CLUTCH

Introduction

A clutch is a machine member used to connect a driving shaft to a driven shaft so that the driven shaft may be started or stopped at will, without stopping the driving shaft.

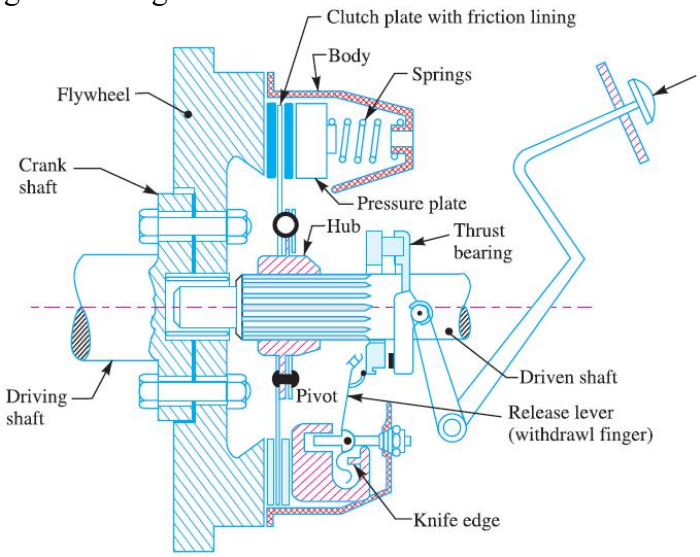
Types of Clutches

1. Positive clutch

2. Gradual Engagement Clutch

I. Friction Clutch
   a. Cone Clutch
   b. Disc Clutch [Single & Multiple]
   c. Centrifugal Clutch [Semi & Full]

II. Fluid Clutch



Single Disc or Plate Clutch

Design of a Disc or Plate Clutch

T = Torque transmitted by the clutch,
p = Intensity of axial pressure with which the contact surfaces are held together,
r_1 and r_2 = External and internal radii of friction faces,
r = Mean radius of the friction face,
μ = Coefficient of friction.

1. In general, total frictional torque acting on the friction surfaces (or on the clutch) is given by

$$T = n.\mu.W.R$$

where n = Number of pairs of friction (or contact) surfaces, and
R = Mean radius of friction surface

$R = \frac{2}{3}\left[\frac{(r1)^3-(r2)^3}{(r1)^2-(r2)^2}\right]$ ... (For uniform pressure); $R = \frac{r1+r2}{2}$ ... (For uniform wear)

2. For a single disc or plate clutch, n = 2;
For a multi plate clutch, $n = n_1 + n_2 - 1$.

where n_1 = Number of discs on the driving shaft, and n_2 = Number of discs on the driven shaft.

3. Since the intensity of pressure is maximum at the inner radius (r_2) of the friction or contact surface,

$$p_{max} \times r_2 = C \text{ or } p_{max} = C / r_2$$

4. Since the intensity of pressure is minimum at the outer radius (r1) of the friction or contact surface,

$$p_{min} \times r_1 = C \text{ or } p_{min} = C / r_1$$

5. The average pressure (p_{av}) on the friction or contact surface is given by

$$p_{av} = W / (\pi[(r_1)^2 - (r_2)^2])$$

[PRACTICE PROBLEMS ON CLUTCH]

Example:

Clutch Problem 1

Clutch Problem 2

GEAR

In precision machines, in which a definite velocity ratio is of importance (as in watch mechanism), the only positive drive is by ***gears*** or ***toothed wheels.***

Advantages

1. It transmits exact velocity ratio.
2. It may be used to transmit large power.
3. It may be used for small centre distances of shafts.
4. It has high efficiency.
5. It has reliable service.
6. It has compact layout.

Disadvantages

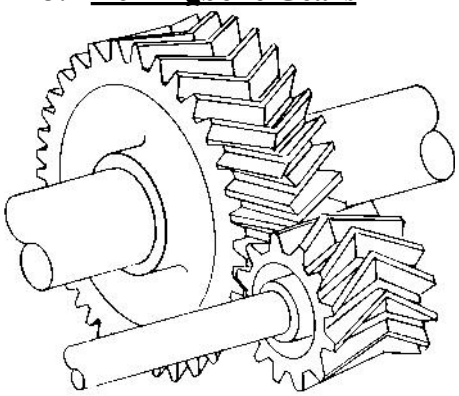
1. Since the manufacture of gears require special tools and equipment, therefore it is costlier than other drives.
2. The error in cutting teeth may cause vibrations and noise during operation.
3. It requires suitable lubricant and reliable method of applying it, for the proper operation of gear drives.

