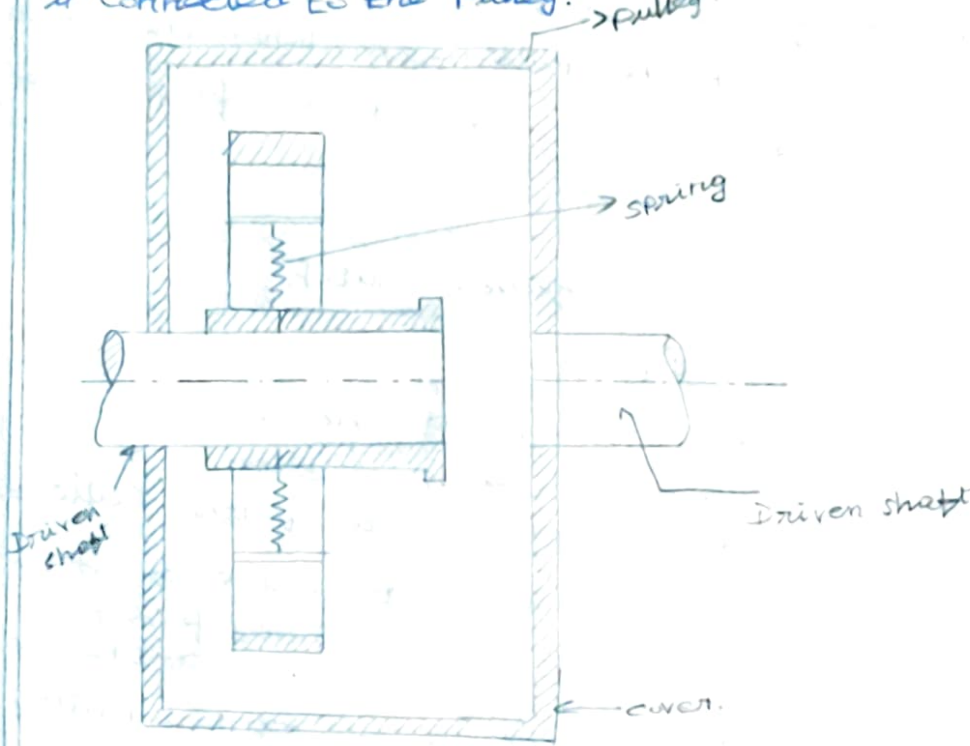
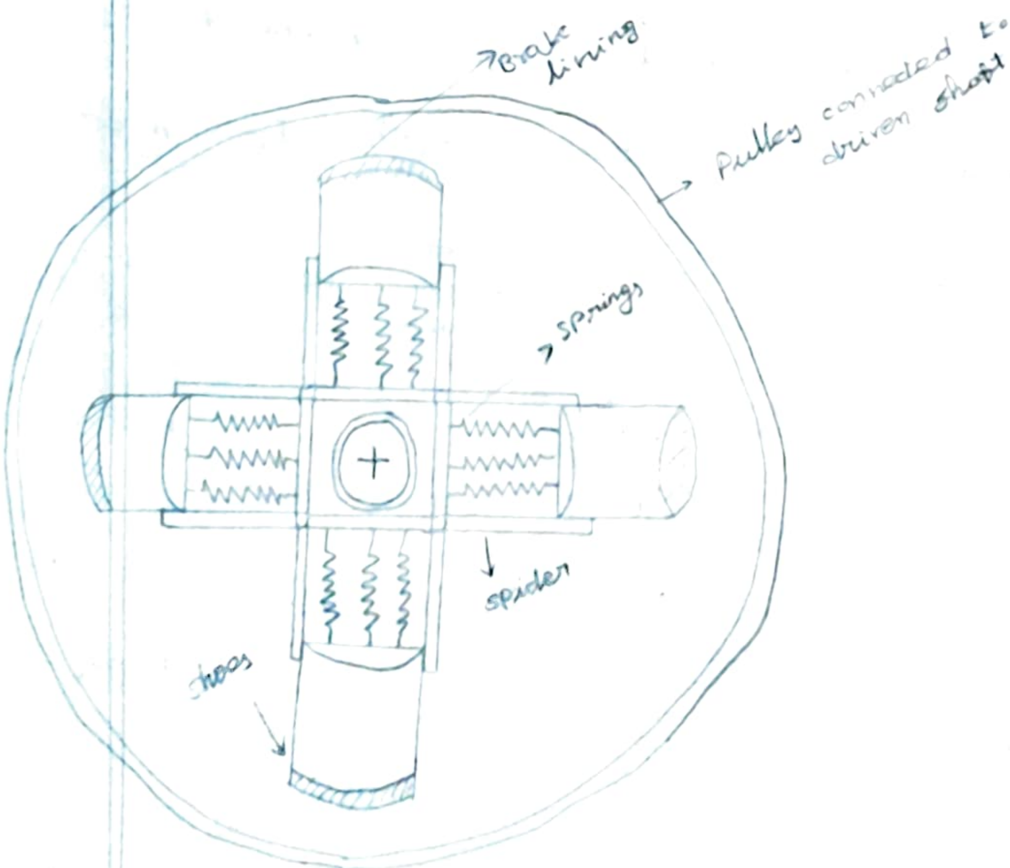
Centrifugal clutch:

