LECTURE NOTES
ON
THEORY OF MECHANICS
4TH SEMESTER,

(MECHANICAL ENGINEERING)

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CHAPTER - 1

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 between them.
(iii) A machine receives some energy & convert it into some useful work. A machine is anything that is use to do some useful work by resiving some work.

Machine

(i) Parts of the machine having relative motion between them.
(ii) Parts are known as kinematic link.
(iii) Parts are always in motion.

structure

(i) Parts of the structure don't having any motion between them.
(ii) Parts are also known as link.

rigid body

(i) The body which doesn't deform by applying force, this known as rigid body.
(ii) In actual & in practical 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. Incompletly "
iii. Sucessfully "

Types of Kinematic Pairs

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

According to the point of contact

① Lowers pair (surface contact)
② Higher pair (point line contact)

Lowers pair

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

According to the connection:-

① Self closed
② Force closed

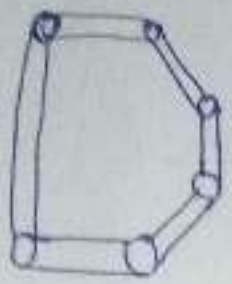
① **Self closed**

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

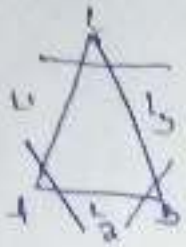
② **Forced closed**

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

Kinematic chain



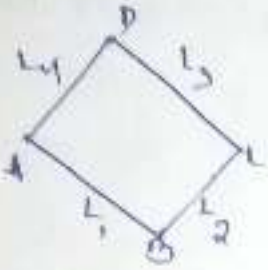
LHS < RHS an constrained kinematic chain
LHS = RHS (constraind kinematic chain)
LHS > RHS (locked chain)



link = 3
joint = 3
pair = 3

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

$P = \frac{3}{2} l - 2$
$3 = \frac{3}{2} \times 3 - 2$
$3 = 4.5 - 2$
$3 = 2.5$
$3 > 2.5$
LHS > RHS.



L = 4
J = 4
P = 4

$l = 2P - 4$
$\Rightarrow 4 = 2 \times 4 - 4$
$\Rightarrow 4 = 8 - 4$
$\Rightarrow 4 = 4$ LHS = RHS

Compound kinematic chain

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

Types of joint

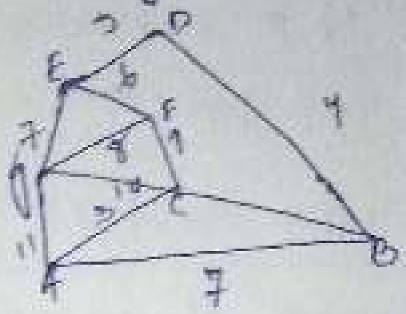
(1) Binary joint
(2) quarternary joint
(3) Ternary joint

Binary joint

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

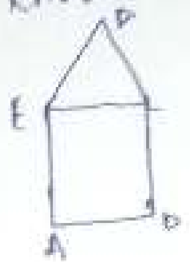
(2) Quanternary Joint

(i) When 4 links are joint at the same connection the joint is called quanternary joint.



(3) Ternary Joint

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



$P = 9$

$L = 6$

$J = 5$

$L = 2P - 4$

$6 = 2 \times 9 - 4$

$6 = 14$

$6 < 14$

$J = \frac{3}{2} L - 2$

$7 = \frac{3}{2} \times 6 - 2$

$7 = 7$

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 mechanism with more then 4 link called compound mechanism.

Degree of Freedom

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

Grubler's criterion for plane mechanism

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

$n_0 = 0$, $n = 1$

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

$l = 3l - 3 - 2j$

$= \boxed{2l - 2j - 4 = 0}$

Inversion

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

Types of kinematic chain

Four bar chain or quadratic chain

(i) single slider crank chain

(ii) 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.

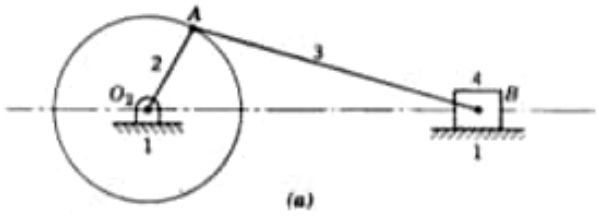
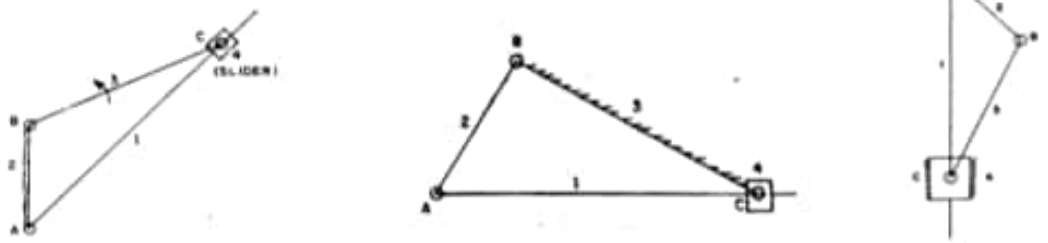


Fig1.27

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*.

① Screw Friction

Screw is a fastening that have thread which have made by cutting a countinues helical grew on a cylindrical surface.

② EX :- V-thread, Square thread etc.

Types of thread

① External
② Internal

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

EX: bolt.

Internal

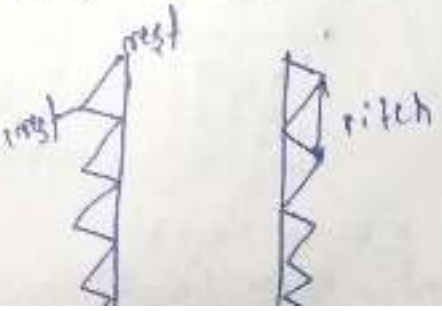
① The threads are cut on the internal surface then it is called internal thread.

② 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 beetw one point of a screw to the adjacent next point



(3) Lead

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

(4) Depth of thread

The distance between crest & rest is called dof.

