

CLUTCH

- A power transmission system usually consists of the following parts:
- **Clutch** – The device that connects or disconnects two torque transmitting devices.
- **Transmission/gear** – A device for transmitting power at a multiplicity of speed and torque.
- **P.T.O. Drive** – The parts that transmit torque from the engine to the PTO spline on the rear of the tractor.
- **Differential** – The device, usually in the axle housing, that allows the two wheels on an axle to rotate at different speeds.
- **Brake** – The device, usually in the axle housing, that stops the motion of the tractor.
- **Axle** – The shaft and connecting parts that transmits torque from the differential or final gear reduction, to the wheels.

PATH

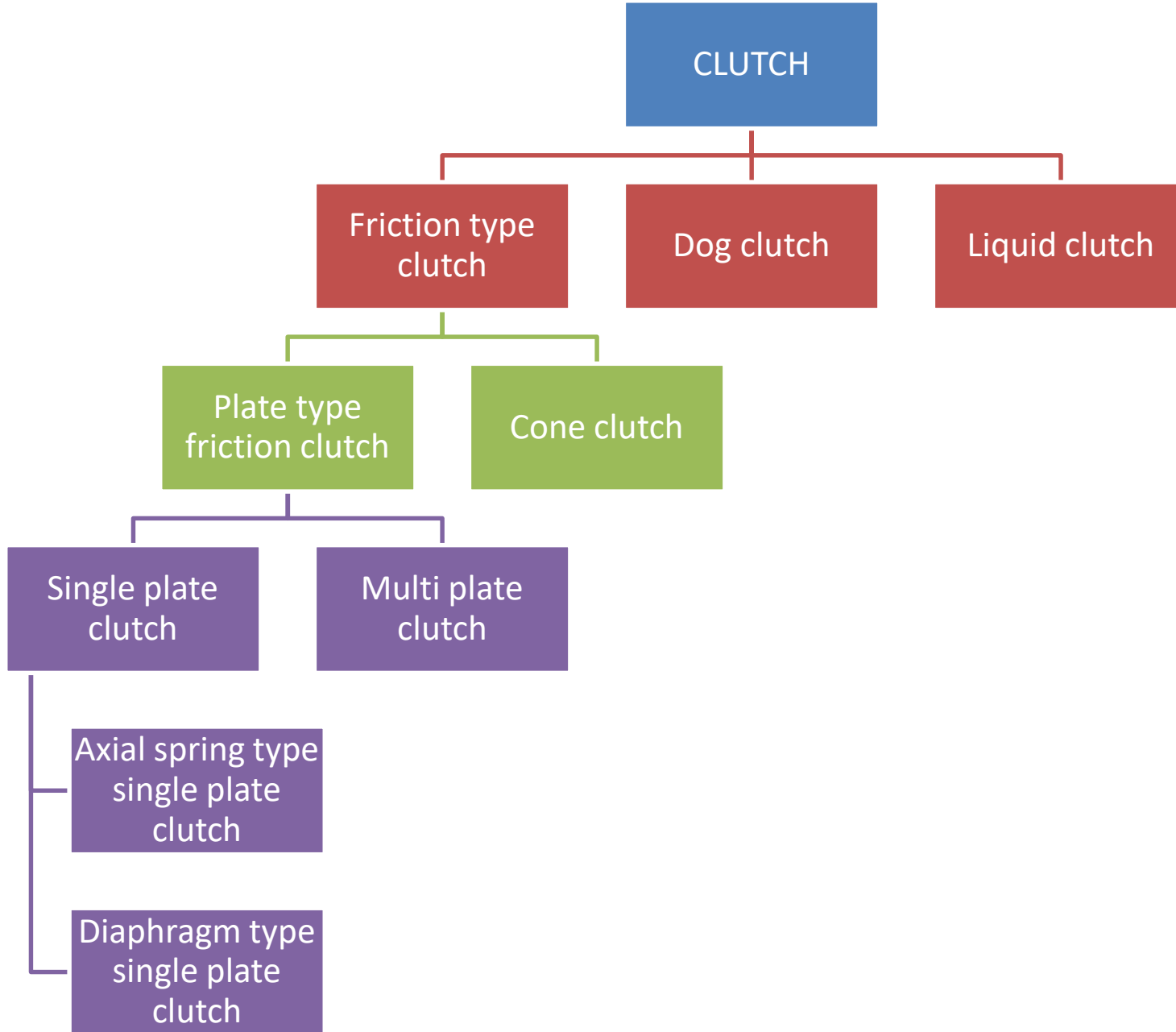
Engine – Crankshaft – flywheel –
clutch – transmission/gear box –
differential – final drives – axle –
drive wheels.

