached to the output shaft. one side of the row is connected to a spring balance & the other side to a loading side the power is absorve in friction between row & the drum. Therefore drum in rope break dynamometer required cooling.

(iv) rope break dynamometers are cheap & can be constructed quickly. but break powers can n't be measured accurately because of change in friction co-efficient of rope change temp^n.

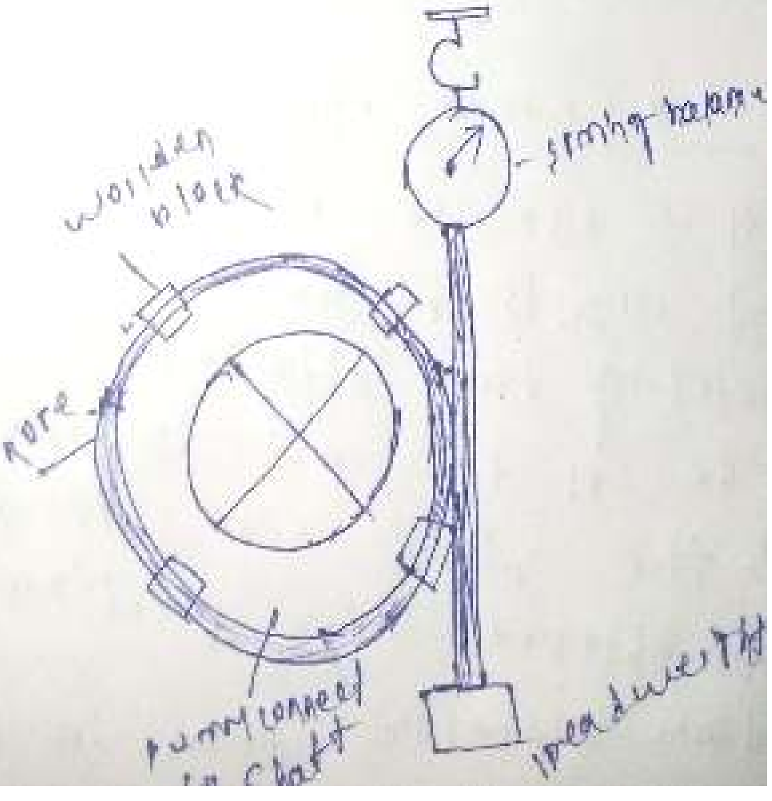
$$F_n = W - S\left(\frac{D + d}{2}\right)$$

parts of rope break dynamometers

① Rope :- made of synthetic fibers
② pully :- made of wood
③ dead weight :- cast iron
④ spring balance :- mild steel
⑤ ply wood frame :

D = diameters of break drum
d = diameters of rope
S = spring balance
W = weight attached

$$P = \frac{2\pi N (W - S)(D + d)}{60}$$



(2)(i) In a rope break dynamometer a rope is mounted over the pully which is connected to the shaft of engine.

(ii) The diameter of rope depends upon the power of machine.

(iii) The spacing of rope is done by 3-4 U shape wooden block. which also prevent rope form sleeping of pully

(iv) The upper end of the rope is attached to the spring balance whereas the lower end supports the weight of suspended of mass.

(v) If the power is high the heat produced due to friction between the rope & wheel will also high. so a pulling arrangment is high. nessesary. For this the channel of fly wheel usually has flanged on inside in which water form a read is supplyed

(vi) The rope break dynamometer is frequently use to test the power of engine. It is easy to manufacture & required no lubricant.

(vii) If the rope is warpped several times over the wheel the tension of the slag side of the rope can be reduce to be a negeegible value

Unit:II BELT DRIVES

Introduction

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds.

The amount of power transmitted depends upon the following factors:

1. The velocity of the belt.
2. The tension under which the belt is placed on the pulleys.
3. The conditions under which the belt is used.

Selection of a Belt Drive

Following are the various important factors upon which the selection of a belt drive depends:

1. Speed of the driving and driven shafts,
2. Speed reduction ratio,
3. Power to be transmitted,
4. Centre distance between the shafts,
5. Positive drive requirements,
6. Shafts layout,
7. Space available, and
8. Service conditions.

Types of Belt Drives

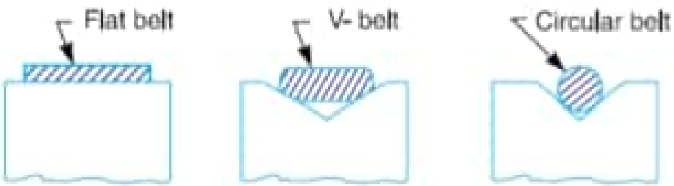
The belt drives are usually classified into the following three groups :

1. ***Light drives***. These are used to transmit small powers at belt speeds upto about 10 m/s, as in agricultural machines and small machine tools.