(5) Single thread screw

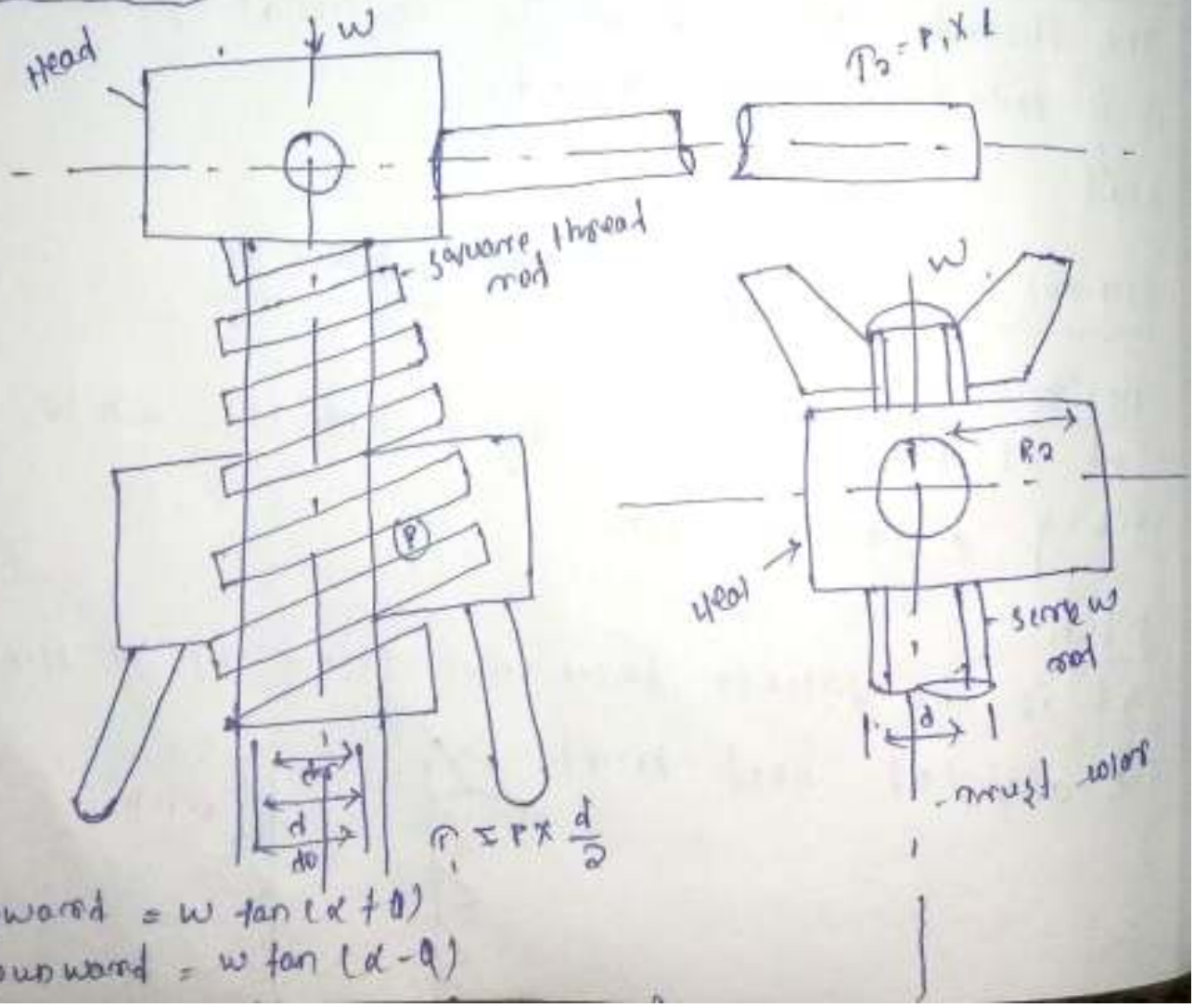
If the lead of the screw is equal to it's pitch it is known as single thread screw.

(6) Helix Angel

It is the slope of the thread the horizontal

pitch tan α = $\frac{l}{\pi d}$

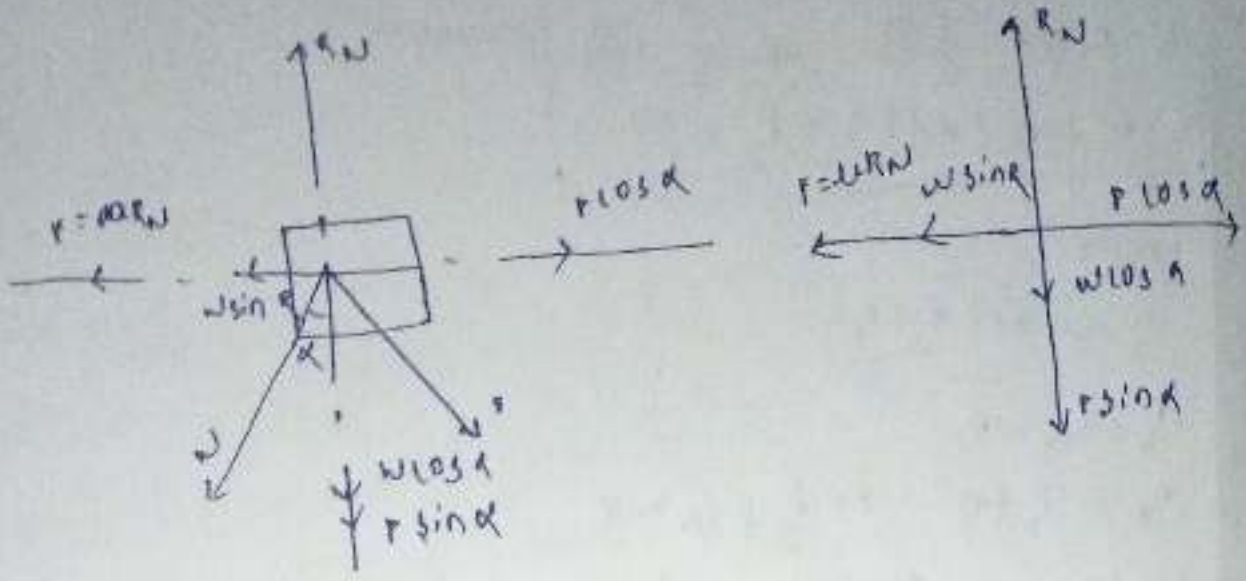
Screw Jack



upward = W tan (α + θ)

downward = W tan (α - θ)

free body digram



$\Sigma V = 0$

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

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

$\Sigma H = 0$

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

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

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

put the value of R_N in eqn (ii)

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

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

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

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

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

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

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

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

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

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

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

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

torque

Colars

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

$T_3 = \mu_1 WR$

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

$= W \tan(\alpha + \theta) + \mu_1 WR$

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

Mechanical Advantages

$$M.A = \frac{W}{P_1} = \frac{W}{\frac{Pd}{2L}} = \frac{W 2L}{Pd} = \frac{2LW}{W \tan(\alpha+\theta) \times d} = \boxed{\frac{2L}{\tan(\alpha+\theta) \times d}}$$

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

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

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

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

(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/minute. The square have single thread of 6mm pitch on a measure diameter of 40mm. The coefficient of friction screw thread is 0.1. Estimate the power of motor

given

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

pitch = 6 mm

$d_0 = 40$ mm

$\mu = 0.1$

$v = 300$ mm/min

$d_m = d_0 \cdot \frac{1}{2}$

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

$\Rightarrow \tan\alpha = 0.0516$

$\tan\phi = \mu = 0.1$

we know $P = W \tan(\alpha + \phi)$

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

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

$= 11428.97$

$= 11.428 \times 10^3\,N$

Power = torque × angular velocity

$P = T \times \omega$

$= 211.45\,Nm \times 5.24\,rad/s$

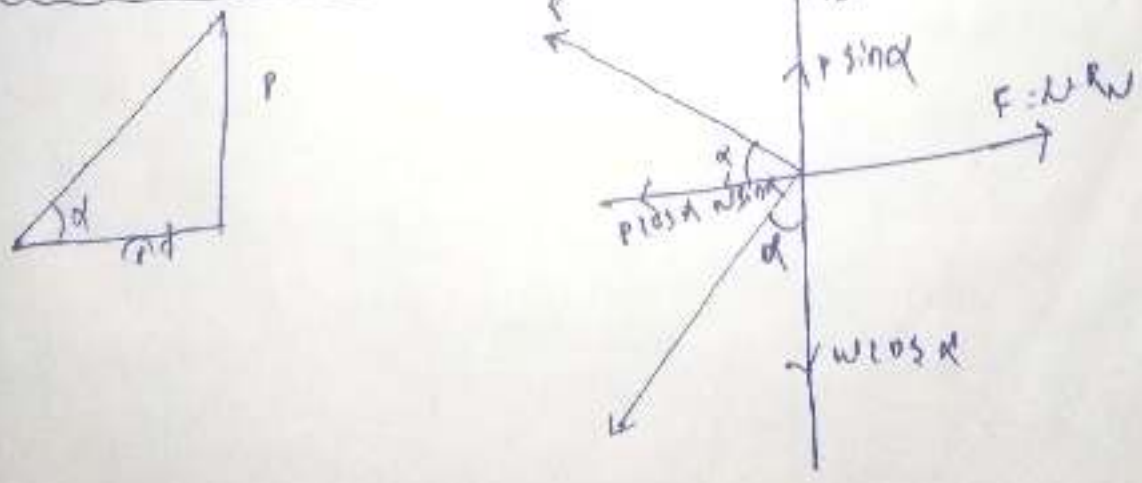
$= 1108\,W = 1.108\,kW$

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

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

$\omega = \frac{V}{p} = \frac{\text{speed of nut}}{\text{pitch}} = \frac{300}{6} = 50$

Torque required to lower the load



$\Sigma V = 0$

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

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

$\Sigma H = 0$

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

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

Putting the value of R_N in eqn (i)

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

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

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

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

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

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

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

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

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

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

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

when $\theta > \alpha$

Bearing

Bearing provides an effective means of supporting rotating shaft while reducing friction.

