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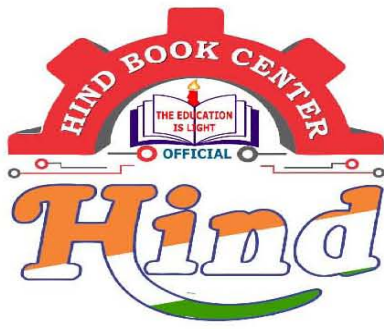
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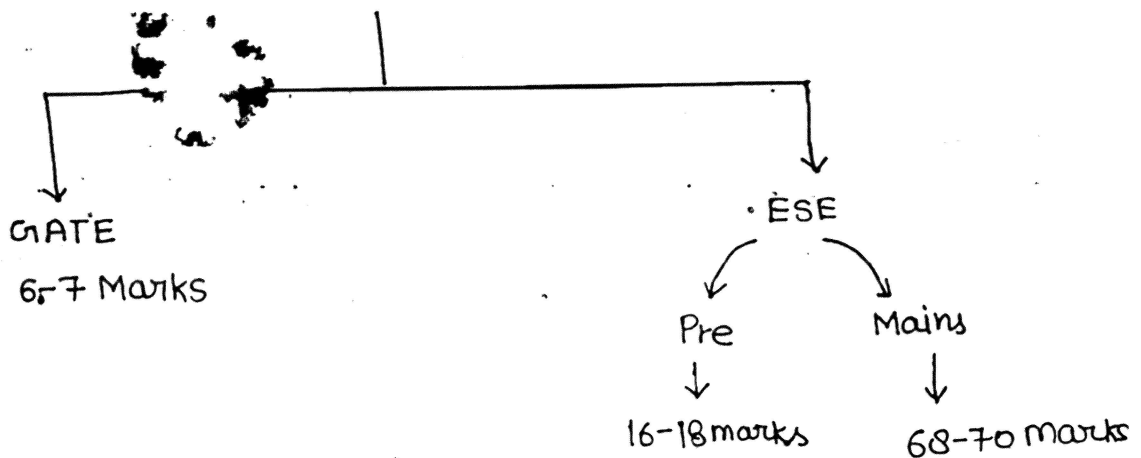
MACHINE DESIGN (MD)

(or)

MACHINE ELEMENT DESIGN (MED)

(or)

DESIGN OF MACHINE ELEMENT (DME)



(i) clutches

(ii) Brakes

(iii) Gear ⇒ (spur Gear)