Centrifugal clutch is being increasingly used in automobile and Machines. obviously, it works on the Principle of centrifugal force. The driving shaft carries the spider, shoes and springs while the driven shaft is connected to the Pulley.





The shoes are mounted radially and spring them away from inner rim of the pulley. have some mass. As the speed of the driving shaft rises, the centrifugal force on the shoes increases causing them to move radially outward within the guides provided.

When centrifugal force is less than the spring force, brake lining cannot make any contact with the pulley rim. When the centrifugal force just exceeds the spring force. It to transmit the Torque.

Design of a centrifugal clutch:-

1) Mass of the shoes:

Let n = Number of shoes.
m = Mass of each shoe.
R = Inside radius of the pulley rim.
r => Distance of centre of gravity of the shoes from the centre of the spider.

N => Running speed of the pulley.
ω => Angular speed of the pulley $= \frac{2\pi N}{60}$

Centrifugal force acting on each side $F_c = m\omega^2 r$.

Spring force exerted by each spring on the shoe $F_s = m\omega_1^2 r$.

Net outward force on the shoe $= F_c - F_s = m\omega^2 r - m\omega_1^2 r$

Frictional force acting on each shoe $F = \mu(F_c - F_s)$.

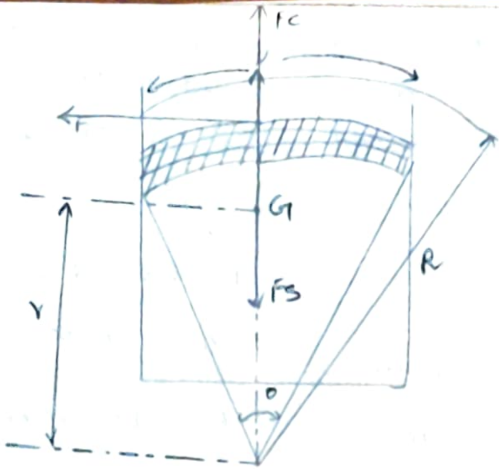
Frictional Torque acting on each shoe $T_r = F \times R$

$\Rightarrow \mu(F_c - F_s)R$

Total frictional Torque Transmitted,

$T = n \times \mu(F_c - F_s)R$

$\boxed{\Rightarrow n \cdot F \cdot R}$



Size of the shoes :-

$l =$ contact length of the shoes

$b =$ width of the shoes.

$R =$ Contact radius of the shoes.

$\theta =$ Angle subtended by the shoes at the Centre of the spider

$p =$ Intensity of Pressure exerted on the shoe

$l - R.\theta$

$A = l.b.$

Net force acting on the shoe $= \boxed{F_c - F_s = A \times P =} \boxed{l.b.P.}$

From the expression, the width of the shoes (b) can be obtained.

Que A Centrifugal friction clutch has a driving member consisting of a spider carrying four shoes which are kept from contact with clutch case ~~has~~ by means of flat springs until increase of centrifugal force overcomes the resistance of the springs and the Power is transmitted by friction between the shoes and the case.

Determine the necessary mass of each side shoe if 25 kW is to be transmitted at 750 rpm with engagement beginning at 75% of the running Speed.

The inside diameter of the drum is 300 mm an radial distance of the centre of gravity of shoe from the shaft axis is 125 mm. Assume μ.