2. ***Medium drives***. These are used to transmit medium power at belt speeds over 10 m/s but up to 22 m/s, as in machine tools.

3. ***Heavy drives***. These are used to transmit large powers at belt speeds above 22 m/s, as in compressors and generators.

Types of Belts



(*a*) Flat belt. (*b*) V-belt. (*c*) Circular belt.

Though there are many types of belts used these days, yet the following are important from the subject point of view:

1. ***Flat belt.*** The flat belt, as shown in Fig. (*a*), is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another when the two pulleys are not more than 8 metres apart.

2. ***V-belt.*** The V-belt, as shown in Fig. (*b*), is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other.

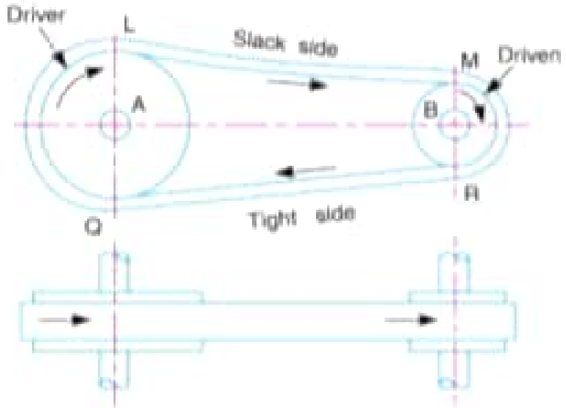
3. *Circular belt or rope*. The circular belt or rope, as shown in Fig. (*c*), is mostly u. the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 8 meters apart.

If a huge amount of power is to be transmitted, then a single belt may not be sufficient. In such a case, wide pulleys (for V-belts or circular belts) with a number of grooves are used. Then a belt in each groove is provided to transmit the required amount of power from one pulley to another.

Types of Flat Belt Drives

The power from one pulley to another may be transmitted by any of the following types of belt drives:

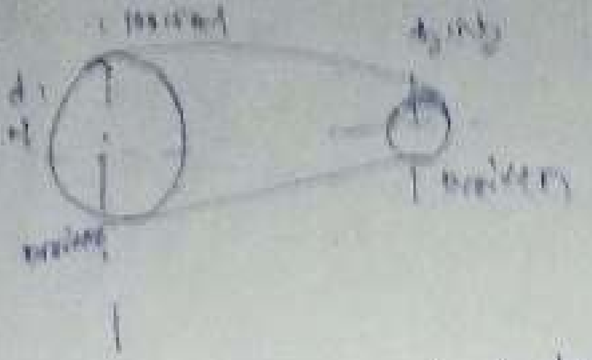
1. *Open belt drive*. The open belt drive, as shown in Fig. 11.3, is used with shafts arranged parallel and rotating in the same direction. In this case, the driver *A* pulls the belt from one side (*i.e.* lower side *RQ*) and delivers it to the other side (*i.e.* upper side *LM*). Thus the tension in the lower side belt will be more than that in the upper side belt. The lower side belt (because of more tension) is known as ***tight side*** whereas the upper side belt (because of less tension) is known as ***slack side***, as shown in Fig.



2. *Crossed or twist belt drive*. The crossed or twist belt drive, as shown in Fig. 11.4, is used with shafts arranged parallel and rotating in the opposite directions. In this case, the driver pulls the belt from one side (*i.e. RQ*) and delivers it to the other side (*i.e. LM*). Thus the tension in the belt *RQ* will be more than that in the belt *LM*. The belt *RQ* (because of more tension) is known as ***tight side***, whereas the belt *LM* (because of less tension) is known as ***slack side***, as shown in Fig.

A little consideration will show that at a point where the belt crosses, it rubs against each other and there will be excessive wear and tear. In order to avoid this, the shafts should be placed at a maximum distance of 20 *b*, where *b* is the width of belt and the speed of the belt should be less than 15 m/s.

