"CLUTCHES"

Clutches:- Clutch is defined as a machine element whose function is to engarage and disengage driver and driven shaft at the will without stoping the prime mover.

* clutch is used to avoid frequent stoping and starting of prime mover but driven machinary can be stop and start frequently.

Clutch	Coupling
① clutch are used to obtain temporary connection b/w driven & driver shaft	① Permanent connection
② are used in application wher driven machinary required interminant service	② Continuous service.
③ clutch are used to transmit power between two co-linear shaft only.	③ couplings are used to transfer power b/w co-linear/non-co-linear shaft.

Rigid coupling
- → Sleeve/Muff coupling
- → Flange coupling

— Oldham's

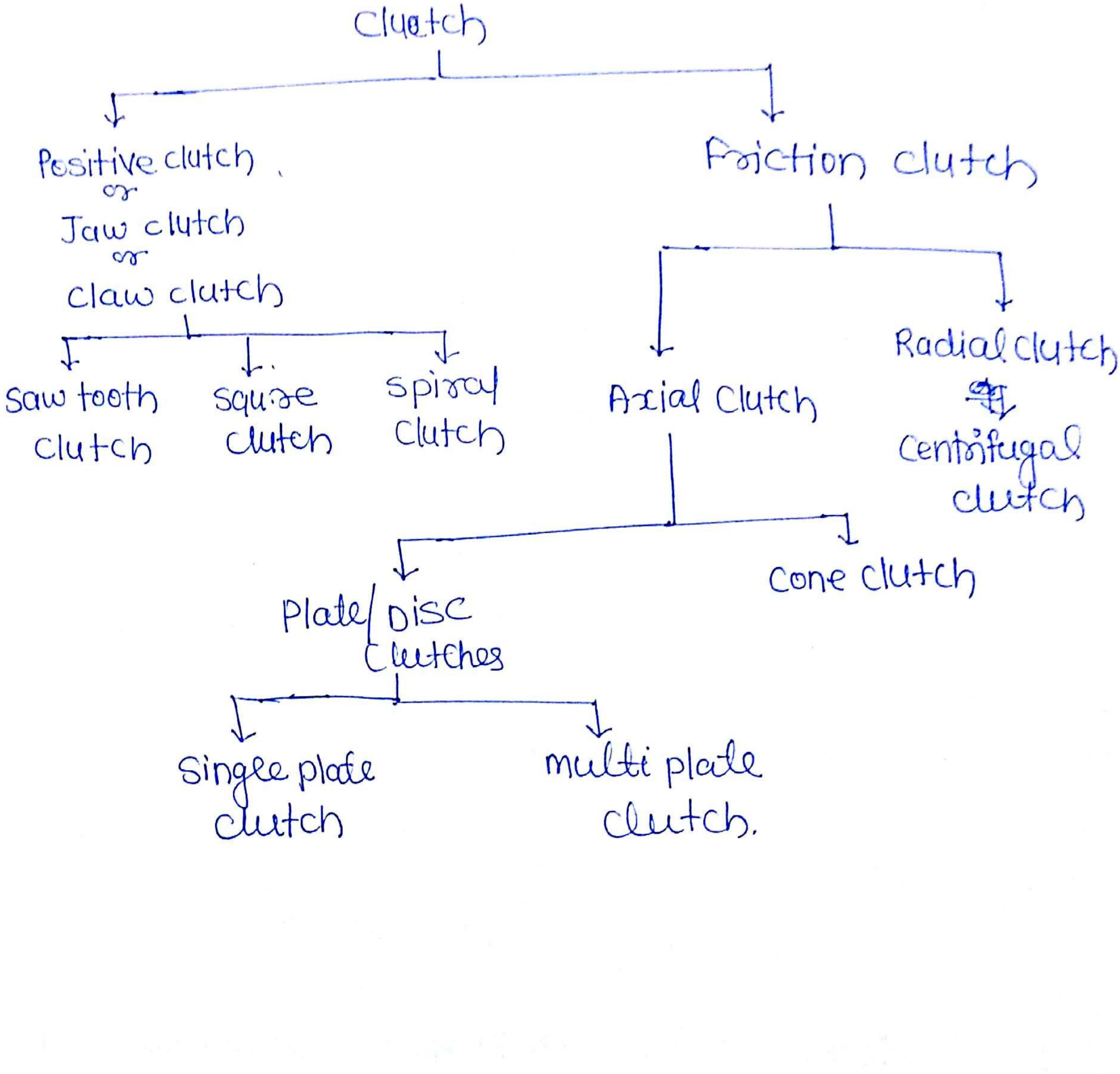
— Bush pin

Universal Hook's joint.