(iv) Riveted Joint

(v) Bolted Joint

(vi) Welded Joint

(vii) Bearing

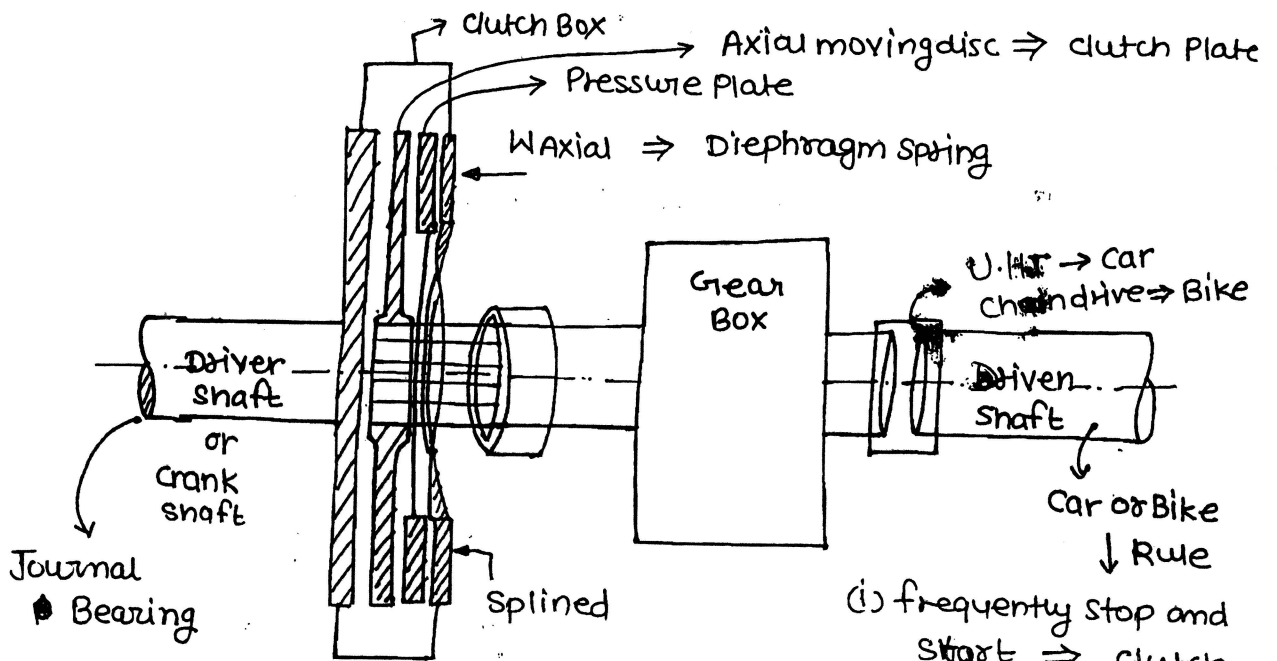
(viii) Fatigue design of shaft

(ix) Spring

(x) Design of flywheel [only ESE]

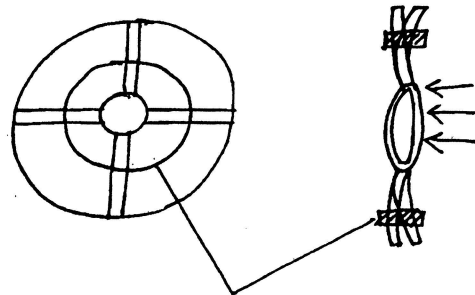
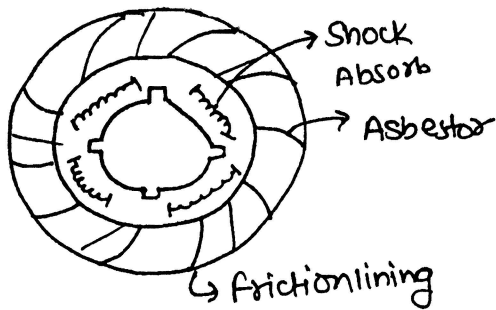
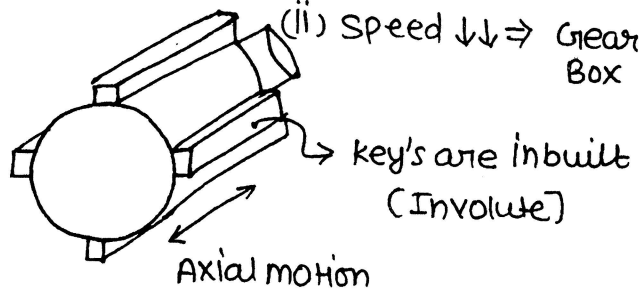
clutch :->

It is defined as a machine element which is use to engage and disengage driver and the driven shaft at the wheel without stopping the prime mover.



- (1) Run continuously
- (ii) Speed ↑↑

- (i) frequently stop and start => clutch
- (ii) Speed ↓↓ => Gear Box



Q Why clutches are prefer at High speed side Pivot => Hing or engine side ?

Ans -> $Power = T_f \times \omega \uparrow \uparrow \uparrow$
High speed

$T_f \rightarrow$ Required torque Less

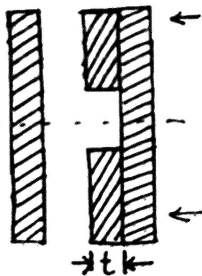
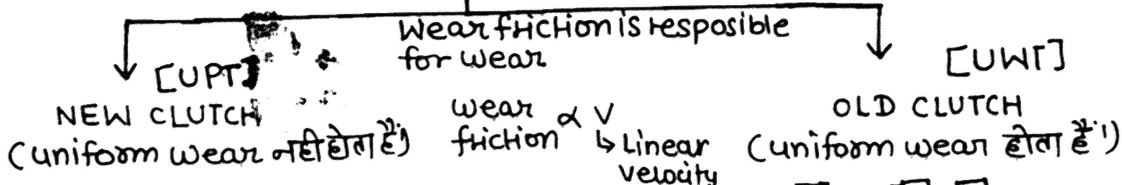
↓
Clutch design Simple

\rightarrow To minimize wear and losses
Clutch @ Low speed side

Power = $T_f \cdot \omega \downarrow \downarrow$

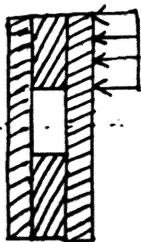
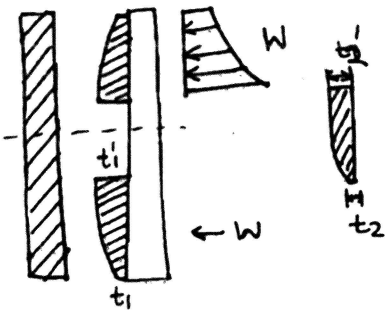
↓
(Torque Required will be more)

clutch

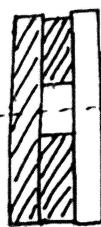


W_{spring}

Wear $\propto v$ friction \rightarrow Linear velocity
Wear $\propto p$ friction \rightarrow Pressure