Given Data:-

$n = 4;$

$P = 22.5\,kW$

$N = 750$ rpm

$N_1 = 75\%\ N$ (or) $\omega_1 = 75\%\,\omega$

$D = 300$ mm

$R = 150$ mm $= 0.15$ m

$r = 125$ mm $= 0.125$ mm

$\mu = 0.25$

To find: Mass of each shoe (m):-

Solution:-

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 750}{60} = 78.54 \text{ rad/s}$$

$$\omega_1 = 0.75\,\omega = 0.75 \times 78.54 = 58.91 \text{ rad/s}$$

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

$$22.5 \times 10^3 = \frac{2\pi \times 750 \times T}{60}$$

$$\Rightarrow 286.48 \text{ N-m}$$

Centrifugal force on each shoe,

$$F_c = m\omega^2 r = m(78.54)^2 \times 0.125$$

$$\Rightarrow 771.06\, m \text{ N}$$

Spring force on each shoe.., the centrifugal force at the engagement speed ω_1 is given by,

$$F_s = m(\omega_1^2)r = m\,(58.91)^2 \times 0.125$$

$$\Rightarrow 433.79\, m\text{N}$$

Frictional force on each shoe $\Big\}$ $\mu = (F_c - F_s)$

$$\rightarrow 0.25\,(771.06 - 433.79)$$

$$\boxed{\Rightarrow 84.317\, m}$$

But the Total Torque Transmitted is given by,

$$T = n \cdot F \cdot R$$

$$286.48 = 4(84.317)\,0.15$$

$$\boxed{m = 5.66\ \text{Kg}}$$

Internal Expanding RIM clutches:

As its name implies, the internal expanding rim clutch transmits Torque due to the expansion of internal rim, as shown in fig.

Three elements of internal expanding rim clutches are:-

- ✓ The Mating friction surface
- ✓ the means of Transmitting the Torque to and from the surfaces.
- ✓ The actuating Mechanism.

It is understood that the engagement (or) disengagement of external and internal rims is achieved by using a suitable actuating Mechanism. The outer dia of the internal rim is slightly lesser than the inner dia of the external rim. As the internal rim rotates, it expands. The actuating force is controlled by a suitable actuating Mechanism. Because of this expansion of internal rim, it is engaged with external rim

For the disengagement of the two rims, the actuating force is applied on the internal rim in the opposite direction. As the internal rim contracts, it automatically disengages from external rim.

Types of internal expanding rim clutches:

- ✓ Expanding-ring Clutch
- ✓ centrifugal clutch.

iii) Magnetic clutch

iv) Hydraulic and Pneumatic clutches.

External contracting RIM clutches:-

The construction, arrangement and working of external contracting rim clutches are similar to the internal expanding rim clutchs except that the actuating force is provided by the contracting external rim instead of expanding internal rim.

An external contracting clutch that is engaged by expanding the flexible tube with compressed air.

It also consists of three elements: the mating frictional surface, the means of transmitting the Torque to and from the surfaces, and the actuating Mechanism.

Classification of Actuating Mechanisms:-

- ✓ Solenoids
- ✓ Levers, linkages, toggle devices
- ✓ Linkages with spring loading.
- ✓ Hydraulic and Pneumatic devices.

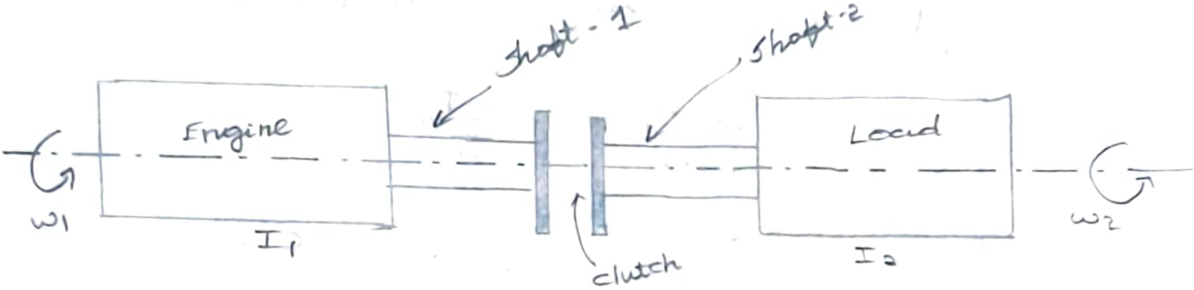
Working:-

→ It is understood that the external rim is rigidly bolted with the outer casing whenever the compressed air is fed into the flexible tube, the external rim contracts. This contraction of external rim provides the required clamping force.