(4) in presence of clutches driven machinary can run at variable speed

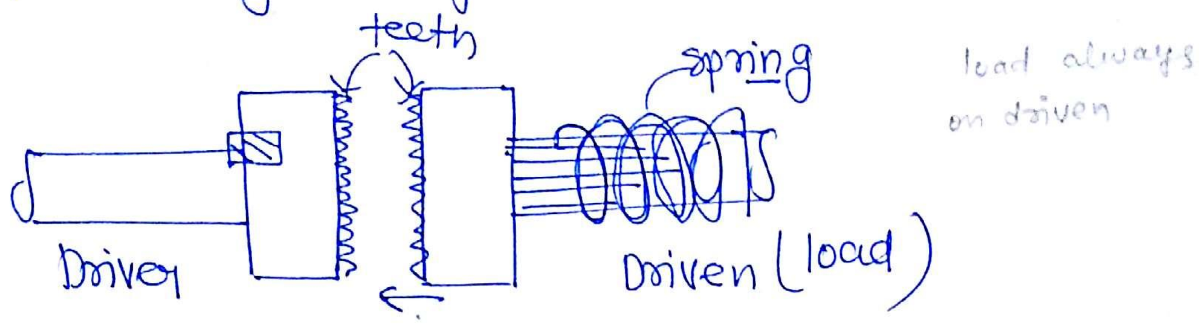
(4) driven can run only speed equal to driver.

Classification of clutches:-



Positive clutch :-

(i) These are positive drives hence no slip occurs.
(ii) sudden engage-ment hence impact and jerk.
(iii) only limited to low speed application.
(iv) clutch can not be engage when load
(v) Power transmission capacity more
eg :- Rolling ~~milling~~ mills & power presses.