Function of clutch

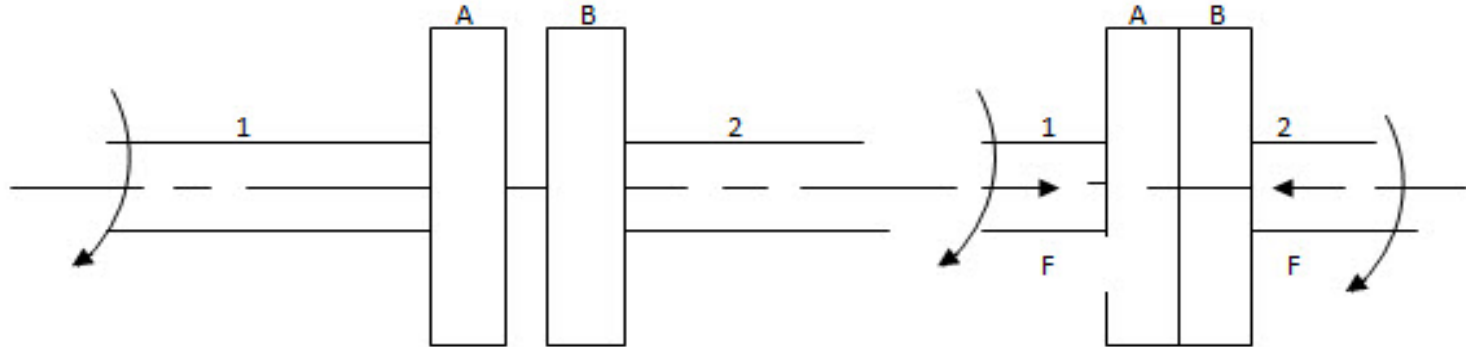
- **It connect/disconnects the engine from the remaining units of the power transmission system**
- A clutch is required to disconnect the rotational power from the flywheel of the engine to the gearbox especially at the time of selection of proper gear, specially at the time of starting, or moving the tractor from position of rest.
- **It also enables the engine to move forward and take up load of driving the vehicle gradually and without jerk (shock) when properly engaged.**

Essential features of a good clutch:

- (i) It should have good ability of taking load without dragging and chattering.
- (ii) It should have higher capacity to transmit maximum power without slipping.
- (iii) Friction surface should be highly resistant to heat effect.
- (iv) The control by hand lever or pedal lever should be easy.



The agricultural tractors mostly use axial spring Clutch, as the name suggests, uses a clutching force (axial force) to transmit the rotational motion from one shaft to another.



To transmit power from shaft 1 to shaft 2, the flat discs are forced together with a force (axial force), F . The friction between the discs, A and B, causes the rotational motion of shaft 1 to be transmitted to shaft 2.