$P_{ind} =$ uniform Pressure
↓
Perfect Engage



$P_{ind} \rightarrow$ Non uniform Pressure
↓
Perfect Engage नहीं होता है

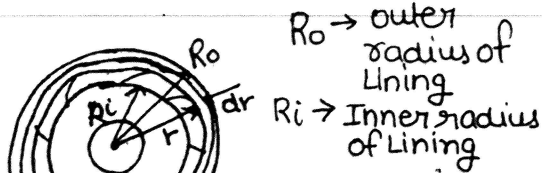
Pressure $\cdot r =$ constant $\Rightarrow P \cdot r = c$
wear friction = constant

↓
Uniform wear Theory (UWT)

$$\int 2\pi r \delta p \cdot dr = \int dw$$

$$2\pi \int_{R_i}^{R_o} \frac{c}{r} \cdot r \cdot dr = W \Rightarrow c = \frac{W}{2\pi(R_o - R_i)}$$

$$P_{ind} = \frac{W}{2\pi r (R_o - R_i)}$$



$P_{ind} = \frac{W}{\pi(R_o^2 - R_i^2)}$

$\int_{R_i}^{R_o} 2\pi r \cdot dr \cdot P = \int dw$
New Clutch (UPT)

$$P_{ind} = \frac{W}{\pi(R_o^2 - R_i^2)}$$

For safe condⁿ
 $P_{ind} \leq P_{per}$ or P_{allow}
 $\frac{W}{\pi(R_o^2 - R_i^2)} \leq P_{per}$

$t - t_1 > t - t_1', t_1 - t_2 = t_2 - t_2'$

For safe condⁿ
 $(P_{ind})_{max} \leq P_{per}$
 $\frac{W}{2\pi r_i (R_o - R_i)} \leq P_{per}$
 $\uparrow P_{ind} = \frac{W}{2\pi r_i (R_o - R_i)}$
 $(P_{ind})_{max} = \frac{W}{2\pi r_i (R_o - R_i)}$
 $\frac{W}{2\pi r_i (R_o - R_i)} \leq P_{per}$
 $W_{max} = 2\pi r_i (R_o - R_i) P_{per}$
Strength of old lining

$W_{max} = \pi(R_o^2 - R_i^2) P_{per} \rightarrow$ Strength of New Lining internally of Load

New clutch
Frictional torque

$$F_r = \mu R_N = \mu dW = 2\pi r dr \cdot p \cdot \mu$$

$$\int_{R_i}^{R_o} dT_f = \int_{R_i}^{R_o} 2\pi \mu p r^2 dr = 2\pi \mu p \int_{R_i}^{R_o} r^2 dr$$

$$T_{f_{max}} = \frac{2}{3} \mu \pi p_{per} (R_o^3 - R_i^3)$$

old clutch

$$\int dT_f = \int 2\pi \mu \cdot p \cdot r^2 dr$$

$$T_f = 2\pi \mu \int_{R_i}^{R_o} \frac{c}{r} \cdot r^2 dr$$

$$T_f = 2\pi \mu c (R_o^2 - R_i^2)$$

$$c = \frac{W}{2\pi (R_o - R_i)}$$

$$T_{f_{max}} = \mu W_{max} \left(\frac{R_o + R_i}{2} \right)$$

$$T_{f_{max}} = \mu \pi p_{per} R_i (R_o^2 - R_i^2)$$

NEW CLUTCH \Rightarrow UPT

\Downarrow
 $P_{ind} = c$

OLD CLUTCH \Rightarrow UWT

\Downarrow
 $p \cdot r = c$

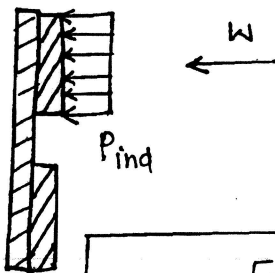
$\cdot P_{ind} = \frac{W}{\pi (R_o^2 - R_i^2)}$

\cdot safe condition

$$P_{ind} \leq P_{per}$$

$\cdot W_{max} = \pi (R_o^2 - R_i^2) P_{per}$

$\cdot T_{f_{max}} = \frac{2}{3} \mu \pi p_{per} (R_o^3 - R_i^3)$



$$R_{eff} = \frac{2}{3} \left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2} \right]$$