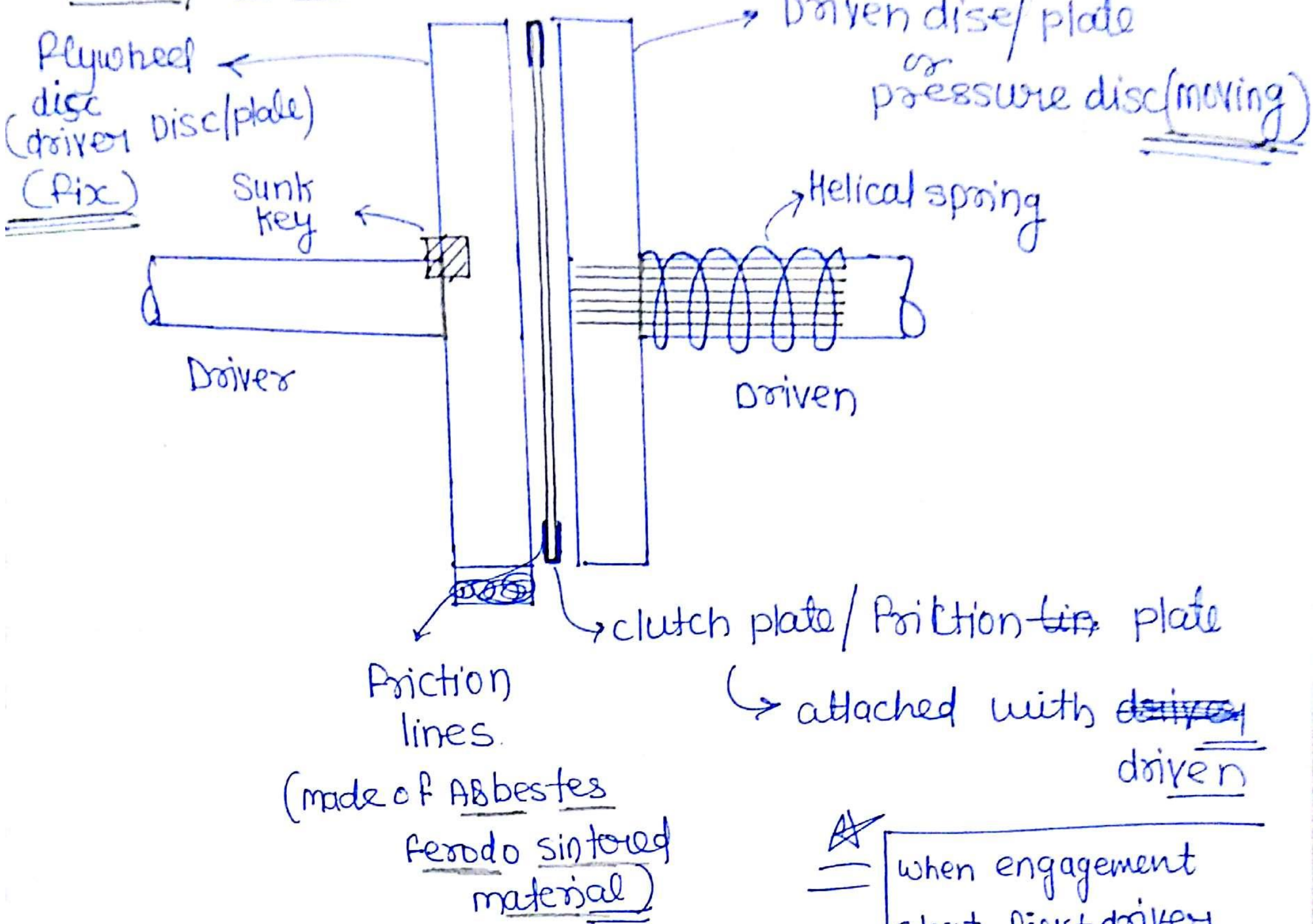
Friction clutch :- (slip)

(i) These are slack drives.
(ii) Hence slip occur. Gradual engagement.
(iii) can be used for high speed application
(iv) can be engaged when loaded.
(v) power transmission capacity is less.

Axial clutch :- force apply for engagement in an axial direction.

Radial clutch :- Force apply for engagement in radial dir^n.

Plate/ Disc clutch :-



when engagement start first driver speed ↓ and driven speed ↑ gradually and after some time both speed same

ω_1 = angular speed of driver.

ω_2 = angular speed of driven.

θ_1 = angular displacement of driver

θ_2 = angular displacement of driven

α_1 = angular acc^n of driver

α_2 = angular acc^n of driven

I_1 = M.O.I. of driver

I_2 = M.O.I. of driven

T_1 = Torque to be transmitted by driver

T_2 = torque on driven shaft

driver ⇒

$$T_1 = -I_1 \alpha_1 \quad (\text{deacc}^n)$$

$$\alpha_1 = -\frac{T_1}{I_1}$$

$$\frac{d^2\theta_1}{dt^2} = -\frac{T_1}{I_1}$$

$$\frac{d\theta_1}{dt} = -\frac{T_1}{I_1} t + c$$

↳ angular speed of driver at any time

at $t = 0 \Rightarrow \frac{d\theta_1}{dt_1} = \omega_1$

$$c = \omega_1$$

$$\frac{d\theta_1}{dt} = -\frac{T_1}{I_1} t + \omega_1 \quad \text{—(1)}$$

driven

$$T_2 = +I_2 \alpha_2 \quad (\text{accelarating})$$

$$\frac{d^2\theta_2}{dt^2} = \frac{T_2}{I_2}$$

$$\frac{d\theta_2}{dt} = \frac{T_2}{I_2} t + c'$$

when $t = 0 \Rightarrow \frac{d\theta_2}{dt} = \omega_2$

$$\frac{d\theta_2}{dt} = \frac{T_2}{I_2} t + \omega_2$$

↳ Angular speed of driven at any time

Now when both speed same

$$\frac{d\theta_1}{dt} = \frac{d\theta_2}{dt} \Rightarrow -\frac{T_1}{I_1} t + \omega_1 = \frac{T_2}{I_2} t + \omega_2$$