* Bearings are mechanical assembly that consist of rolling elements & usually inner & outer races which are use for rotating linear shaft applications.

(1) There are various types of bearing

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

(i) Ball bearing have spherical rolling elements & are use for lower load application while roller bearing use cylindrical rolling elements 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 spherical elements that are captured between circulars inner & outer races. They provides a mean of supporting rotating shaft & minimising friction between shaft & stationary machine members.

(i) Ball bearing are also known as rolling element bearing or anti friction bearing.

Advantage

(i) use to support high speed shaft.
(ii) large range of standerise forms.
(iii) can handel radial & axial load with spherical contact rotation.

Roller bearing

(i) Roller bearing are mechanical assembly that consists cylindrical or tapper rolling elment 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 requried the support of heavyer load than ball bearing provides.
(iv) They are mostly preferd bore.
(v) High load capacity than ball bearing.
(vi) can with stand high axial load.

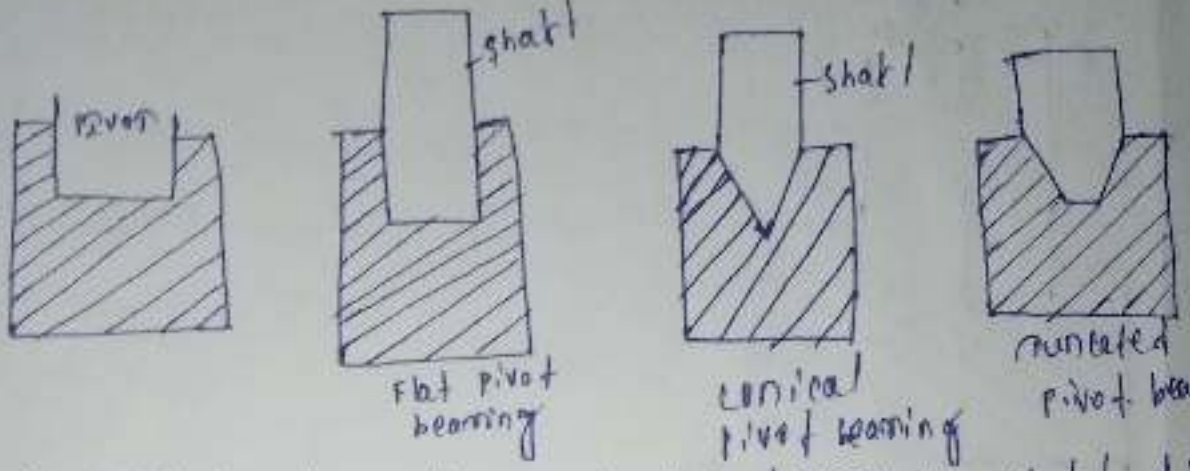
Friction in pivot & collar bearing

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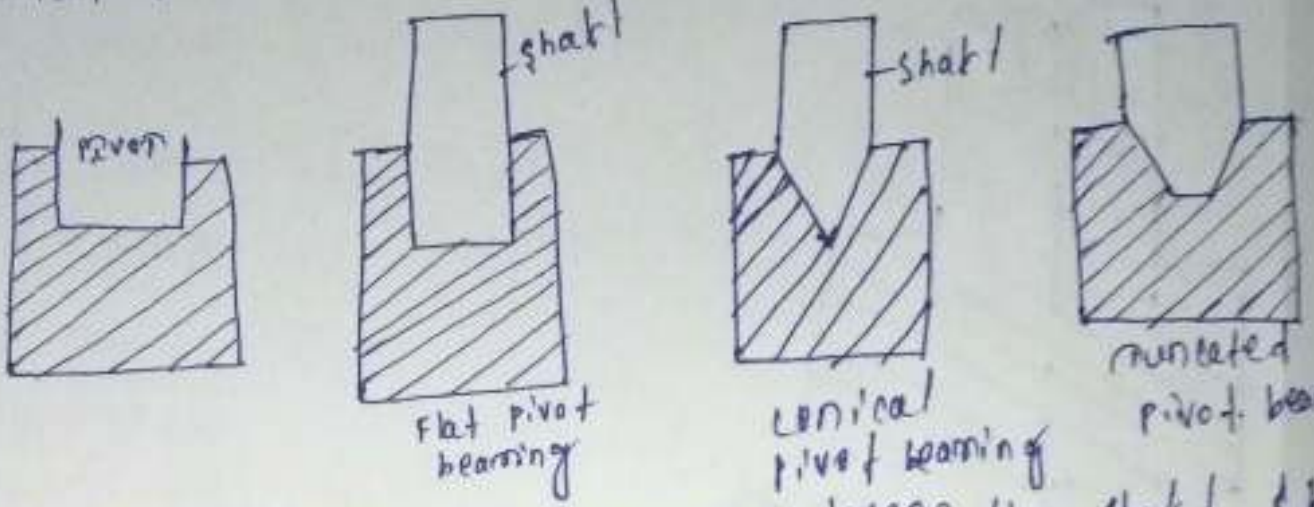

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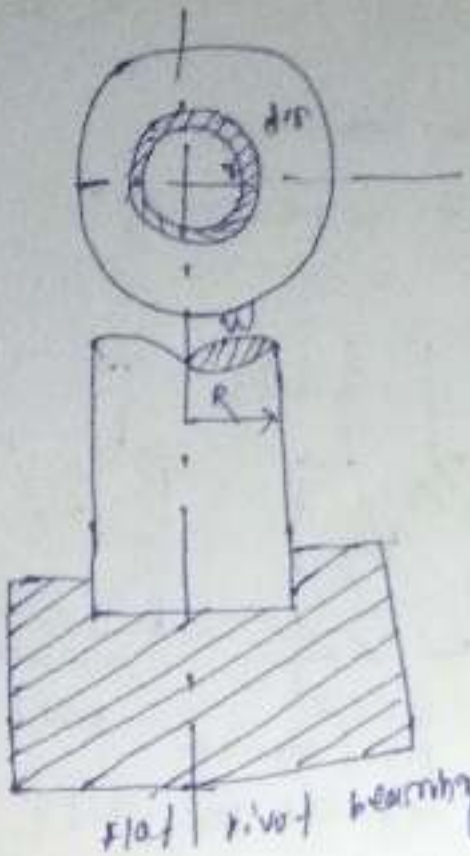


flat pivot bearing

considering uniform pressure

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

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

$$a = 2\pi r dr$$

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

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

$$F_t = F_r \times r$$
$$= 2\pi \mu p r dr \times r$$
$$= 2\pi \mu p r^2 dr$$

total friction torque generated on the bearing surface

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

(21)