Classification of Gears

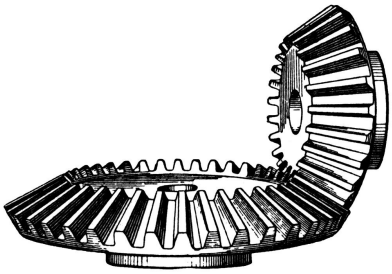
1. **Spur Gear**

2. **Helical Gears**

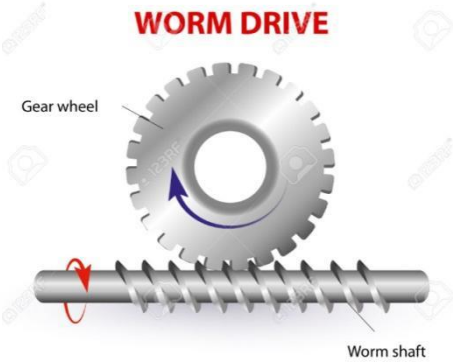
3. **Herringbone Gears**



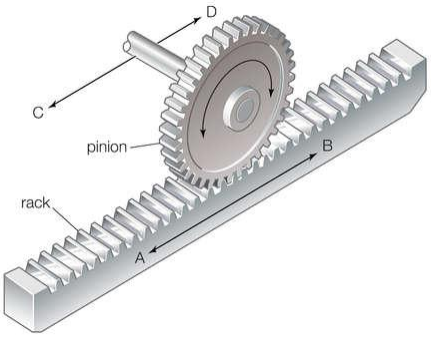
4. **Bevel Gear**

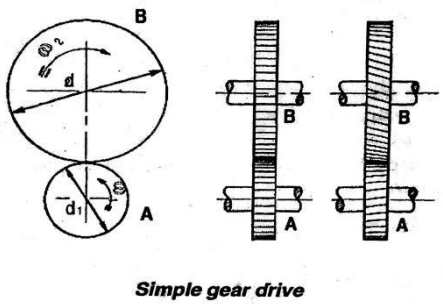


5. **Worm Gear**



6. **Rack and pinion**





Simple gear drive

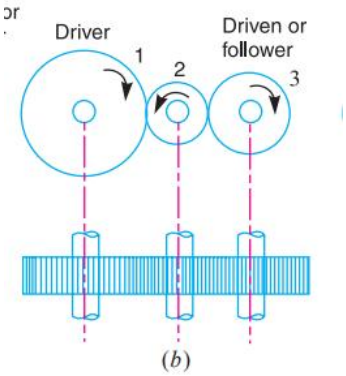
$$\text{Velocity ratio, VR} = \frac{N_1}{N_2} = \frac{d_2}{d_1} = \frac{T_2}{T_1}$$

Gear Trains

Types of Gear Trains

1. Simple gear train, 2. Compound gear train, 3. Reverted gear train, and 4. Epicyclic gear train.

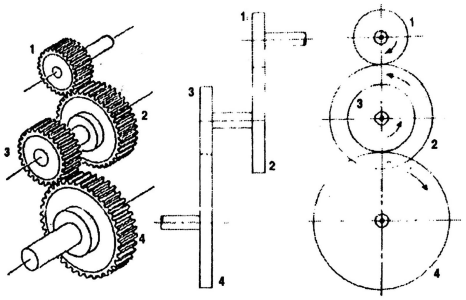
Simple Gear Train



(*b*)

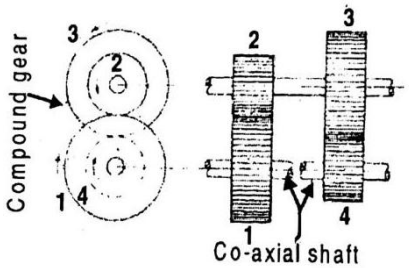
Simple gear train.

Compound Gear Train



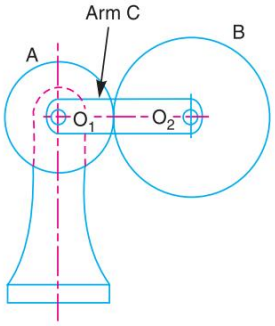
Compound gear train

Reverted Gear Train



Reverted gear train

Epicyclic Gear Train

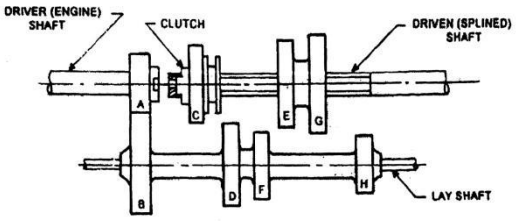


Epicyclic gear train.