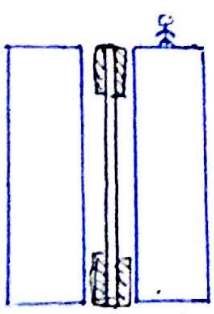
$$\boxed{t = \frac{\omega_1 - \omega_2}{\left(\frac{T_1}{I_1} + \frac{T_2}{I_2}\right)}}$$

t = engagement complition time or slip time or driver speed atain by driven in time

if $T_1 = T_2 = T$

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

Energy loss :- जब तक slip होगी



$$\omega_{slip} = \frac{d\theta_1}{dt} - \frac{d\theta_2}{dt}$$

$$\omega_{slip} = \left[-\frac{T}{I_1} t + \omega_1 - \frac{T}{I_2} t - \omega_2\right]$$

T = torque.

rate of energy loss (u) =

$$T.\omega_{slip} = T\left[\frac{-T}{I_1}t + \omega_1 - \frac{T}{I_2}t - \omega_2\right]$$

$$\int_0^E dE = \int_0^t u.dt$$

$$E_{loss} = \int_0^t T\left[-\frac{T}{I_1}t + \omega_1 - \frac{T}{I_2}t - \omega_2\right] dt$$

Que:- A single plate clutch is design to transmitt

IES 2015 10 KW power at 2000 rpm. The equivlent mass and radius of Gyration of the input shaft are 20kg and 75 mm repectively. The equivalent mass and radius for output shaft is 35 kg & 125 mm. ~~reps~~ Calculate the time require to bring output shaft to the rated speed from rest. Also find out the energy losses during slip time.

Soln

$$P = T\omega$$

$$10\times10^3 = T \times \frac{2000\times2\pi}{60} \Rightarrow T = \frac{300}{2\pi}\ Nm$$

$T = 300$ Nm

ω_1 = given

$\omega_2 = 0$ at Starting

$$t = \frac{\omega_1 - \omega_2}{\frac{T_1}{I_1} + \frac{T_2}{I_2}}$$

$$t = \frac{2\pi \times 2000\,(20 \times 75^2 \times 35 \times 125^2) \times 10^{-6}}{\frac{300}{2\pi}(20 \times 75^2 + 35 \times 125^2) \times 60}$$

$t = 0.409$ sec.

$$\Rightarrow \quad \omega_1 = \frac{2\pi N_1}{60} = \frac{2\pi(2000)}{60} = 209.4 \text{ rad/s}$$

$\omega_2 = 0$

$I_1 = m_1 k_1^2 = 20 \times (0.075)^2 = 0.1125$ kg-m²

$I_2 = m_2 k_2^2 = 35 \times (0.125)^2 = 0.5468$ kg-m²

$P = T_1 \omega_2 \Rightarrow 10000 = T_1 \times 209.4$

$T_1 = 47.74$ N-m

$$t = \frac{(209.4 - 0)(0.1125)(0.5468)}{(0.1125 + 0.5468)\,47.74} = 0.409 \text{ Sec.}$$

$$E_{loss} = \int_0^t T\left[-\frac{T}{I_1}t + \omega_1 - \frac{T}{I_2}t - \omega_2\right] dt$$

$$E_{loss} = T\left[-\frac{Tt^2}{2I_1} + \omega_1 t - \frac{Tt^2}{2I_2}\right]_0^{0.409}$$

$$E_{loss} = 47.74\left[-\frac{47.74(0.409)^2}{2 \times 0.1125} + 209.4 \times 409 - \frac{47.74(0.409)^2}{2 \times 0.5468}\right]$$

$E_{loss} = 2.46$ J

Multiplate clutch :— Pros Pros Compact

(i) Due to more no. of frictional contact surfaces in multiplate clutches more heat Generated which required coolant therefore reduction in μ (COF) between surface hence the power transmission cap. decrease.

(ii) Hence in four wheelers where radial space is not a constraint single plate clutch preferred over multiplate clutch.

(iii) For the given power transmission capacity multiplate clutch are compact in size hence in two wheelers where radial space is a constraint multiplate clutches preferred over single plate clutch.