Velocity ratio of belt drive (open belt drive)



$d_1 < d_2$

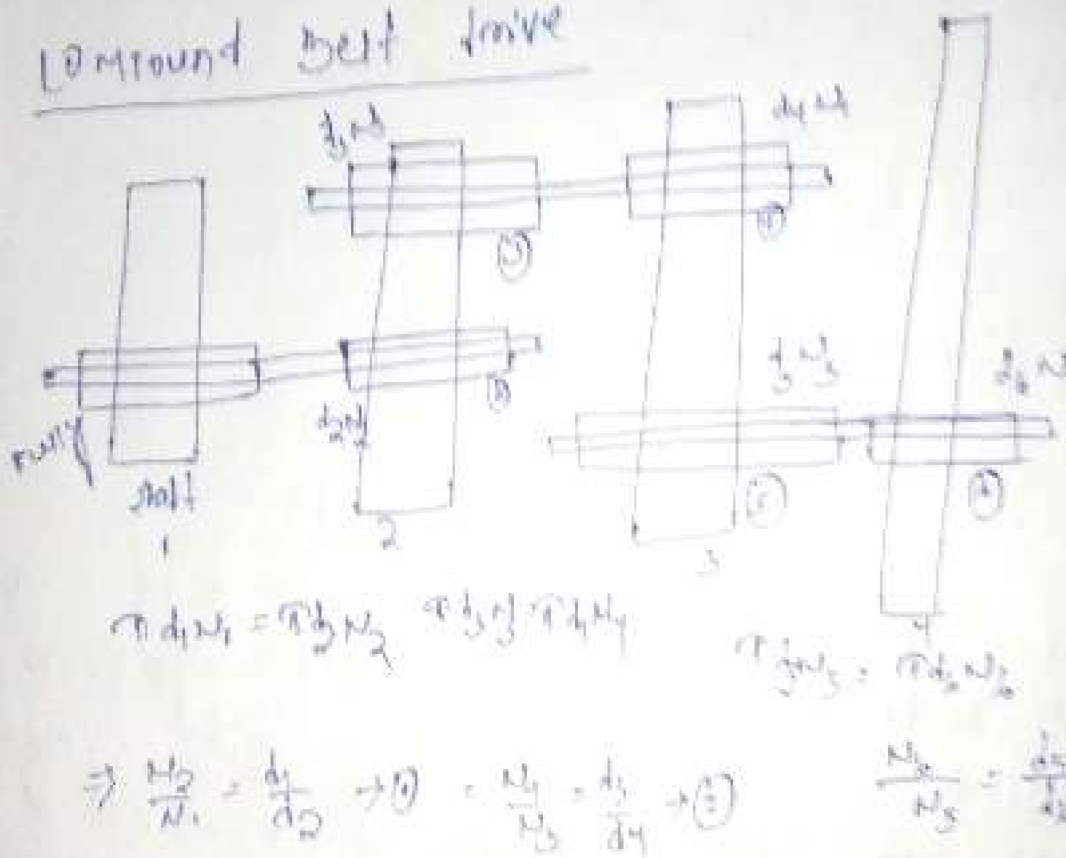
velocity of belt at driver = v of driven

velocity of belt

$\pi d_1 N_1 = \pi d_2 N_2$

$$\frac{\pi d_1 N_1}{60} = \frac{\pi d_2 N_2}{60} \Rightarrow \boxed{\frac{N_2}{N_1} = \frac{d_1}{d_2}}$$

Compound belt drive



$\pi d_1 N_1 = \pi d_2 N_2$ $\quad \pi d_3 N_3 = \pi d_4 N_4$ $\quad \pi d_5 N_5 = \pi d_6 N_6$

$$\Rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2} \to (1) \qquad \frac{N_4}{N_3} = \frac{d_3}{d_4} \to (2) \qquad \frac{N_6}{N_5} = \frac{d_5}{d_6} \to (3)$$

$$\frac{N_2}{N_1} \times \frac{N_4}{N_3} \times \frac{N_6}{N_5} = \frac{d_1}{d_2} \times \frac{d_3}{d_4} \times \frac{d_5}{d_6}$$

$$\frac{N_6}{N_1} = \frac{d_1 \times d_3 \times d_5}{d_2 \times d_4 \times d_6}$$

Slip of the belt

Slip

Due to insufficient frictional grip there is some forward motion of driver without carrying the belt with it & also there is some forward motion of belt without carrying the driven pully with it. It is generally expressed as percentage.

Driver $\longrightarrow$ Driven

$s_1\%$ $\quad$ $s_2\%$

$$\frac{\pi d_1 N_1}{60} - \frac{\pi d_1 N_1}{60} \times \frac{s_1}{100} \qquad \frac{\pi d_2 N_2}{60}$$

$$\Rightarrow \frac{\pi d_1 N_1}{60}\left(1 - \frac{s_1}{100} - \frac{s_2}{100}\right) = \frac{\pi d_2 N_2}{60}$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2}\left\{1 - \left(\frac{s_1}{100} + \frac{s_2}{100}\right)\right\}$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2}\left(1 - \frac{s}{100}\right)$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}\left(1 - \frac{s}{100}\right)$$

