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Explain condition for maximum power transmission.

Question:
Explain condition for maximum power transmission.

Answer:

Condition for maximum power transmission

We know that power transmitted by a belt,

$$P = (T_1 - T_2)\, v \qquad \text{...(i)}$$

where T_1 = Tension in the tight side of the belt

T_2 = Tension in the slack side of the belt

and v = Velocity of the belt in m/s.

We have also seen that the ratio of driving tensions is

$$\frac{T_1}{T_2} = e^{\mu.\theta} \quad \text{or} \quad T_2 = \frac{T_1}{e^{\mu.\theta}} \qquad \text{...(ii)}$$

Substituting the value of T_2 in equation (i),

$$P = \left(T_1 - \frac{T_1}{e^{\mu.\theta}}\right) v = T_1 \left(1 - \frac{1}{e^{\mu.\theta}}\right) v = T_1 . v . C \qquad \text{...(iii)}$$

where $C = 1 - \frac{1}{e^{\mu.\theta}}$

We know that $T_1 = T - T_C$

where T = Maximum tension to which the belt can be subjected , and

T_C = Centrifugal tension in newtons.

Substituting the value of T_1 in equation (iii),

$$P = (T - T_C)\, v.C \qquad (\text{Substituting } T_C = m.\, v^2)$$

$$= (T - m.v^2)\, v.C = (T.v - m\, v^3)\, C$$

For maximum power, differentiate the above expression with respect to v and equate to zero.

$$i.e. \quad \frac{dP}{dv} = 0 \quad \text{or} \quad \frac{d}{dv}(T.v - mv^3)\, C = 0$$

$$\therefore \quad T - 3\, m\, .\, v^2 = 0$$

$$\text{or} \quad T - 3\, T_C = 0 \text{ or } T = 3\, T_C \qquad \text{...(iv)}$$

It shows that when the power transmitted is maximum, 1/3rd of the maximum tension is absorbed as centrifugal tension.