After engagement completed :-

Single Plate Clutch

UPT	UWT
$P = \frac{2\pi N T_f}{60}$, T_f = known	$P = \frac{2\pi N T_f}{60}$
$T_f = \frac{2}{3}\mu P_{per}\pi(R_o^3 - R_i^3)$	$T_f = \mu \pi P_{per}(R_o^2 - R_i^2)$
Axial load $= \pi(R_o^2 - R_i^2)P_{per}$	Axial load $= 2\pi R_i(R_o - R_i)P_{per}$

Multiplate clutch:-

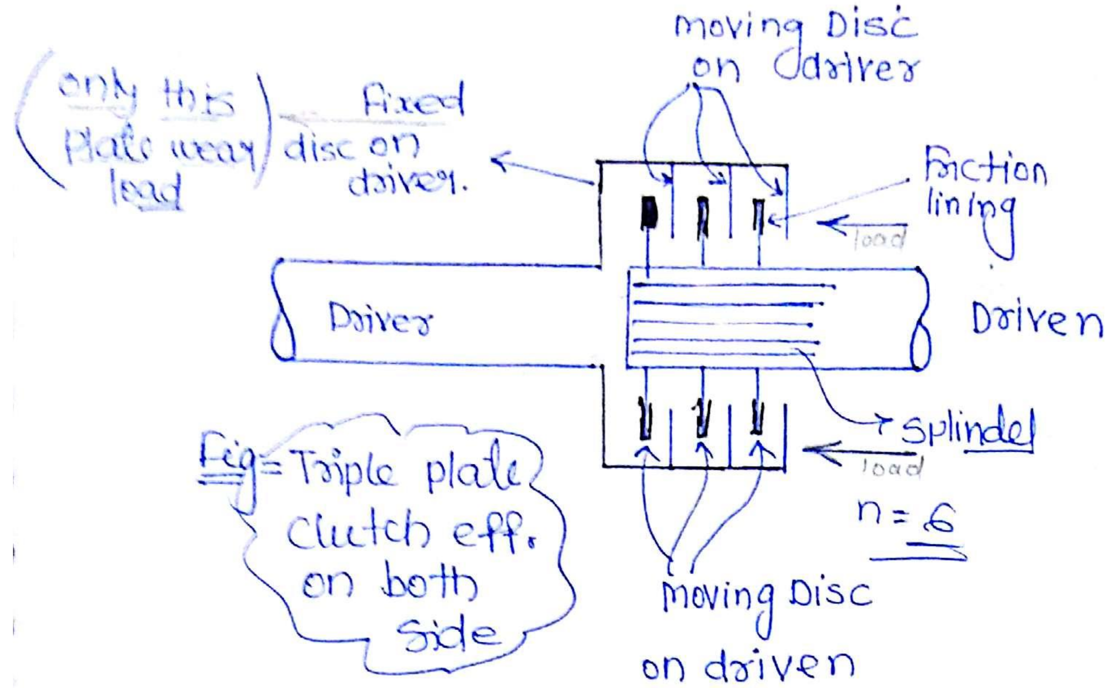
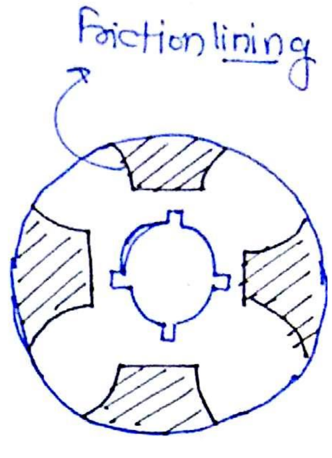
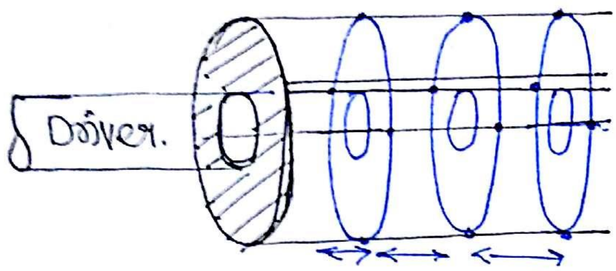
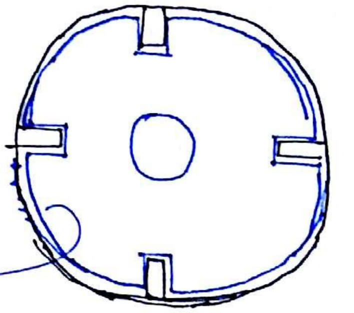