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

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

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

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

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

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

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

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

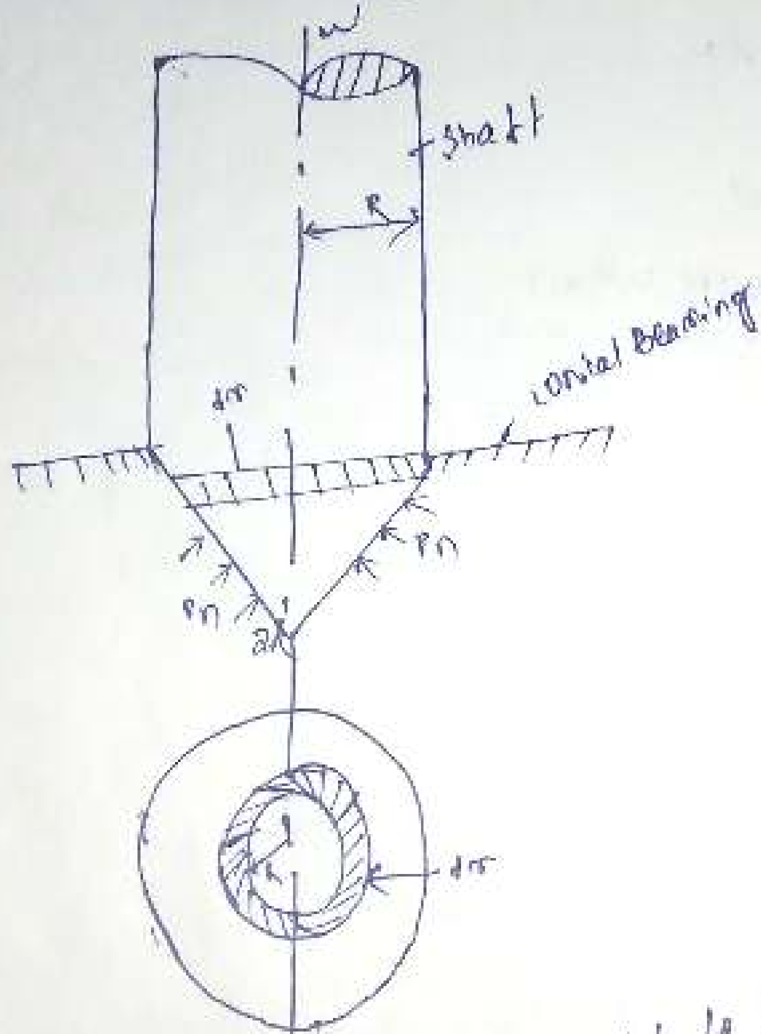
$= 2\pi\mu c \times \frac{R^2}{2}$

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

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

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

Conical pivot bearing



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

$a = 2\pi r \times dl$

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

$\delta w = p_n \times a$

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

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 $\int p_n 2\pi r\, dr$

$= p_n 2\pi \int r\, dr$

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

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

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

frictional resistance

$F_r = \mu \times \delta W$

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

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

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

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

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

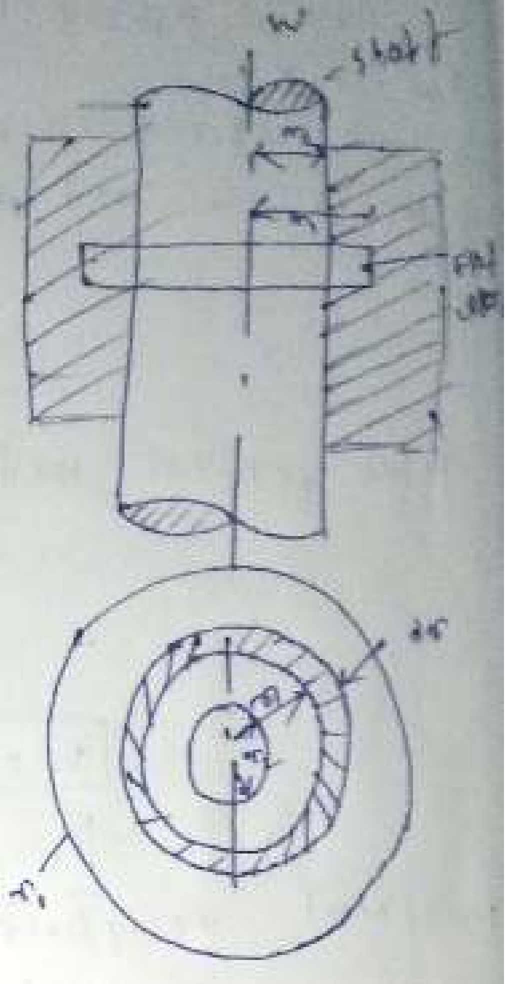
$= 2\pi \mu \times \frac{W}{\pi R^2} \times \operatorname{cosec}\alpha \times \frac{R^3}{3}$

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

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

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

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

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

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

$= 2\pi C\, dr$

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

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

$$T_R = 2\pi r \cdot r\,dr$$

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

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

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

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

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

MULTIPLE COLLAR BEARING

(Q) A shaft has a number of collars integral with 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 0.03. Find:

(1) power absorbed in the shaft runs 105 rpm carrying a load 150 KN.

(2) No. of collar.

Given

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

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

$p = 0.35\text{ N/mm}^2$

$W = 150\text{ KN}$

$\mu = 0.03$

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

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

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

$= 1240$ N.m

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

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

Friction clutch

① It is use in the transmission of power of shaft machine which must be started stopped frequently. It is also use to deliver power to the machines that is normally not fully loaded.

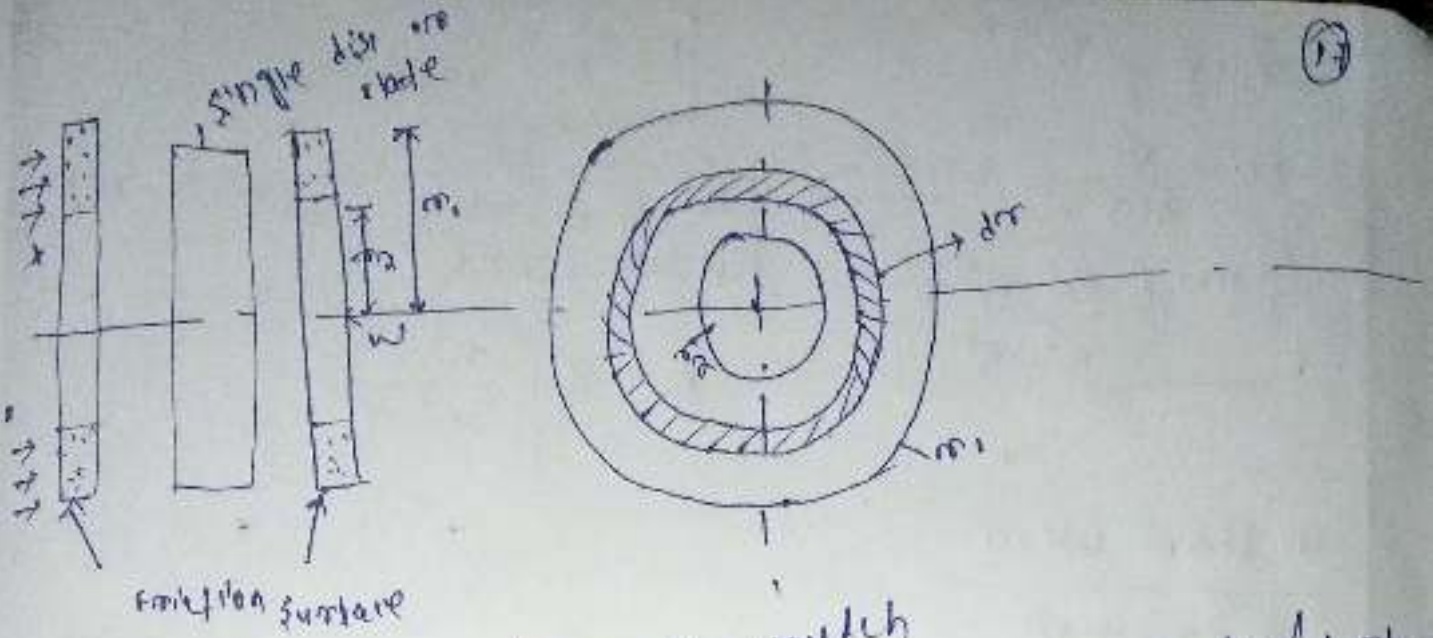
② Friction clutch is use to connect to engine to driven shaft. In operating such a clutch care should be taken so that the friction surface engage gradually bring the driven shaft upto proper speed.