The torque that this system can transmit is given by

$$T = \mu FR$$

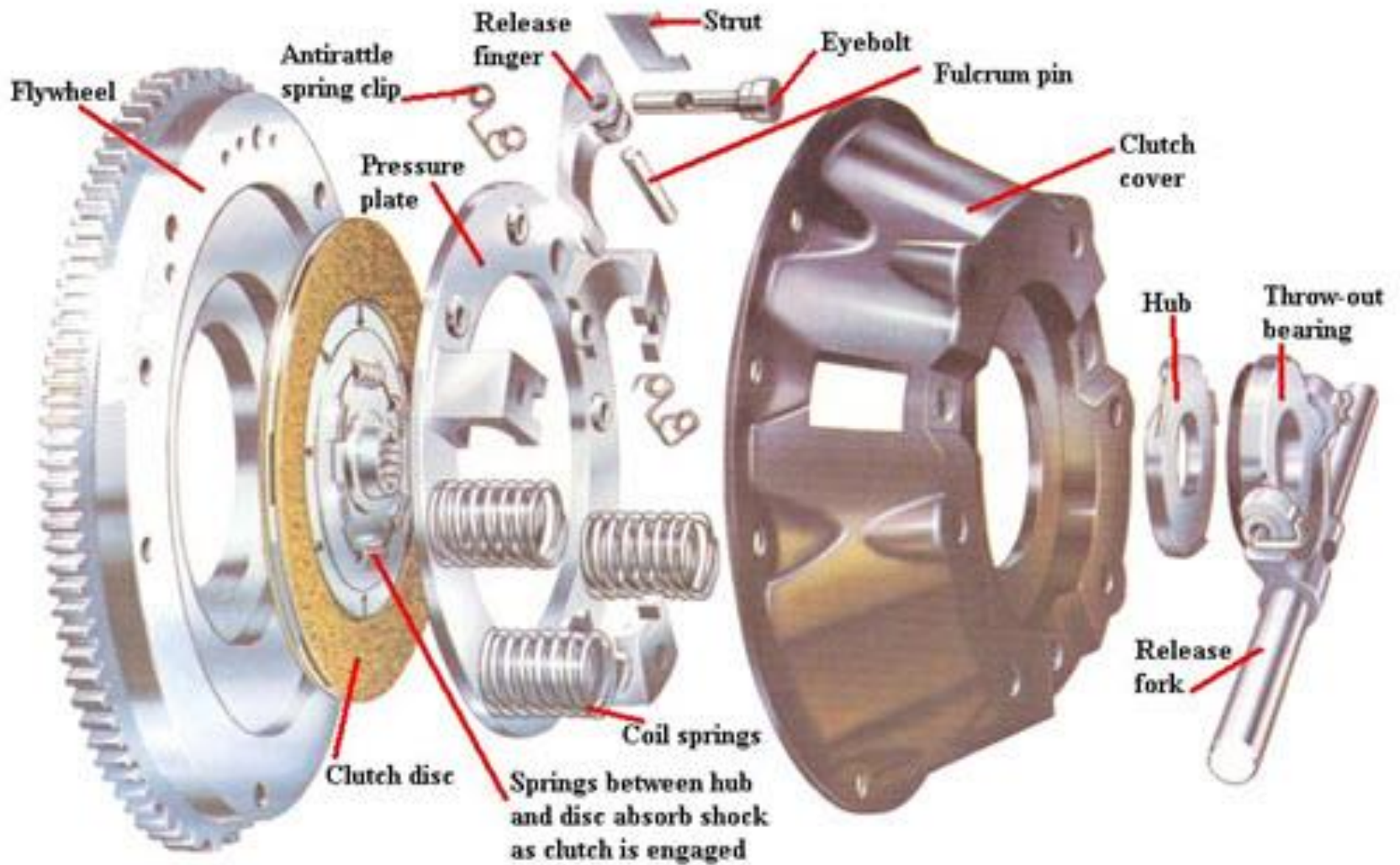
Where

μ = coefficient of friction between the two discs A and B

F = Axial force with which the two discs are put together.

R = mean effective radius of the friction surface of the discs.

Main components of a Single Plate Axial Spring type friction clutch



Flywheel: It is connected to the engine crankshaft and is used to store the energy.

Clutch Plate: It consists of a steel disc with the centre splined. Frictional material is mounted (riveted) around the circumference of the steel disc.

Pressure Plate: The pressure plate pushes the clutch plate onto the flywheel due to spring pressure so that the clutch plate on one side and the flywheel on the other.

Axial Springs: Axial springs provide the clamping force due to which the power can be transmitted from the flywheel to the clutch plate.

Clutch cover: It not only covers the clutch components, but also provides motion from the flywheel to the pressure plate.

Clutch release system: It consists of those components which are required for engaging -disengaging the power transmission to the clutch plate.

Main components of clutch

Driving member

It consists of a pressure plate assembly and the flywheel bolted together such that the assy rotates at the same speed of the engine.