Fig = Triple plate clutch eff. on both side

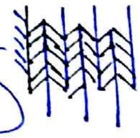


Driven disc





Axial relative motion



only this plate wear load

$n = 6$

$n_1 = 4,\ n_2 = 3$

n = Total no of friction contact surface

n_1 = no. of disc on driver.

n_2 = no. of disc on Driven

☆ $n = n_1 + n_2 - 1$ ⇒ alway even

$n_1 = n_2 + 1$

eg $n = 10.3$

$n = 11$ ✗

$n = 12$ ✓ even

$n_1 = 7,\ n_2 = 6$

eg. $n = 1$ → Single plate clutch

$n = 2$ → Single plate clutch effective on both side

$n = 4$ → Double plate clutch effectiven on both side.

Multi plate clutch

UPT

Power = known

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

T_f = known

$$T_f = n \cdot \frac{2}{3} \mu \pi P_{per} (R_o^3 - R_i^3)$$

Axial load $W = \pi (R_o^2 - R_i^2) P_{per}$.

$$T_f = n \cdot T_{f\,plate}$$

$$\boxed{W_{plate} = W}$$

$$T_f = n \cdot \mu \frac{2}{3} W_{plate} \left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2} \right)$$

$$T_f = n \cdot \frac{2}{3} \mu W \left(\quad \right)$$

in clutch aim is power transmission

UWT

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

* $T_f = n \cdot \mu \pi P_{per} R_i (R_o^2 - R_i^2)$

* $W = 2\pi R_i (R_o - R_i) P_{per}$.

Que:- A single plate clutch effective on both side carries an axial thrust 1500 N and the effective radius of friction surface is 100 mm with CoF(μ) = 0.2. Find out the torque in N-m that can be transmitted.

Sol^n

$$T = n \cdot \mu W R$$

$$T = 2 \times 0.2 \times 1500 \times \frac{100}{1000}$$

$$T = 60\ Nm$$

Ques:- A multiplate clutch transmitt 50 kW power at 1400 rpm and the intensity of pressure 0.15 MPa. The inner radius of friction lining is 80 mm and it is 0.7 times of outer radius determine the no. of disc req. on driver & driven shaft and also time axial load require to transmitt power assume $\mu = 0.2$

only clutch so old clutch → UWT

Sol^n

$$P = T_f\,\omega$$

$$T_f = \frac{P}{\omega}$$

$$P = n \cdot \frac{2}{3} \mu \pi p_{per} (R_o^3 - R_i^3) \times \frac{2\pi N}{60}$$

$$T_f = \frac{50 \times 10^3 \times 60}{2\pi \times 1400}$$

~~$50 \times 10^3 = n \cdot \frac{2}{3} \times 0.2 \times \pi \times 0.15 \times 10^6 \times (80$~~

$$T_f = 341.04\ N\text{-}m$$

$$50 \times 10^3 = n \times 0.2 \times \pi \times 0.15 \times 10^6 \times 0.080 \left(\left(\frac{0.080}{0.7}\right)^2 - (0.080)^2 \right) \times \frac{2\pi N}{60}$$

$$n = 11.3 \rightarrow n = 12$$

$$2n_2 = 12 \Rightarrow n_2 = 6$$

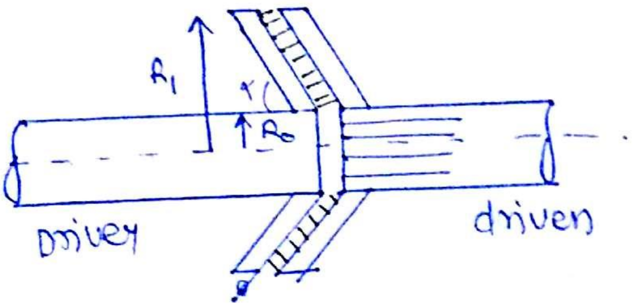
$$n_1 = \underline{\underline{7}}$$

$$W = 2\pi R_i (R_o - R_i) P_{per}$$

$$W = 2\pi \times 0.080 \left(\frac{0.080}{0.7} - 0.080 \right) \times 0.15 \times 10^6$$