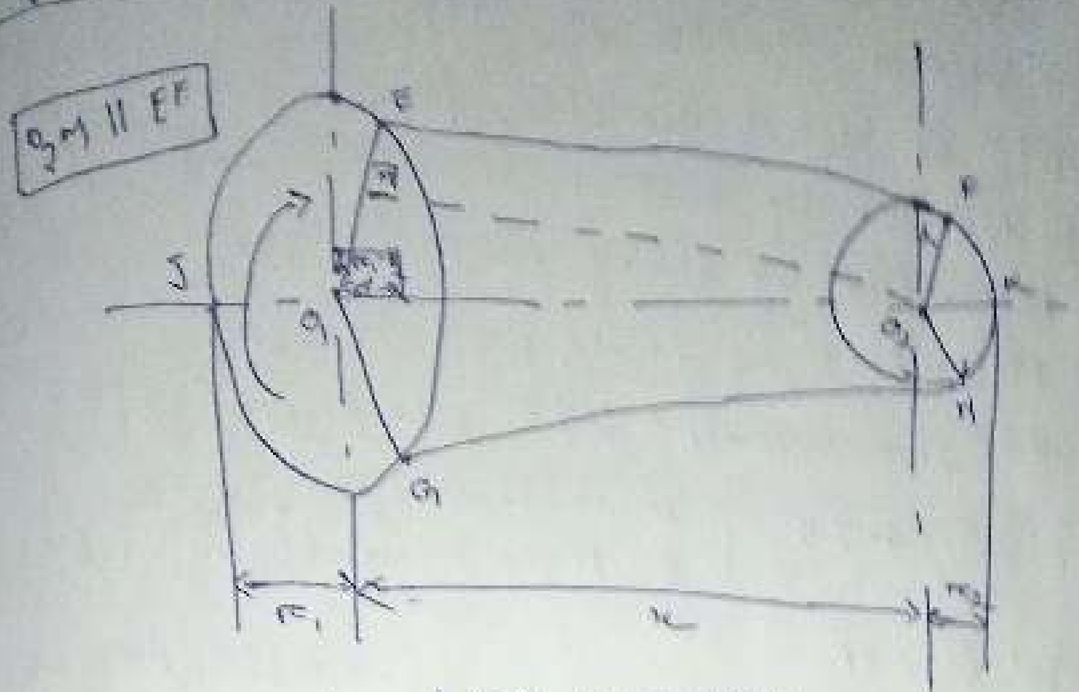
Creep

(1) When the belt passes from the slag side to the tide side. A certain portion of belt extent it contract again when the belt passes to tide side to slag side, due to these change of length there is a motion betw the belt & pully this is known as

The effect of creep is to reduce slightly the speed of the driven pully or follower.

Velocity ratio $\frac{N_2}{N_1} = \frac{d_1}{d_2} \times \frac{E + \sqrt{\sigma_2}}{E + \sqrt{\sigma_1}}$

Length of open belt drive



Arc GJE + EF + Arc FKH + GH

$\Rightarrow 2(\text{Arc } JE) + 2(EF) + 2(\text{Arc } FK)$

$L \Rightarrow 2(\text{Arc } JE + EF + \text{Arc } (FK))$

$$L = 2\left\{r_1\left(\frac{\pi}{2}+\alpha\right) + x - \frac{(r_1-r_2)^2}{2x} + r_2\left(\frac{\pi}{2}-\alpha\right)\right\}$$

$$= 2\left(r_1\times\frac{\pi}{2} + r_1\alpha + x - \frac{(r_1-r_2)^2}{2x} + r_2\times\frac{\pi}{2} - r_2\alpha\right)$$

$$= 2\left(r_1\times\frac{\pi}{2} + r_2\times\frac{\pi}{2} + r_1\alpha - r_2\alpha + x - \frac{(r_1-r_2)^2}{2x}\right)$$

$$= 2\left(\frac{\pi}{2}(r_1+r_2) + \alpha(r_1-r_2) + x - \frac{(r_1-r_2)^2}{2x}\right)$$

$$= 2\left(\frac{\pi}{2}(r_1+r_2) + \frac{(r_1-r_2)}{x}\times(r_1-r_2) + x - \frac{(r_1-r_2)^2}{2x}\right)$$

$$= \pi(r_1+r_2) + 2\frac{(r_1-r_2)^2}{x} + 2x - \frac{(r_1-r_2)^2}{x} \quad \text{[multiply 2]}$$

$$= \boxed{\pi(r_1+r_2) + 2x + \frac{(r_1-r_2)^2}{x}} \text{ (in radius)}$$

$$= \frac{\pi}{2}(d_1+d_2) + 2x + \frac{(d_1-d_2)^2}{4x} \rightarrow \text{(in diameter)}$$

