Subject: Theory of Machine Laboratory Manual.
Class: Third Stage.
First & Second Course .
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Experiment Name :- Gear Trains

Experiment Number :- (4)

Purpose of experiment:-

Determine the speed ratio of simple gear trains.

Theory:-

Sometimes, two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination is called gear train or train of toothed wheels. The nature of the train used depends upon the velocity ratio required and the relative position of the axes of shaft. A gear train consist of spur, bevel or spiral gears.
The motion from one shaft to another may be transmitted with belt, ropes and chains. These method are mostly used when the two shaft are having long center distance. But if the distance between the two shafts is very small, then gears are used to transmit motion from one shaft to another. Gear drive is positive and smooth drive, which transmits exact velocity ratio. The gear is defined as a toothed element which is used for transmitting rotary motion from one shaft to another.
For small power transmission, the friction wheels shown in fig (1) can be used. These wheels are mounted on the two shafts, having sufficient rough surface and pressing against each other.
The friction wheel or gear (1) is keyed to the rotating shaft whereas the friction wheel or gear (2) is keyed to the shaft which is to be rotated. When the friction gear (1) rotates, it will rotate the friction gear (2) in the opposite direction as shown in fig (1). There will be no slip between the two wheels for small power transmission.
The tangential velocities at the contact surfaces of gears should be same.

The apparatus:

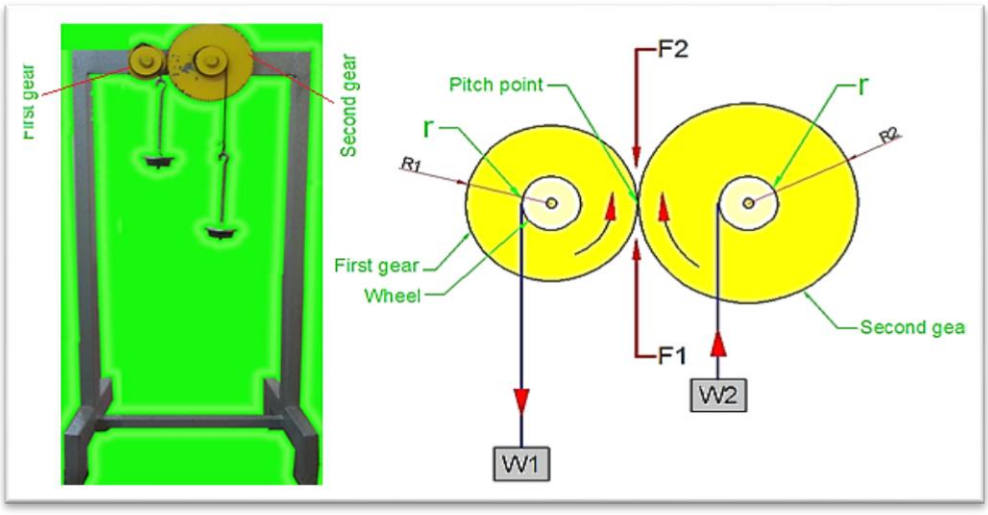


Fig (1). Simple gear trains.

At pitch point:

$$V_1 = V_2 \qquad V = \omega r$$

$$\therefore \omega_1 r_1 = \omega_2 r_2 \qquad \omega = \frac{2\pi N}{60}$$

$$\frac{2\pi N_1}{60} * r_1 = \frac{2\pi N_2}{60} * r_2$$

$$N_1 * r_1 = N_2 * r_2$$

$$\frac{N_1}{N_2} = \frac{r_2}{r_1} \quad or \quad \frac{N_1}{N_2} = \frac{d_2}{d_1} \qquad \ldots(1)$$

Where:

N_1= Speed of gear (1) or (driver) in (rpm)

N_2= Speed of gear (2) or (driven) in (rpm),

r_1 = Radius of gear (1) in (m) and

r_2= Radius of gear (2) in (m).

Simple gear trains

When there is only one gear on each shaft, as shown in fig (2), it is known as simple gear trains. The gears are represented by their pitch circle.

When the distance between the two shafts is small, the two gears (1) and (2) as shown in fig (1) or four gears (1,2,3 and 4) as shown in fig (2) are made to mesh with each other to transmit motion from one shaft to another.

To determine speed ratio of simple gear trains by two gears as shown in fig (1):

$$\frac{N_1}{N_2} = \frac{d_2}{d_1} \qquad or \qquad \frac{N_1}{N_2} = \frac{t_2}{t_1}$$

And to determine speed ratio of simple gear trains for the train shown in fig (2):

$$\frac{N_1}{N_2} = \frac{t_2}{t_1} \quad , \quad \frac{N_2}{N_3} = \frac{t_3}{t_2} \quad , \quad \frac{N_3}{N_4} = \frac{t_4}{t_3}$$

Multiplying:

$$\frac{N_1}{N_2} * \frac{N_2}{N_3} * \frac{N_3}{N_4} = \frac{t_2}{t_1} * \frac{t_3}{t_2} * \frac{t_4}{t_3}$$

$$\therefore \frac{N_1}{N_4} = \frac{t_4}{t_1} \qquad \ldots(2)$$

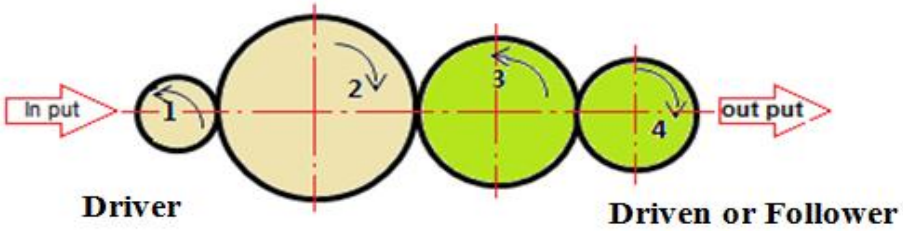


Fig (2). Simple gear trains.

