Unit - 5

Drive line and Rear axle

Propeller shaft:

* Propeller shaft, sometimes called a carden shaft, transmits power from the gearbox to the rear axle.

* Normally the shaft has a tubular section and is made in one - or two - piece construction.

Design of propeller shaft:

* Propeller shaft must be strong to resist the twisting action of the driving torque

* It should be resilient to absorb the torsional shock.

* It must resist the natural tendency to sag under its own weight because Vibration occurs when center of gravity does not coincide with the axis of the shaft

* A tubular section propeller shaft is normally used because it has
(i) Low weight
(ii) Provides large resistance to misalignment
(iii) Has good torsional strength
(iv) Provides low resistance to change in angular speed.

* Even after a perfect static alignment, shaft sages at the center due to its own weight. When this sagging becomes excessive, rotation of the shaft causes the bow to increase due to the centrifugal effect.

* This deformation setups a vibration that becomes severe as it approaches the whirling speed.

* The critical speed at which this condition occurs depends on two vital dimension i.e, the mean diameter of the tube and the length of the shaft.

* Since propeller shaft of road vehicles are sufficiently long and operate at high speed, which may occur whirling at certain critical speed.

* This produces bending stresses in the material that are higher than the shearing stresses caused by transmitted torque.

* While critical speed increase, moment of Inertia decreases.

* The whirling of shaft is reduced by making shaft as tubular and should be perfectly balanced.

* The propeller shaft tubing is usually rolled from flat sheet, straightened within 0.25 mm, runout and balanced within 0.00018 kg-m

The critical speed is given by

$$N_c = \frac{60}{2\pi} \frac{\pi^2}{l^2} \sqrt{\frac{EI}{\rho A}} \text{ (rpm)}$$

Where,

$I \Rightarrow$ moment of Inertia of the shaft section $= \frac{\pi}{64}(d_o^4 - d_i^4)\ m^4$,

$A \rightarrow$ Cross sectional area $= \frac{\pi}{4}(d_o^2 - d_i^2)\ m^2$

$d_o \rightarrow$ Outside diameter

$d_i \rightarrow$ Inside diameter

g – acceleration due to gravity

E = Modulus of elasticity = 1.96×10^{11} N/m²

ρ = density of steel = 7860 kg/m³

* Propeller shaft are so designed that the calculated Critical Speed is about 60% higher than the engine speed at maximum power.

* Propeller shaft can also be designed for a given torque rating, which is the torque required to stress them to elastic limit.

If

T_e → Engine torque

G → Overall Gear ratio

T_t → Torque transmitted by propeller shaft

T_d → Design torque for the shaft

f_s → Safe shear stress.

I_p → Polar moment of inertia

$= \frac{\pi}{32}(d_o^4 - d_i^4)$, mm⁴

y → Distance from the neutral axis to the outermost fibre of the shaft $\left(\frac{d_o}{2}\right)$

$$\frac{T_t}{I_p} = \frac{f_s}{y}$$

$$T_t = T_e \times G$$

$$\text{Load on each wheel} = \frac{\text{Tractive effort}}{\mu}$$

$$\text{Tractive effort} = \frac{T_t}{r}$$

Composite material in propeller shaft

* The composite propeller shaft is an alternative to the divided arrangement.

* The tubular shaft is made of epoxy resin, which is strengthened by using glass and carbon fibres and bonded to a steel spigot for connection to the universal joint.

* The advantages of composite shafts over conventional type is

* Weight reduction by 50 %
* High Internal Shock Absorption
* Good noise, Vibration, harshness (NHV) performance
* Exceptional Corrosion Resistance