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 surfaces 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 in the strip.
$f_R = \mu \delta W = \mu \times p \times 2\pi r\,dr$ → (iii)
→ Frictional torque applied on the strip
$f_T = f_R \times r = \mu p 2\pi r\,dr \times r = 2\pi\mu p r^2 dr$ → (iv)

Total torque applied on the friction surface

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

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

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

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

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

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

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

$p_r \times r = \text{const.}$

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

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

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

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

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

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

$$\therefore \boxed{\frac{1}{2} \mu w (r_1 + r_2)}$$

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

Frictional Brake

Def: 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.

(i) In this process the brake absorbed either kinematic energy of moving member or potential energy given by hoists being lowers by hoists.

(ii) The energy absorbed by brakes is dissipated in the form of heat.

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

(iv) The capacity of a brake depends upon the following factors:
(a) The unit pressure between the braking surface.
(b) Coefficient of friction.
(c) Peripheral velocity of the brake drum.
(d) Projected area of friction surface
(e) Ability or capacity of brake to dispate heat equivalent to the energy being absorbed.

Types of frictional Brake

(1) Hydraulic Brake : Ex : pumps or hydrodynamic brake / fluid agitator.

(2) Electric Brake :- Generators & Eddy current brakes.

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

* The hydraulic & electric breaks can't bring the motion to rest & are mostly use where large amount of energy are to be transfers. While the break is retarding the road such as in dynamometer, highway trucks electric locomotives.

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

Mech

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

(1) Radial Break

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

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

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

(2) Axial Break

(a) In these breaks the force acting on the breaking is in axial direction.

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

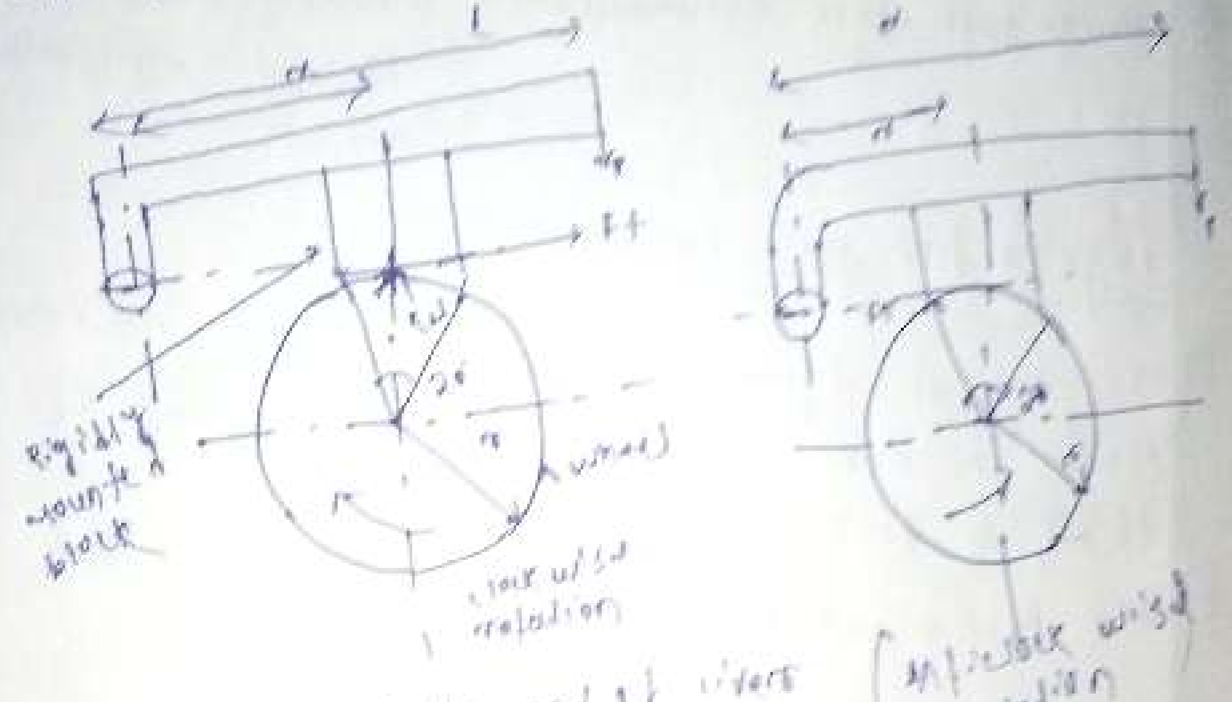
single block or shoe break

(i) It consists of a block or shoe which is pressed against the rim of the 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 wheels, and it is also used in trolley cars, tramways, etc.

(iii) The friction between the block and wheel causes a tangential braking force to act on the wheel, which retards 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

$F_r = \mu \times R_N$

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

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

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 torque, torque & power.

Types of dynamometer

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

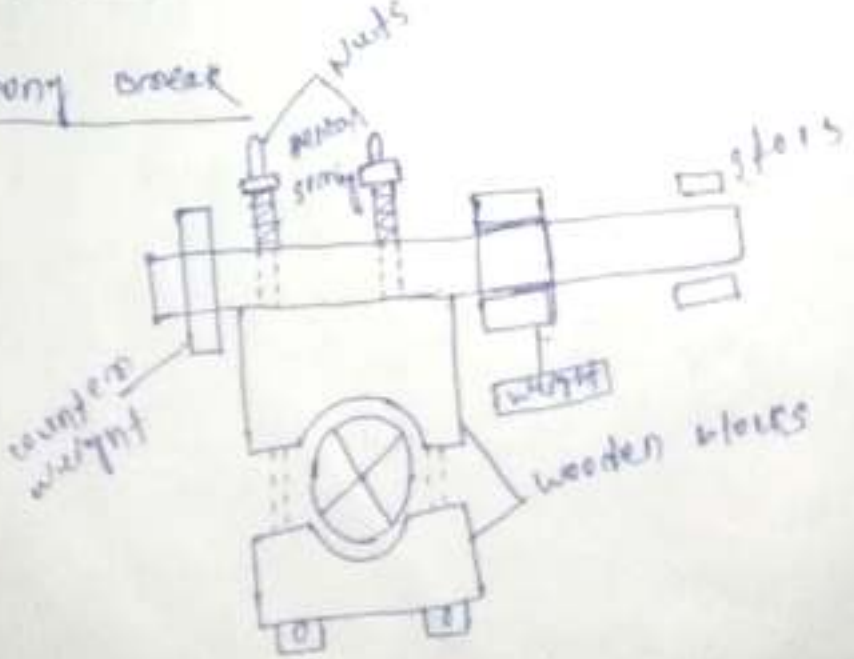
(2) Transmission type dynamometers : (i) Belt transmission dynamometer (ii) Epicyclic dynamometer (iii) Torsion "

Absorption type dynamometers

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

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

Prony break



(9) It is one of the simplest dynamometer for measuring brake powers.

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

(11) The prony break consists in a wooded block & counter weight, helical spring, stirrup

(12) It works on principle of converting power into heat by dry friction.

(13) Spring loads bolts are provided to increase friction by tiling the wooden block.