* T_1 & T_2 : tension in tide side & T_2 tension in slag side.
* work per second = $(T_1 - T_2)v$ N-m/s.
* V = velocity of belt in metre/second.
* Power transmitted by belt $P = (T_1 - T_2)v$ watt.
* Torque transmitted by driving pulley $(T_1 - T_2)r_1$.
* Torque transmitted by driven pulley $(T_1 - T_2)r_2$.
* The relationship between tide side & slag side =

$$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu \times \theta$$

[μ = coefficient of friction
θ = Angel in contact in radian]

* centrifugal tension

(i) since the belt continuously runs over the pully some centrifugal force is caused whose effect is to increase the tension on tide as well as slag side. The tension caused by the centrifugal force is called centrifugal tension.

(ii) It is very low below the belt speed 10 m/s.

(iii) It is dinoted by T_c. $T_c = M \times v^2$

Gear Train

- A gear … rom one shaft to anothe … speed of driven shaft. …

Simple Gear Train

- Series of gears, capable of receiving and transmitting motion from one gear to another is called a simple gear train.

Train value

$$= \frac{N_2}{N_1} = \frac{T_1}{T_2}$$

$$= \frac{\text{Number of teeth on driving gears}}{\text{Number of teeth on driver gear}}$$

Speed ratio

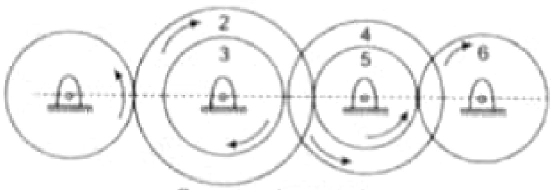
$$= \frac{1}{\text{Train value}}$$

Gears-and-gear-trains

- The intermediate gears have no effect on the speed ratio and therefore they are known as idlers.

Compound Gear Train

- When a series of gears are connected in such a way that two or more gears rotate about an axis with the same angular velocity.



Compound gear train

Train value

$$= \frac{\text{Product of number of teeth on driving gears}}{\text{Product of number of teeth on driven gears}}$$

Planetary or Epicyclic Gear Train

- A gear train having a relative motion of axes is called a planetary or an epicyclic gear train. In an epicyclic train, the axis of at least one of the gears also moves relative to the frame.
- If the arm a is fixed the wheels S and P constitute a simple train. Howeve wheel S is fixed so that arm a can rotate about the axis of S. The P woul around S therefore it is an epicyclic train

CHAPTER-4

(1) function of governers
(2) classification of governer
(3) working of watt, potter, porel & Hartnell governers
(4) conceptual explanation of sensitivity & stability & isochronism
(5) function of fly wheel
(6) comparison between fly wheel & governer.
(7) function of energy & coefficient of fluctuation of speed.

GOVERNER

The function of a governer is to maintain or regulate the speed of an engine with specified limit whenever there is variation of load.

Types of governers / classification of governer

The broadly classification of the governer are given below

Centrifugal governer

In this type of governer the action of governer depends upon the centrifugal effects produced by the masses of two balls.

Inertia governer

In this type of governer, position of the balls are effected by the forces setup by an angular acceleration or deceleration of the given spindle in adition to centrifugal forces on the balls.

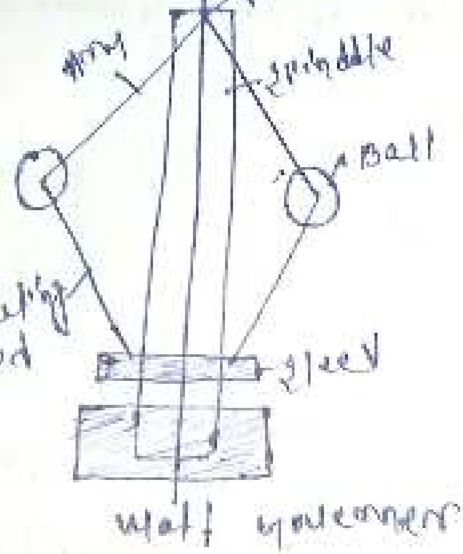
- Centrifugal GOVERNER
  - Pendulum type
    - Watt governer
  - Loaded type
    - Loaded type
      - Dead weight gov.
        - Porter governer
        - Proell governer
      - Spring controlled governer

Spring controlled governer
- Hartnell governer
- Hartung governer
- Wilson Hartnell governer
- Pickering governers

Working of governer

Watt governer

The simplest forms of a centrifugal governer is a watt governer is fig. It is basically a conical pendulum with links attached to a sleeve of negligible mass. The arm of governer may be connected to the spindle in following ways.