$$W = 2.583 \text{ kN}$$

Cone clutch



$$b = \frac{R_o - R_i}{\sin\alpha}$$

$$\mu \rightarrow \frac{\mu}{\sin\alpha}$$

Multi Cone clutch

UPT

Axial load $= \pi (R_o^2 - R_i^2) P_{per}$

$T_f = n \cdot \frac{2}{3} \frac{\mu \pi}{\sin\alpha} P_{per} (R_o^3 - R_i^3)$

UWT

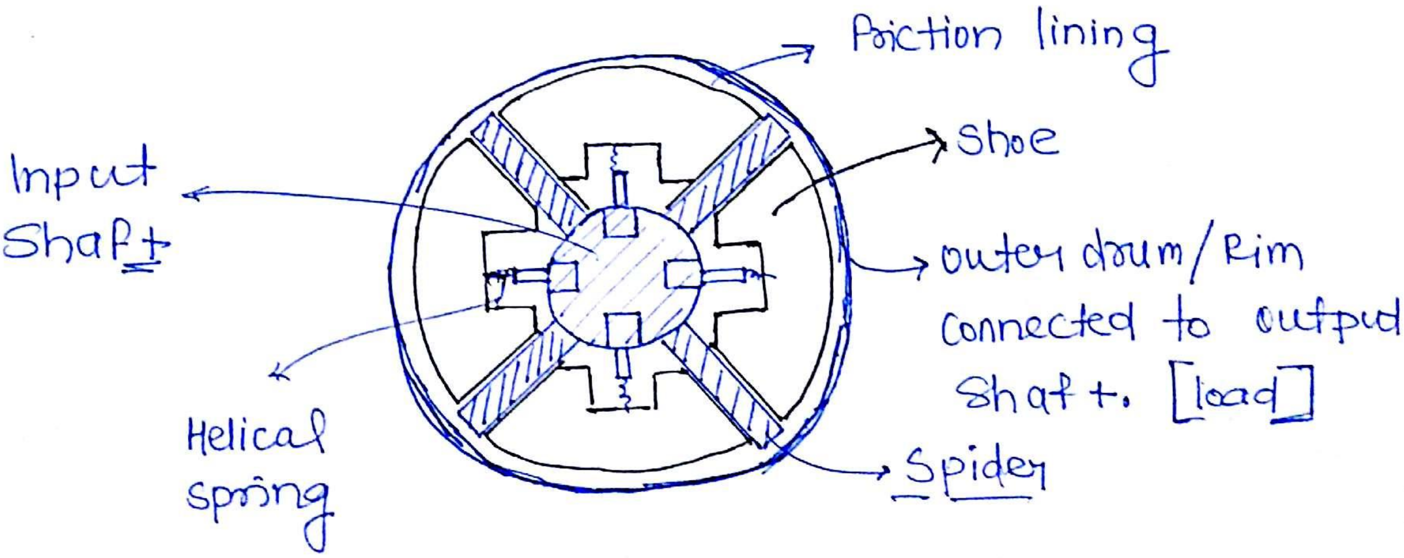
Axial load $= 2\pi (R_o - R_i) R_i P_{per}$.

$T_f = n \cdot \frac{\mu \pi}{\sin\alpha} P_{per} R_i (R_o^2 - R_i^2)$

clutch $\Rightarrow 15 \leq 2\alpha \leq 30°$

Bearing $\Rightarrow 120° \leq 2\alpha \leq 160°$

Centrifugal clutch:-



There are some engines motors or machinery which can not start with the load (Produced less power and torque) hence centrifugal clutchs are require.

Centrifugal clutch permit the engine and motor to start and accelerate at a perticular velocity without load, then the load will apply gradually on the input shaft.

eg:- (i) Mopeds

(ii) lawn movers

(iii) Chain saw.