(14) Some hole of the power observed is converted into heat & hence this type of dynamometer must be pulled.

(15) Break powers = $\frac{2\pi NT}{60}$ & Torque = $\frac{\text{weight apply (w)}}{\text{distance (L)}}$

Rope break dynamometer

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

(2) It consists of some turns of rope lone around the rotating drum attached to the output shaft. one side of the rope is connected to a spring balance & the other side to a loading side the power is absorbed in friction between rope & the drum. therefore drum in rope break dynamometer required is rolling.

(14) Rope break dynamometers are cheap & can be constructed quickly, but break power can't be measured accurately because of change in friction co-efficient of rope change temp^ure.

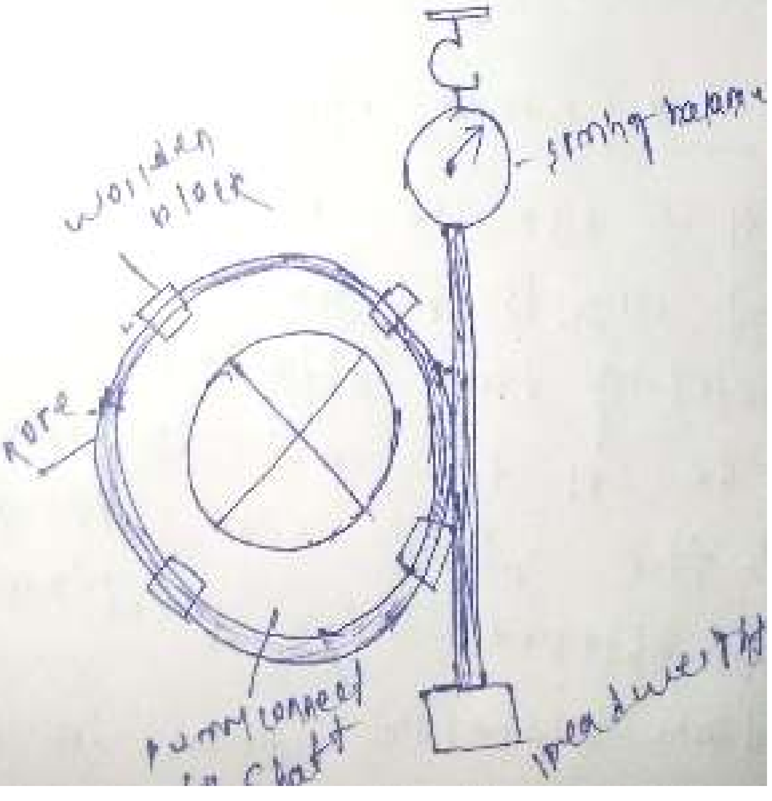
$$F_n = W - S\left(\frac{D + d}{2}\right)$$

Parts of rope break dynamometers

1. Rope :- made of synthetic fibers
2. Pulley :- 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

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



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

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

(12) The grading of rope is done by 3-4 v shape wooden block, which also prevent rope from sleeping of pully.

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

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

(15) The rope break dynamometer is frequently used to test the powers of engine. It is easy to man lacture & required no lubricant.

(16) If the rope is warapped several times over the wheel the tension of the slag side of the rope can be reduce to be a negligible 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:

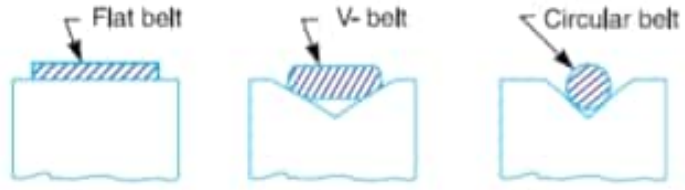
1. Speed of the driving and driven shafts,
2. Speed reduction ratio,
3. Power to be transmitted,
4. Centre distance between the shafts,
5. Positive drive requirements,
6. Shafts layout,
7. Space available, and
8. Service conditions.

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.

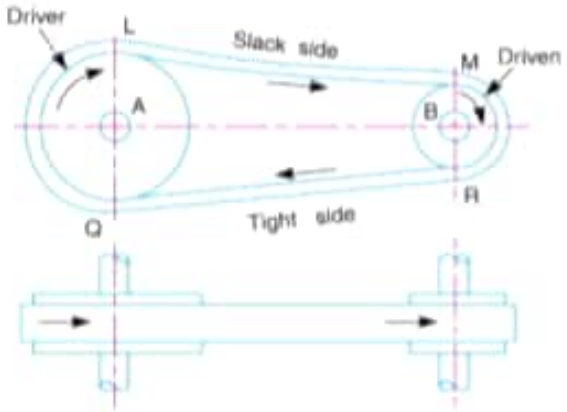
3. *Circular belt or rope*. The circular belt or rope, as shown in Fig. (*c*), is mostly u. the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 8 meters apart.

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:

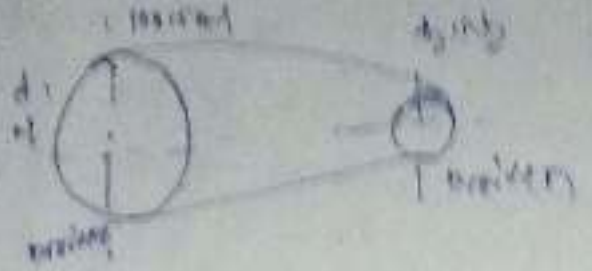
1. *Open belt drive*. The open belt drive, as shown in Fig. 11.3, is used with shafts arranged parallel and rotating in the same direction. In this case, the driver *A* pulls the belt from one side (*i.e.* lower side *RQ*) and delivers it to the other side (*i.e.* upper side *LM*). Thus the tension in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



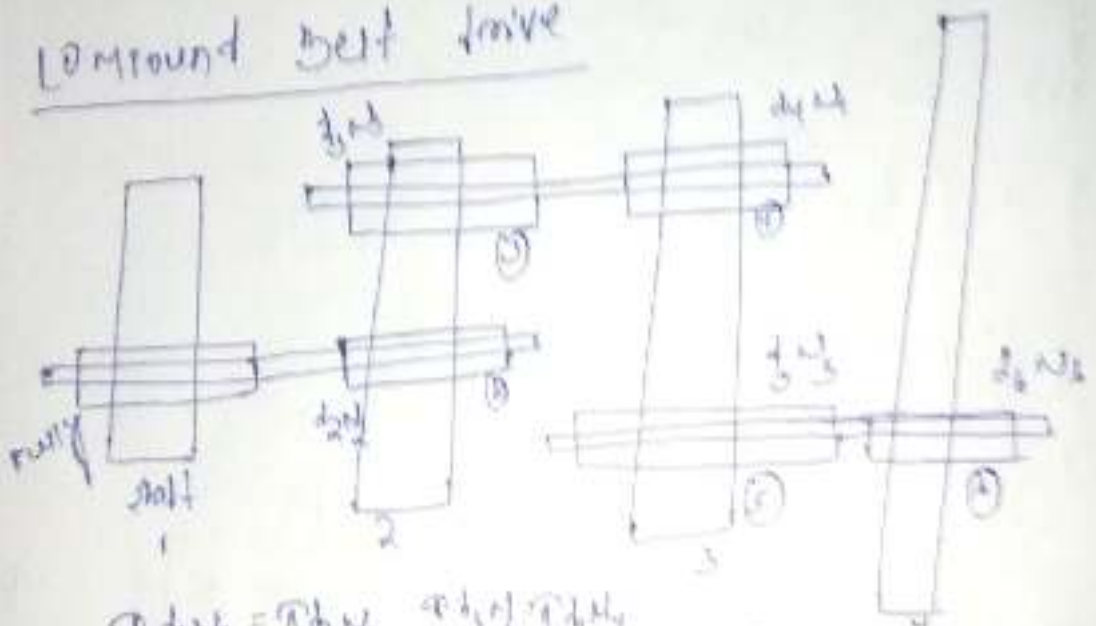
$d_1 < d_2$

velocity of belt of driver = velocity of belt of driven

$$\pi d_1 N_1 = \pi d_2 N_2$$

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

Compound belt drive



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

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

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

Slip of the belt

Slip

Due to insufficient frictional grip there is some forward motion of driven 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 → Driven