Watt governer

Watt governer is used to supply the required amount of fuel at different speed. The main reason is to control the engine speed according to the condition.

Watt governer consist of two balls which are attached to both arms as shown in fig. These arms get connected at the point is called pivot on the spindle & on the bottom of the spindle there is a sleeve which move up & down which the left of balls.

(5) when the balls rotates with high speed at a fixed center of the pivot the arms get stretched & the rest of connection between the ball & the sleeve get gets lifted from the bottom rising along the center of the spindle. In this type of governor when the ball rotates at high speed almost both the balls get in straight line which is also the final position of balls that rotates & help to supply fuel.

Watt governor is not sufficient to supply a more quantity of fuel this is used at only low speeds.

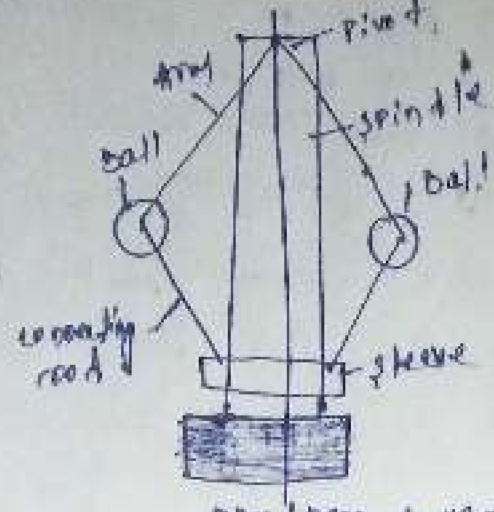
Porter governor

Porter governor is dead weight loaded type of gravity controlled centrifugal governor. It is similar to watt governor when a heavy central load is attached to the sleeve of watt governor, it becomes a porter governor.

working

The engine is connected to the central spindle of governor through gear trains. when the load on an engine decrease, there will be a sudden increase in speed of the engine. governor spindle speed also increses. the centrifugal effect tends ball pair to move outward direction. The upper arms of ball pivot at the top. Hence the lower arm pushes the sleeve upward as ball move outward. It decreses the fuel supply. Hence speed is maintaind. In case of increasing the load speed of the engine decreses.

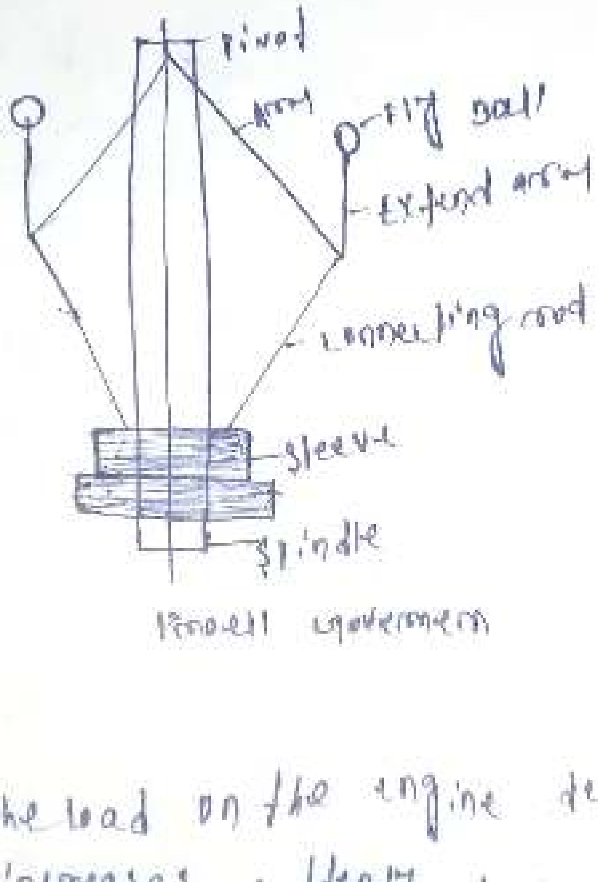
(9)



porther governer

PROELL GOVERNER

Proell governer is a type of gravity controlled centrifugal governer.