Shown in fig (1), to find the forces and torques on first gear weight must be added to raise the load in the second gear:
For gear (1):

$$T_W = W_1 * r_1, \quad T_G = F_1 * R_1$$
$$\because T_W = T_G, \quad \therefore W_1 * r_1 = F_1 * R_1$$
$$\therefore F_1 = \frac{W_1 * r_1}{R_1}$$

Where:
T_W = Torque on wheel in (N.m)
T_G = Torque on gear in (N.m)
For gear (2):

$$T_W = W_2 * r_2, \quad T_G = F_2 * R_2$$
$$\because T_W = T_G, \quad \therefore W_2 * r_2 = F_2 * R_2$$
$$\therefore F_2 = \frac{W_2 * r_2}{R_2}$$

From fig (1), to find the minimum theoretical load (W_1) on gear (1) required to pulling up the load (W_2) on gear (2):

$$F_1 > F_2$$
$$\frac{W_1 * r_1}{R_1} > \frac{W_2 * r_2}{R_2}$$
$$\frac{W_1 * r_1}{W_2 * r_2} > \frac{R_1}{R_2} \qquad \because \frac{R_1}{R_2} = \frac{t_1}{t_2}, \quad r_1 = r_2$$
$$\frac{W_1}{W_2} > \frac{t_1}{t_2}$$
$$\therefore W_{1th} > \frac{W_2 * t_1}{t_2}$$

From fig (1), to find the gear train efficiency of simple gear trains:

$$\eta = \frac{P_{out}}{p_{in}} \qquad \ldots(1)$$
$$P_{in} = \omega_1 * T_1$$
$$\because \omega_1 = \frac{2\pi * N_1}{60}$$

$$P_{in} = \frac{2\pi * N_1}{60} * T_1 \qquad \ldots(2)$$

$$P_{out} = \omega_2 * T_1$$

$$\because \omega_2 = \frac{2\pi * N_2}{60}$$

$$\therefore P_{out} = \frac{2\pi * N_2}{60} * T_2 \qquad \ldots(3)$$

Sub equation (2) and (3) in equation (1) get

$$\eta = \frac{2\pi * N_2 / 60}{2\pi * N_1 / 60} * \frac{T_2}{T_1}$$

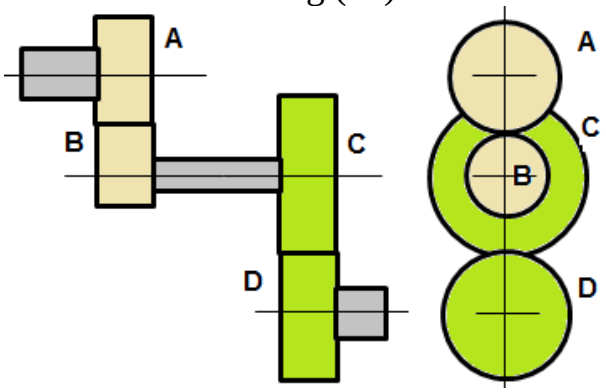
$$\eta = \frac{N_2}{N_1} * \frac{T_2}{T_1} \qquad \because \frac{N_2}{N_1} = \frac{t_1}{t_2}, \qquad T_1 = W_1 * r_1, \qquad T_2 = W_2 * r_2$$

$$\therefore \eta = \frac{t_1}{t_2} * \frac{W_2 * r_2}{W_1 * r_1} \qquad r_1 = r_2$$

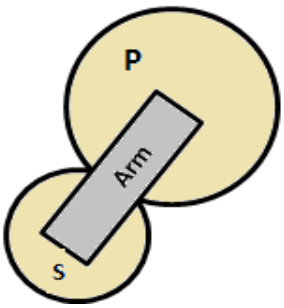
$$\eta = \frac{t_1}{t_2} * \frac{W_2}{W_1}$$

The main types of gear trains:

1- Simple gear trains … each shaft carries a single gear as shown in fig (2).
2- Compound gear trains … each shaft carries two wheels as shown in fig (3a).
3- Epicyclical gear trains as shown in fig (3b).



(a) Compound gear trains.



(b) Epicyclical gear trains.

Fig (3). Compound gear trains and Epicyclical gear trains.

Results & Calculation:-

1- Draw the following table for each gears:

NO.	Gear(1)	Gear(2)
1	$(W_1)gm$	$(W_2)gm$
2	$(R_1)mm$	$(R_2)mm$
3	$(r)mm$	$(r)mm$
4	$(t_1)teeth$	$(t_2)teeth$

2- Find the values of (F_1, F_2) acting on the contacting teeth of the gear trains.
3- Find the values of the torques on gears (1, 2).
4- Find the minimum theoretical (W_{1th}) on gear (1) required to up pulling the load (W_2) on gear (2).
5- Find the value of speed ratio of the simple gear trains.
6- Find the gear train efficiency.

Discussion:-

1- List two advantage and disadvantage of gear trains.
2- What are the types of teeth and gearing.
3- With the aid of a sketch, list the main types of gears trains.