S_1 % S_2 %

$$\frac{\pi d_1 N_1}{60} - \frac{\pi d_1 N_1}{60} \times \frac{S_1}{100} \qquad \frac{\pi d_2 N_2}{60}$$

$$\Rightarrow \frac{\pi d_1 N_1}{60}\left(1 - \frac{S_1}{100} - \frac{S_2}{100}\right) = \frac{\pi d_2 N_2}{60}$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2}\left\{1 - \left(\frac{S_1}{100} + \frac{S_2}{100}\right)\right\}$$

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

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

Creep

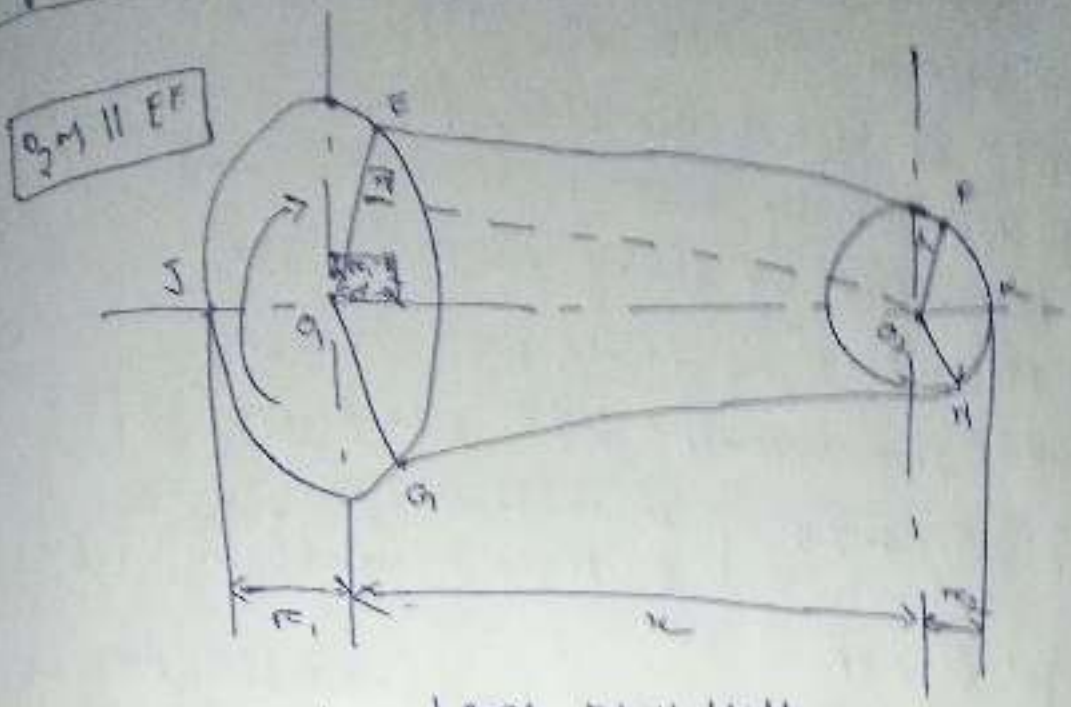
slag side

① When the belt passes from the tide side to the tide side. A certain portion of belt extent it contract again when the belt passes from tide side to slag side, due to these change of length there is a motion between 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 $\frac{N_2}{N_1} = \frac{d_1}{d_2} \times \frac{E + \sqrt{r_2}}{E + \sqrt{r_1}}$

Length of open belt drive



Arc GSE + EF + Arc FKH + HJ

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

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

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

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

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

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

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

$$= \pi(r_1+r_2) + 2\frac{(r_1-r_2)^2}{x} + 2x - \frac{(r_1-r_2)^2}{x}$$ [$\because \alpha = \frac{r_1-r_2}{x}$]

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

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

* T_1 & T_2 = tension in tide side & 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 pully $(T_1 - T_2)r_1$
* Torque transmitted by driven pully $(T_1 - T_2)r_2$
* The relation ship 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 touch over the pully so centrifugal force is caused whose effect is to increase the tension on tide as well as slag side, one 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. $T_c = mxv^2$

Gear Train

- A gear ·om one shaft to anothe Theory-of-Machines1.pdf-35.pdf 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

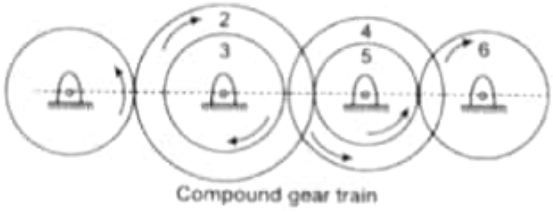
$$= \frac{1}{\text{Train value}}$$

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

(2) function of governors
(3) classification of governor
(4) working of watt, porter, proell & Hartnell governors
(5) conceptual explanation of sensitivity & stability & isochronism
(6) function of fly wheel
(7) comparison between fly wheel & governor.
(8) 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 addition to centrifugal forces on the balls.

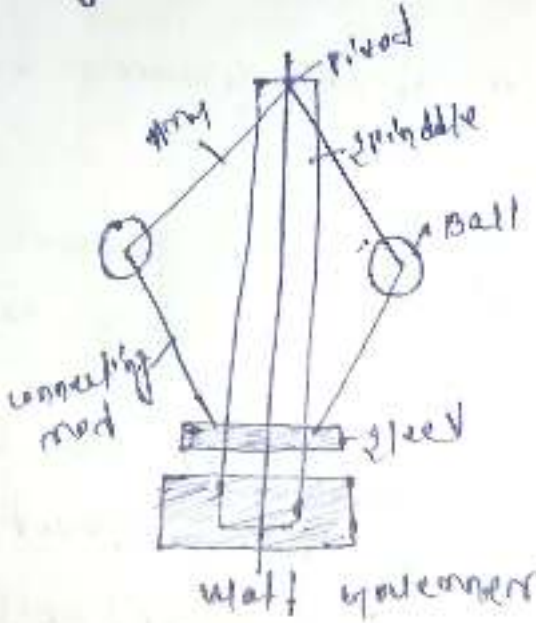
- centrifugal governer
  - pendulum type
    - watt governer
  - loaded type
    - loaded type
      - dead weight gov.
        - porter governer
        - proell governer
      - spring controlled governer

- spring controlled governor
  - Hartnell governor
  - Harduing governor
  - wilson - Hartnell governor
  - Pickering governors

Working of governer

Watt Governer

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



Watt governer is used to supply the required amount of fue 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 fed connected at the point is called fixed on the spindle & on the bottom of the spindle there is a sleeve which move up & down which the help of ball is.

(5) when the balls rotates with high speed at a fixed center of the pivot the arms get stretched & the help of connection between the ball & the sleeve gets lifted from the bottom point along the center of the spindle. on this type of governer 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 governer is not suitable to supply a proper quantity of fuel this is used at only low speeds.

Porter governer

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

working

The engine is connected to the central spindle of governer through gear trains. when the load on an engine decrease, there will be a sudden increase in speed of the engine. governer spindle speed also increases. 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 unward as ball move outward. it decreases the fuel supply. Hence speed is maintained. in case of increasing the load speed of the engine decreases.