proell governer

working

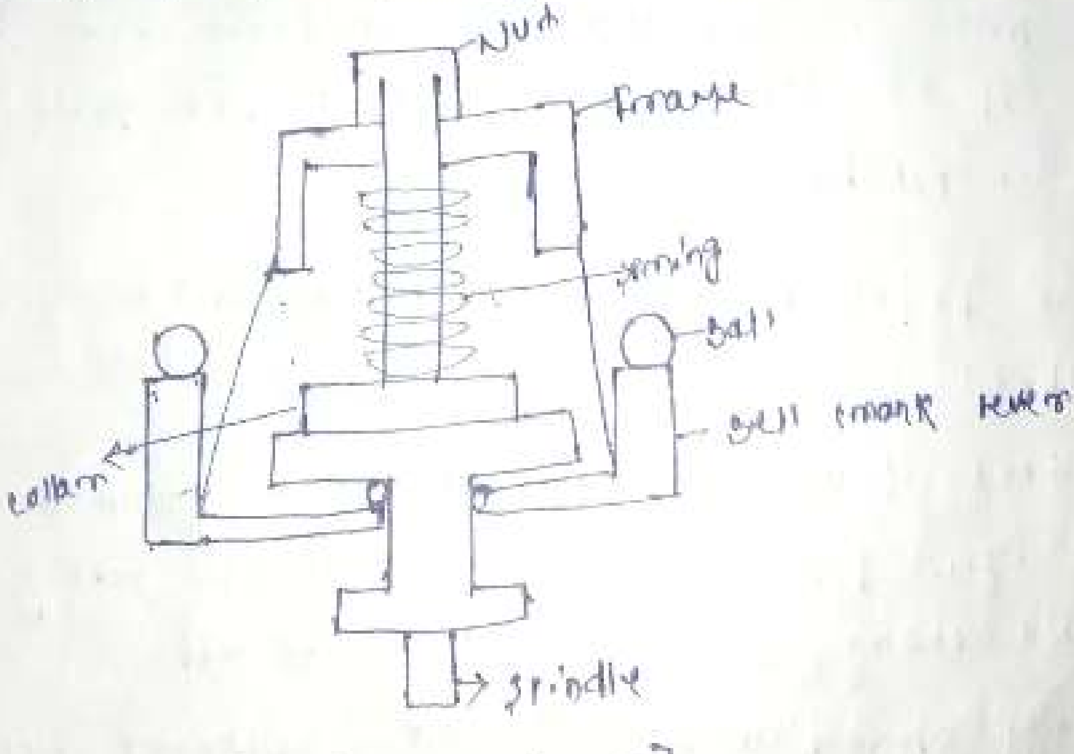
When the load on the engine decreases, the speed of engine increases suddenly & also spindle rotation speed is increased as the spindle is connected to the engine. As the rotation of spindle becomes fast, the arms pivoted to top of spindle also rotates with high speed & the balls move outward due to increased centrifugal forced on the balls. When the ball move outward, the sleev connected to the arm moves up & actuates

(5) a mechanism which closes the throttle valve & decreases the fuel supply which decreases the engine speed. Hence the engine speed is maintaind.

on the other hand, when the load on the engine increases, speed of the engine decreses.

HARTNELL GOVERNER

Hartnell governer is basically a centrifugal governer with a spring-loaded weight insted of dead weight on the sleeve to increase the speed of the balls required to lift the sleeve on the spindle. which is enable the governer to operate the mechanism to give necessary change in the fuel supply.



[Hartnell governer]

FLYWHEEL

A flywheel is a heavy rotating body which acts as a reservoir of energy. It acts as a bank of energy between the energy source & machinery.

Energy stored in a flywheel is in the form of kinetic energy.

Function of Flywheel

(1) When the power available at variable rate but is required at uniform rate. Ex the machinery driven by reciprocating internal combustion engine.

(2) When the power is available at uniform rate but we need it at non uniform rate. Ex power required in punching press.

Difference between flywheel & governor

Flywheel	Governor
(i) A flywheel is used to mitigate cyclic fluctuations in available energy.	(i) But a governor is used to adjust the supply of fuel as per the load.
(ii) The energy stored in fly wheel is kinetic which is readily available.	(ii) But governor mechanism involves friction.
(iii) Fly wheel is not used when cyclic fluctuation of energy is small or negligible	(iii) While a governor is necessary for all the types of engines because it regulates the fuel supply as per demand.

(iii) Fly wheel has no influence on the mean speed of engine.

(iv) Governor has no influence in cyclic fluctuations in energy.

(v) Fly wheel controls cyclic fluctuations in energy.

(v) Governor controls mean speed of the engine.

Fluctuation of ENERGY

The variations of energy above & below the mean resisting torque line are called fluctuation of energy.

Co-efficient of fluctuation of energy :-

It may be defined as the ratio of the maximum fluctuation of energy to the workdone per cycle.

Mathematically co-efficient of fluction of Energy

$$E = \frac{\text{Maximum fluctuation of energy}}{\text{workdone per cycle}}$$

Scanned with CamScanner

CHAPTER - 5

(1) Balacing of Machine
(2) concept of static & dynamic balacing
(3) static balacing of rotating parts
(4) Principle of balacing of reciprocating parts.
Difference between static & dynamic balacing.

