Gear Ratio (or) Movement Ratio

If the number of turns of the Steering wheel required to move the drop arm from the straight ahead to the position of full lock are known, then the gear ratio or movement ratio of the Steering ~~wheel~~ can be calculated as follows

$$\text{Gear ratio of Steering box} = 360 \times \frac{\text{No of turns of Steering wheel}}{\text{No of degrees turned by drop arm}}$$

If the Steering gear is of the worm and wheel type, then the gear ratio of Steering Box is given by

$$\text{Gear ratio of Steering Box} = \frac{\text{No of teeth on worm wheel}}{\text{No of Starts on worm}}$$

This is Identical with the gear ratio for rear axle drives using worm and wheel.

Steering Box Torque

Let,

$F \rightarrow$ Force exerted by each hand of diver on the Steering wheel, (N)

$d \rightarrow$ diameter of Steering wheel (m)

$T_s \rightarrow$ Torque applied to the Steering wheel

$$T_s = F \times d \quad (Nm)$$

$G_s \rightarrow$ Gear ratio of Steering box

$\eta_s \rightarrow$ Efficiency of gearing of Steering box

$T_t \rightarrow$ Torque transmitted to the drop-arm Shaft (N.m)

$$T_t = F d \, G_s \, \eta_s$$

In practice, the torque exerted through the Steering wheel by the driver is multiplied by 10 to 20 times or even more.

Problems

1) Calculate the gear ratio of a Steering box which requires 1.25 turns of Steering wheel to move the drop arm through 30° from its central position to full lock in one direction

Given data:

No of turns of Steering wheel = 1.25.

No of degrees turned through by drop arm = 30°

To find:

Grear ratio

Solution:

$$\text{Grear ratio} = \frac{360 \times \text{No of turns of Steering wheel}}{\text{No of degrees turned through by drop arm}}$$

$$= \frac{360 \times 1.25}{30} = 15$$

Gear ratio = 15 : 1

Result:

Gear ratio = 15 : 1

2. A Steering box has a gear ratio of 16:1 and an efficiency of 85%. Assume the driver to exert a force of 60 N at the rim of a wheel 0.4m in diameter, determine the torque at the drop arm Shaft.

Given:

$$F = 60\ N$$

$$G_s = 16:1 = 16$$

$$\eta_s = 85\% = 0.85$$

$$d = 0.4\ m$$

To find:

$$T_t$$

Solution

$$T_t = F\ d\ G_s\ \eta_s$$

$$= 60 \times 0.4 \times 16 \times 0.85$$

$$\boxed{T_t = 326.4\ Nm}$$

Result:

$$T_t = 326.4\ Nm$$

3. The gear ratio of a Steering box is 14:1. When the driver applies a force of 25N with each hand on the Steering wheel of 0.38m diameter, the torque transmitted to the drop-arm shaft is 110 Nm. Determine the efficiency of the Steering mechanism.

Given data:

$G_{1_S} = 14:1 = 14.$

$F = 25N$

~~$d = 0.3$~~ $d = 0.38m$

$T_t = 110\ Nm$

To find

η_s

Solution:

$$T_t = F\, d\, G_s\, \eta_s$$

$$110 = 25 \times 0.38 \times 14 \times \eta_s$$

$$\boxed{\eta_s = 0.8271 \text{ (or) } 82.71\%}$$

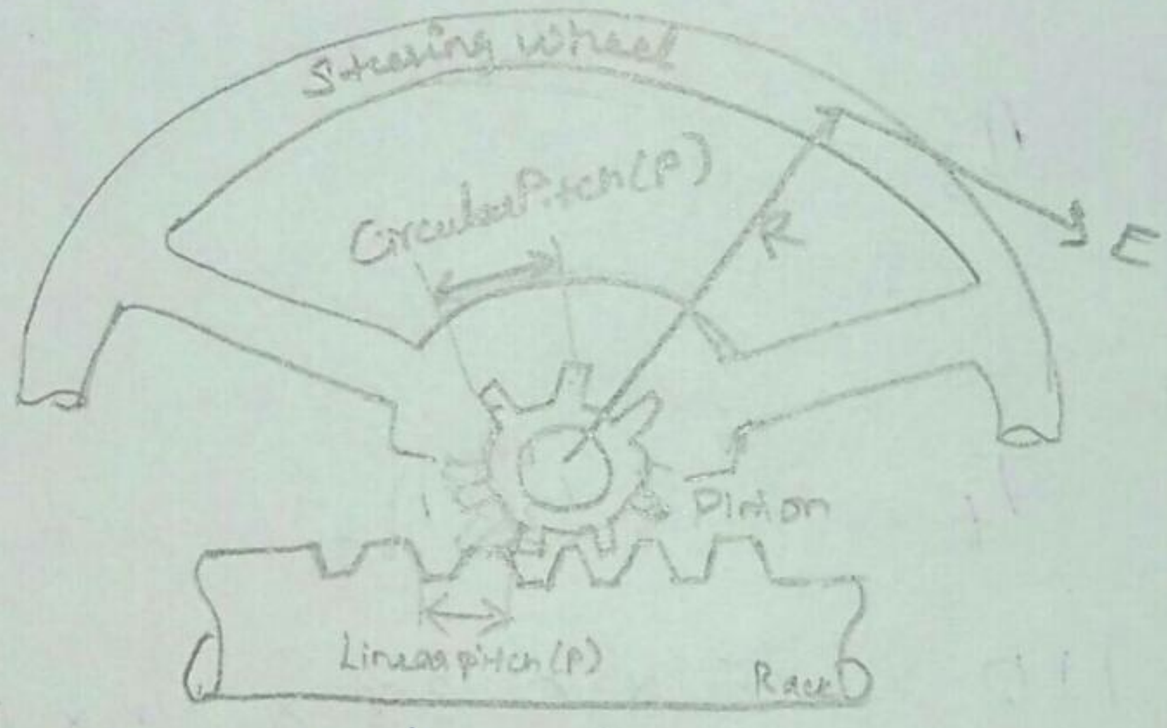
Result:

$\eta_s = 82.71\%$

Rack and Pinion Steering Gear Mechanism

The rack and pinion gear mechanism transfer the circular input motion of the pinion into the linear rack output movement so that side-to-side travel of the rack is transferred through the tie rods to the tie rod Steering arms and Stub axle.

The circular pitch of the pinion should be equal to the linear pitch of the rack for correct mesh.



Let R = Steering wheel radius

r = pinion pitch circle radius

t = number of pinion teeth

P = Linear or circular pitch

E = Input Steering wheel effort

W = Output rack load.

In order to make one revolution of pinion, the input steering wheel moves through $2\pi R$ and output rack moves through $2\pi r = tp$

Therefore,

Movement ratio

$$= \frac{2\pi R}{2\pi r} = \frac{R}{r} = \frac{2\pi R}{tp}$$

1) A rack and pinion Steering System has a pinion of 16 mm pitch circle diameter. What effort must be applied on 320 mm diameter Steering Wheel to overcome a resistance of 500 N. experienced transversely on the rack?

Given:

$D = 320$ mm

$R = 160$ mm

$d = 16$ mm

$r = 8$ mm

$W = 500$ N

To find:

E

Solution:

$$\text{Movement ratio} = \frac{R}{r} = \frac{160}{8} = 20$$

Movement ratio = 20:1

When there is no friction, $\text{Movement ratio} = \frac{W}{E}$

$$20 = \frac{500}{E}$$

E = 25 N

Result

Input Steering wheel effort E = 25 N

2) A rack and pinion Steering gear has 5 teeth pinion of 10 mm pitch. If an effort of 15 N is applied by each on the 350 mm diameter Steering wheel, determine (a) Movement ratio (b) Force transmitted to the tie rods.

Given data:

$t = 5$

$P = 10\,mm$

$E = 15\,N$

$D = 350\,mm \Rightarrow R = 175\,mm$

To find:

(i) Movement ratio

(ii) W

Solution:

$$\text{Movement ratio} = \frac{2\pi R}{tp} = \frac{2 \times \pi \times 175}{5 \times 10} = 22$$

Movement ratio = 22:1

Output load $W = E \times$ Movement ratio

$= 2 \times 15 \times 22$

$W = 660\,N$

Result:

(i) Movement ratio = 22:1

(ii) $W = 660\,N$