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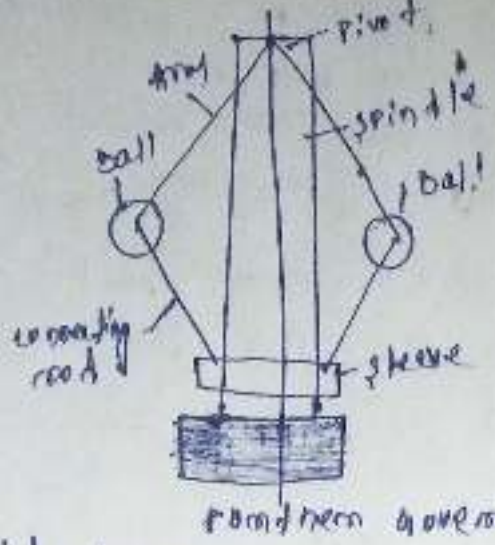
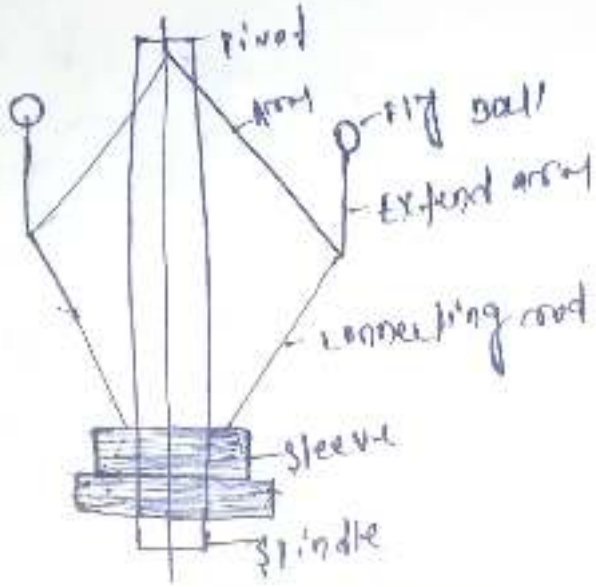


Porter governor

PROELL GOVERNER

Proell governor is a type of gravity controlled centrifug governor.



Proell governor

working

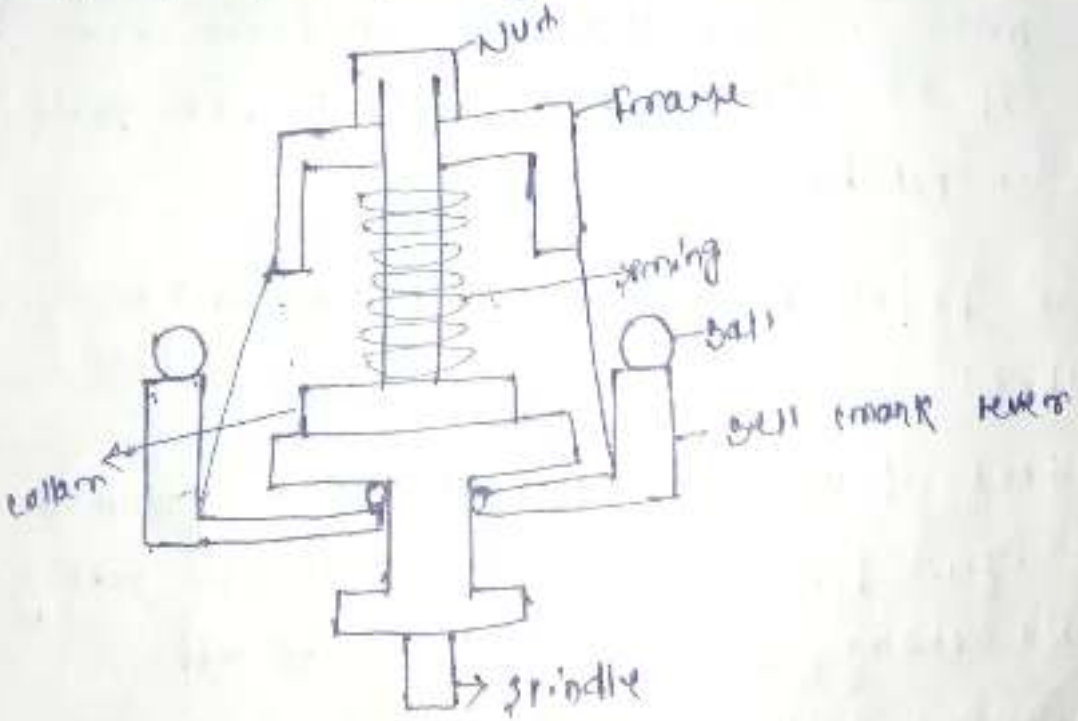
When the load on the engine decreases, the speed o engine increases suddenly & also spindle rotation spee is increased as the spindle is connected to the engine. As the rotation of spindle becomes fast, the arms pivoted to top of spindle also rotates with high speed & the balls move outward due to increased centrifugal formed 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 maintained.

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

HARTNELL GOVERNER

Hartnell governer is basically a centrifugal governer with a spring-loaded weight instead 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 fly of engines because it regu the fuel supply as per demand.

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

(iv) Fly wheel controls cyclic fluctuations in energy.

(iii) Governor has no influence in cyclic fluctuations of energy.

(iv) Governor control 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 defind as the ratio of the maximum fluctuation of energy to the workdone per cycle.

Mathematically Co-efficient of fluction of Energy

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

CHAPTER - 5

Balancing of Machine

(a) Concept of static & dynamic balancing
(b) Static balancing of rotating parts
(c) Principle of balancing of reciprocating parts.
Difference between static & dynamic balancing.

Static Balancing

(i) If the shaft carries a number of unbalanced masses such that the centre 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 balancing is a balance of forces due to action of gravity.

Dynamic Balancing

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

on 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 parts so wisely, that the unbalance is is reduced upto 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. Others examples are grindstones discs or car wheel.

Difference between static & dynamic Balancing?

Static balancing	Dynamic balancing
(i) Static balance returns to the ability of a stationary an 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 doesn't exist any resultant centrifugal force as well as resultant couple.

SET-1

QUESTIONS

Q1. (a) what do you understand by 'Lower pair' & Higher pair?
(b) difference between structure & Machine.
(c) Discuss Binary, Ternary & quaternary link with sketches.

Q2. what are the various type of bearings? Derive an expression for the frictional torque of a flat pivot bearing by taking into consideration:
(a) uniform pressure theory.
(b) uniform wear theory.

Q3. derive an expression for limiting tension ratio in case of flat belt drive?
OR derive the length of open belt drive?

Q4. what do you understand by 'gear train'? Explain with a neat diagram the following:
(a) Compound gear train.
(b) Epicyclic gear train.

Q5. what is the use of a governor? Explain with the help of neat sketch the working of Porter governor & Hartnell governor.

Q6. what do you mean by 'balancing of rotating Masses'? Explain the method of balancing several Masses rotating in the same plane.

8.
7. (a) what do you mean by :
(i) free & forced vibrations
(ii) undamped & damped vibrations.
(b) what do you mean by damping ? Explain the following
(i) viscous damping
(ii) Eddy current damping

8. (a) write short note on the following :
(i) Limiting angle of friction.
(ii) slip in belts.
(iii) comparison between flywheel & governors.

SET-2

1. (a) what is a kinematic chain ?
(b) what is the different between lowers pairs & higher pair ? Explain briefly different types of lowers 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 neat 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 dynamometer?
(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 absorbed 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.

Scanned with CamScanner

7.
(a) state the function of cam & followers.
(b) Explain the working principle of bicycle gear to
(c) Function of governor? Explain the term sensi
stability & isochronisms of a governor.

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