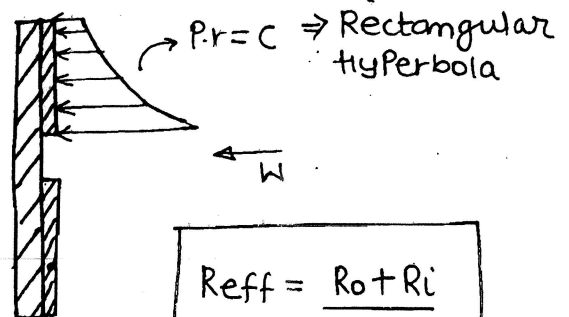
$\cdot P_{ind} = \frac{W}{2\pi r (R_o - R_i)}$

safe condition

$\cdot (P_{ind})_{max} \leq P_{per}$

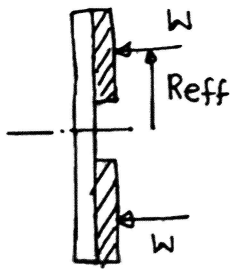
$\cdot W_{max} = 2\pi R_i (R_o - R_i) P_{per}$

$\cdot T_{f_{max}} = \mu \pi p_{per} (R_o^2 - R_i^2)$



$$R_{eff} = \frac{R_o + R_i}{2}$$

Imagine



$$T_f = \mu W R_{eff}$$

It is an imaginary radius for that we can assume the total friction force or the total load is acting.

NOTE:

1. clutch \Rightarrow Always assume \rightarrow old clutch
Hence clutches are design by uniform wear theory (UWT)
2. Always $T_f(\text{UPT})$ is greater than $T_f(\text{UWT})$

\rightarrow
Que \rightarrow 14/wB/ch-5

$$\begin{aligned} R_o &= 50\text{mm} \\ R_i &= 20\text{mm} \\ \mu &= 0.4 \\ P_{ind} &= 2\text{MPa} \end{aligned}$$

$$T_f = \frac{2}{3} \times 0.4 \times 3.14 \times 2 \times [(50)^3 - (20)^3]$$

$$T_f = 196\text{Nm}$$

\rightarrow
Que \rightarrow 6/wB/ch-5

$$5000 = \frac{2}{3} \mu \pi P_{per} (R_o^3 - R_i^3) \times \frac{2 \times \pi \times 2000}{60}$$

$$5000 = \frac{2}{3} \times 0.25 \times 3.14 \times 10^6 [R_o^3 - (0.025)^3] \times \frac{2 \times \pi \times 2000}{60}$$

$$R_o = 0.0394\text{m} = 39.4\text{mm}$$

wB/ch-5
Que \rightarrow 12 Ans: (b)

Q: A single plate clutch use to transmit Power in given radial distance space. Find out the Ratio of Outer dia. to inner diameter for the Lining to transmit max. Power

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

Given Radial Space \rightarrow fix R_o

$T_f = f(R_i)$ only

$$\frac{dT_f}{dR_i} = 0 \Rightarrow R_o^2 - 3R_i^2 = 0$$

$$\frac{R_o}{R_i} = \frac{D_o}{D_i} = \sqrt{3}$$

For driven

$$T_2 = I_2 \alpha_2$$

Similarly

$$\frac{d\theta_2}{dt} = \frac{T_2}{I_2} t + \omega_2 \rightarrow (2)$$

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

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

if T_B and T_E are Not Given

$$T_1 = T_2 = T_f = T$$

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

If Driven Inertia ' I_1 ' is Not given

assume $\Rightarrow I_1 \rightarrow \infty$

\rightarrow driver speed remains constant

$$t = \frac{(\omega_1 - \omega_2) I_2}{T} \quad \star$$

\rightarrow

Que \rightarrow T3/WB/ch-5

motor \rightarrow flywheel
(Driver) (Driven)

$$I_1 = ?$$

$$I_2 = m_2 k_2^2 = 0.3584 \text{ kg-m}^2$$

Let us assume driver speed constant $\Rightarrow I_1 \rightarrow \infty$

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

$$\omega_1 = \frac{2\pi N_1}{60} = 94.248 \text{ rad/s}$$

$$\omega_2 = 0$$

$$\text{Power} = T\omega_1$$

$$T = 9.27 \text{ N-m}$$

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

$$t = \frac{(94.24 - 0)(0.3584)}{T}$$

$$t = 3.64 \text{ sec}$$