Thus the driving and driven members are engaged. In order to disengage these members, the pressure of the compressed air is regulated by a suitable control mechanism.

Derivation of Energy Equation:

The operation of a simple clutch is depicted as a Mechanical Model of a Two-inertia system.



Let I_1 and ω_1 = Moment of inertia and angular velocity of the driving Member (engine) respectively, and

I_2 and ω_2 = Moment of Inertia and Angular Velocity of the driven Member (load) respectively.

We know that when the clutch plates are brought in contact some slippage occurs between them before the speeds of driving and driven shafts become equal. The kinetic Energy will be absorbed in work by friction during the clutching operation. The design of the clutch system should be such that the Energy thus absorbed must dissipate fast so that there is not much rise in Temperature.

It is assumed that the two shafts are rigid and that the clutch Torque is constant. Due to clutching operation, the shaft 1 is decelerated and its equation of Motion will be

$$I_1 \cdot \frac{d^2\theta}{dt^2} = -T \qquad \left[\because T = I\alpha = I\ddot{\theta}\right.$$

On the other hand, clutching will induce accelera.. in shaft e and its equation of Motion is given as,

$$I_2 \cdot \frac{d^2\theta}{dt^2} = T$$

Where θ = Angle displacement in time, 't'.

$$\frac{d^2\theta_1}{dt^2} = \frac{-T}{I_1}$$

$$\frac{d\theta_1}{dt} = \frac{-T}{I_1} \cdot t + c.$$

But at $t=0$, $\quad c = \frac{d\theta_1}{dt} = \omega_1$

$$\frac{d\theta_1}{dt} = \frac{-T}{I_1} \cdot t + \omega_1$$

$$\frac{d\theta_2}{dt} = \frac{T}{I_2} \cdot t + \omega_2.$$

The difference in velocities (i.e., relative velocity) is given by.,

$$\frac{d\theta}{dt} = \frac{d\theta_1}{dt} - \frac{d\theta_2}{dt}$$

$$\Rightarrow \left(\frac{-T}{I_1} \times t + \omega_1\right) - \left(\frac{T}{I_2} \times t + \omega_2\right)$$

$$\Rightarrow \omega_1 - \omega_2 - T\left(\frac{I_1 + I_2}{I_1 \cdot I_2}\right) t$$

Time required for complete operation (t_1): The clutching operation is completed at the instant in which the two angular velocities ω_1 and ω_2 become equal

Let $t_1 =$ Time required for the entire operation.

Then $\omega = 0$ when $\omega_1 = \omega_2$. Hence equation can be written as.,

$$t_1 = \frac{I_1 \cdot I_2 (\omega_1 - \omega_2)}{T(I_1 + I_2)}$$

The above equation shows that the time required for the engagement operation is directly proportional to the velocity differences and inversely proportional to the Torque.

Angular displacement (θ):

By integrating the equation (10.20), one can find the angular displacement θ during clutching operation over a time interval of t_1.

$$\theta = \int_0^t d\theta = \int_0^{t_1} (\omega_1 - \omega_2)\, dt - \frac{T(I_1 + I_2)}{I_1 \cdot I_2} \int_0^{t_1} t \cdot dt$$

$$\theta = (\omega_1 - \omega_2)\, t_1 - \frac{T(I_1 + I_2)}{I_1 \cdot I_2} \times \frac{t_1^2}{2}$$

Substituting the value of t_1, we get,

$$\theta = \frac{I_1 \cdot I_2 (\omega_1 - \omega_2)^2}{T(I_1 + I_2)} - \frac{T(I_1 + I_2)}{2 I_1 I_2} \times \frac{(I_1 I_2)^2 (\omega_1 - \omega_2)^2}{T^2 (I_1 + I_2)^2}$$

$$\theta = \frac{1}{2} \frac{I_1 \cdot I_2 (\omega_1 - \omega_2)^2}{T(I_1 + I_2)}$$

Energy dissipated during clutching operation (E):-

The work done by Torque T (or) the Energy dissipated is independent of clutch Torque but directly proportional to square of the difference of the angular velocities of driving and driven shafts at the start of clutching.