Static Balacing

(i) If the shaft carries a number of unbalanced masses such that the center of mass of the system is said to be static balance.

(ii) A rotating mass is said to be statically balanced if the rotating mass can rest, without turning at any angular position in it's bearing

(iii) static balacing is a balance of force due to action of gravity.

DYnamic Balacing

(i) A system of rotating masses in dynamic balance where there does not exits any resultant centrifugal force as well as resultant couple.

or (2)
(iii) A rotating mass is said to be dynamically balanced when it doesnot vibrate in it's running state. To make a rotating mass dynamically balanced, it must be first statically balanced.

Balancing of rotating parts

The balancing of rotating bodies is important to avoid vibration. In heavy industrial machines such as gas turbines & electric generators, vibration can cause catastrophic failure, as well as noise & discomfort. In the case of narrow wheel, balancing simply involves moving the center of gravity to the centre of rotation. For a system to be in complete balance both force & couple polygons should be closed. In order to prevent the effect of centrifugal force. Balancing is important to design the machine part's so wisely, that the unbalance is is reduced up to the minimum possible level or eliminated completely.

Static balance

Static balance occurs when the centre of gravity of an object is on the axis of rotation. The object can therefore remain stationary with the axis horizontal, without the application of any braking forces

(3) It has no tendency to rotate due to the force of gravity. This is seen in bike wheels where the reflective plate is placed opposite the valve to distribute the centre of mass to the centre of the wheel. Other examples are grindstones discs or car wheel.

Difference between static & dynamic balancing?

Static balancing	Dynamic balancing
(i) static balance refers to the ability of a stationary or object centre of gravity is on the axis of rotation.	(i) whereas as dynamic balance is the ability of an object to balance whilst in motion or when switching between positions.
(ii) In static balancing, the rod around which mass is rotating is to be fixed.	(ii) whereas as in dynamic balancing, the rod moves along with the rotating mass.
(iii) static balance will be produced if the sum of the weight about the axis of rotation is zero.	(iii) In dynamic balanced when there doesnot exist any resultant centrifugal force as well as resultant couple.

SET-1

QUESTIONS

Q.1 (a) What do you understand by 'Lower pair' & Higher pair?

(b) Difference between structure & Machine.

(c) Discuss binary, ternary & quaternary link with sketches.

Q.2. What are the various type of bearings? Derive an expression for the frictional torque of a flat pivot bearing by taking into consideration:

(i) Uniform pressure theory.

(ii) Uniform wear theory.

Q.3. (a) Derive an expression for limiting tension ratio in case of flat belt drive?

or Derive the length of open belt drive?

Q.4. What do you understand by 'gear train'? Explain with a neat diagram the following:

(i) Compound gear train.

(ii) Epicyclic gear train.

Q.5. What is the use of a governor? Explain with the help of neat sketch the working of Porter governor & Hartnell governor.

Q.6. What do you mean by 'balancing of rotating masses? Explane the method of balancing several masses rotating in the same plane.

Q.
7(a) what do you mean by:-
(i) free & force vibrations
(ii) undamped & damped vibrations.
(b) what do you mean by damping ? explain the following
(i) viscous damping
(ii) Eddy current damping
Q.
8. write short note on the following:-
(i) Limiting angle of traction.
(ii) slip in belts.
(iii) comparison between flywheel & governor.

SET. 2

1(a) what is a kinematic chain ?
(b) what is the different between lower pair & higher pair ? Explain briefly different types of lower pair.
(c) what is four bar mechanism ? state & explain different inversion of four bar mechanism.

2(a) what is a Bearing ?
(b) state the classification of bearings. with net sketch of Ball bearing.
(c) Derive the torque transmitted in pivot bearing considering the uniform wear.

3.
(a) what do you mean by absorption type dynamometers.
(b) Derive the length of open belt drive.
(c) A shaft has number of collars integral with it. The external diameter is 400 mm & shaft diameter 250 mm. If the intensity of pressure is 0.35 N/mm². & coefficient of pressure friction is 0.05. Estimate
(1) power absorve on the shaft runs 150 rpm carrying a load 150 kN.
(2) No. of collars

(4)
(a) What is a gear train?
(b) with neat sketch define pitch circle, circular pitch.

(5)
(a) State the function of flywheel.
(b) with neat sketch explain the working of porter governor.

(6)
(a) what is the difference between static & dynamic balancing?
(b) Explain briefly natural, forced & damped vibration.
(c) Describe the method of balancing of several masses rotating different planes.

7.
(a) state the function of each of followem.

(b) Explain the working principle of a bicycle gear box

(c) Function of governor? Explain the term sensitivity, stability & isochronisms of a governor.

——— X ———