Practical Applications of Reverted Gear Train

- Back Gear of Lathe
- Gearbox of an Automobile

Automobile Gearbox



Four speed gear box

EQUATIONS IN GEAR DRIVE

d = Diameter of the pitch circle, and
T = Number of teeth on the wheel.

Circular pitch, $p_c = \pi d/T$

Diametral pitch, $p_d = T/d$

Module, $m = D/T = 1/p_d$

Velocity ratio, $VR = \frac{N_1}{N_2} = \frac{d_2}{d_1} = \frac{T_2}{T_1}$

Simple gear train

the train value of simple gear train of 3 gears is:

$$\frac{N_3}{N_1} = \frac{T_1}{T_3}$$

$$\text{i.e. Train value} = \frac{\text{Speed of follower}}{\text{Speed of driver}} = \frac{\text{No. of teeth on driver}}{\text{No. of teeth on driven}}$$

$$\therefore \text{Speed ratio} = \frac{1}{\text{train value}} \text{ Or, } \frac{N_1}{N_3} = \frac{T_3}{T_1}$$

Compound gear train

the train value of compound gear train is

$$\therefore \frac{N_4}{N_1} = \frac{T_1 T_3}{T_2 T_4}$$

$$\text{i.e. Train value} = \frac{\text{Speed of follower}}{\text{Speed of driver}} = \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the followers}}$$

Reverted gear train

the train value of reverted gear train is,

$$\therefore \frac{N_4}{N_1} = \frac{T_1 T_3}{T_2 T_4}$$

$$\text{i.e. Train value} = \frac{\text{Speed of follower}}{\text{Speed of driver}} = \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the followers}}$$

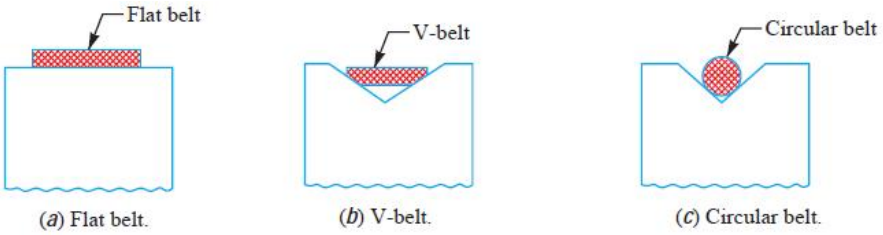
$$r_1 + r_2 = r_3 + r_4 \quad \text{Or} \quad d_1 + d_2 = d_3 + d_4$$

$$T_1 + T_2 = T_3 + T_4$$

BELT DRIVE

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds.

Types of Belts



(*a*) Flat belt. (*b*) V-belt. (*c*) Circular belt.

Types of Flat Belt Drives

1. Open Belt Drive
2. Crossed Belt Drive
3. Quarter Turn Belt Drive
4. Belt Drive with Idler Pulleys
5. Compound Belt Drive
6. Stepped or Cone Pulley Drive
7. Fast and loose pulley drive

Velocity Ratio of a Belt Drive

$\pi d_1 N_1 = \pi d_2 N_2$ i.e., $d_1 N_1 = d_2 N_2$

Or, $V.R = \frac{N_2}{N_1} = \frac{d_1}{d_2}$

Or, in words, the velocity ratio ,

$V.R = \frac{\text{Speed of follower}}{\text{Speed of driver}} = \frac{\text{Diameter of driver}}{\text{Diameter of follower}}$

For a Compound Drive

$$V.R = \frac{N_4}{N_1} = \frac{d_1 d_3}{d_2 d_4}$$

Slip

$$\therefore V.R = \frac{N_2}{N_1} = \frac{d_1}{d_2}\left(1 - \frac{S}{100}\right)$$

If thickness of th belt 't' is taken into consederation, then

$$V.R = \frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}\left(1 - \frac{S}{100}\right)$$

Length of Belt

For Open Belt Drive:

$$L_o = \frac{\pi}{2}(d_2 + d_1) + 2C + \frac{(d_2 - d_1)^2}{4C}$$

For Crossed Belt Drive:

$$L_c = \frac{\pi}{2}(d_2 + d_1) + 2C + \frac{(d_2 + d_1)^2}{4C}$$

Ratio of Belt Tensions

$$\therefore \frac{T_1}{T_2} = e^{\mu\theta}$$

POWER TRANSMITTED BY BELT

$\therefore$ Power transmitted, $P = (T_1 - T_2)\frac{\pi d N}{60}$

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$P = T_1\left(1 - \frac{1}{e^{\mu\theta}}\right)\frac{\pi d N}{60} \text{ watts}$$

Comparison of Belt Drive and Chain Drive

Types of Chain Drives