Driven member

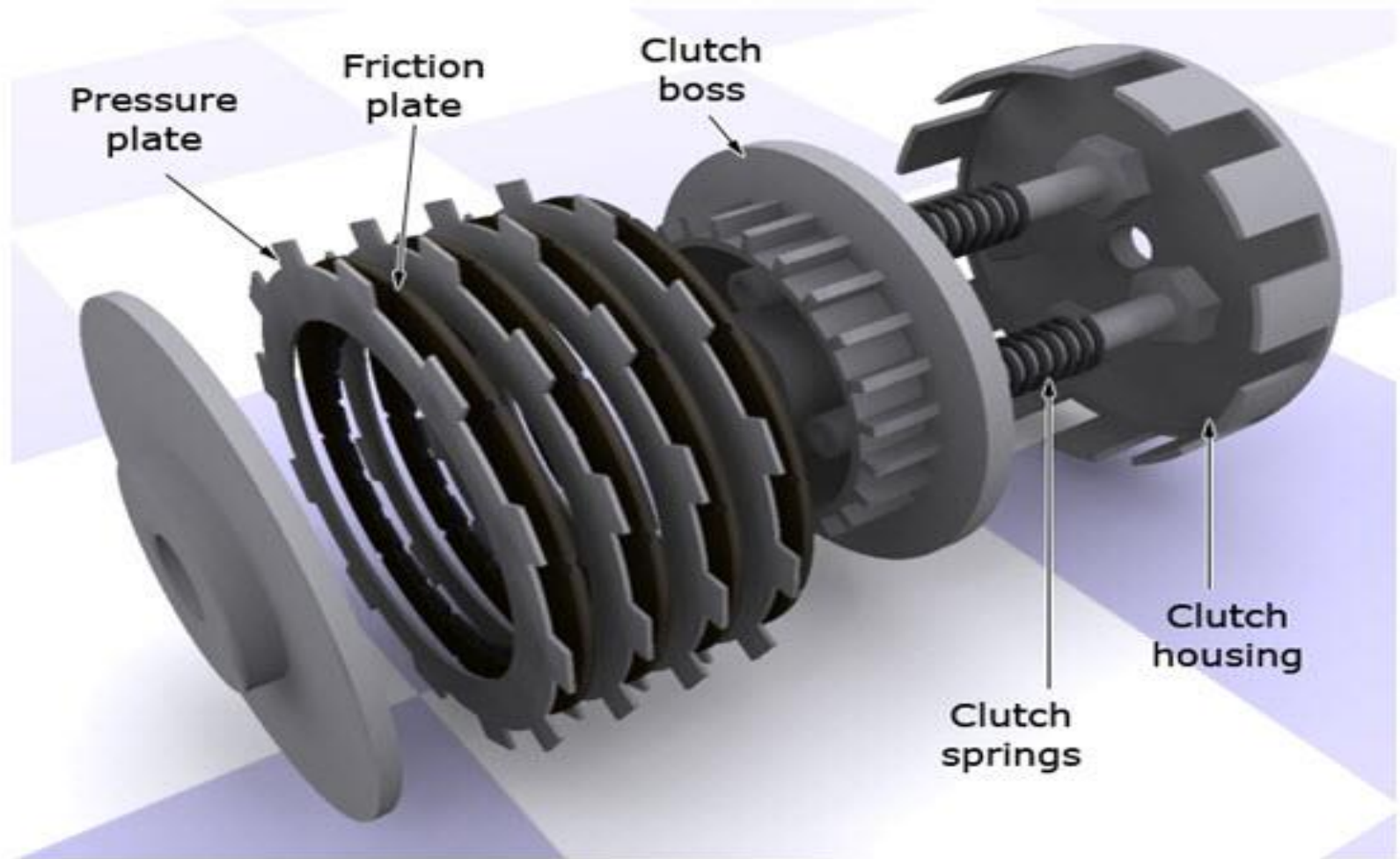
It consists of a disc or plate assembly and the clutch shaft. This driven plate assembly is gripped between the flywheel and the pressure plate assembly under the action of pressure springs.

OPERATION PRINCIPLE

- While starting the engine, the clutch pedal is depressed for changing gear.
- After that the pedal slowly released to increase the pressure gradually on frictional surface.
- Thus driven plate gripped firmly to the driving plate.

Multi Plate Clutch

- A multi plate clutch is an extension of a single plate clutch where the number of friction surfaces is increased.
- Due to this increase in number of frictional surfaces, the area which transmits torque is increased which in turn increases the capacity of the clutch to transmit torque.
- This type of clutch finds its application in case of heavy torque transmission or where there is limitation of space available.



Method of working

- The construction of the pressure plates and the clutch plates is such that the pressure plates have teeth at its outer periphery, or it is grooved from outside. This is done so that the teeth on the pressure plates mesh with the corresponding grooves on the flywheel. The clutch plates are grooved on the inside periphery to sit on the splines of the clutch shaft.
- The pressure plates are meshed in the grooves on the flywheel and are free to move away from or towards the flywheel depending on whether the clutch pedal is released or pressed. When the clutch pedal is pressed, the axial force binding the clutch plates is removed, stopping the power being transmitted by the clutch.

- The number of clutch plates to be used is decided by the total surface area of the clutch plate in contact with the flywheel or pressure plate driving the clutch plates.
- Mathematically the torque transmitted by the clutch as discussed, is given by:

$$T = \mu FR$$

- This relation holds for single contact surface.

- For a single plate clutch with two contact surfaces, the torque transmitted is

$$T = 2\mu FR$$

- For a clutch with 'n' number of plates, the torque transmitted is given by:

$$T = 2n\mu FR$$

$$T = N \cdot U \cdot F \cdot R$$

- In single plate clutch there are 2 transmitting surface for torque
- For n pair of surface there is n+1 number of discs or plates
- If there are n₁ no of discs in driving shaft and n₂ no of driven shaft,

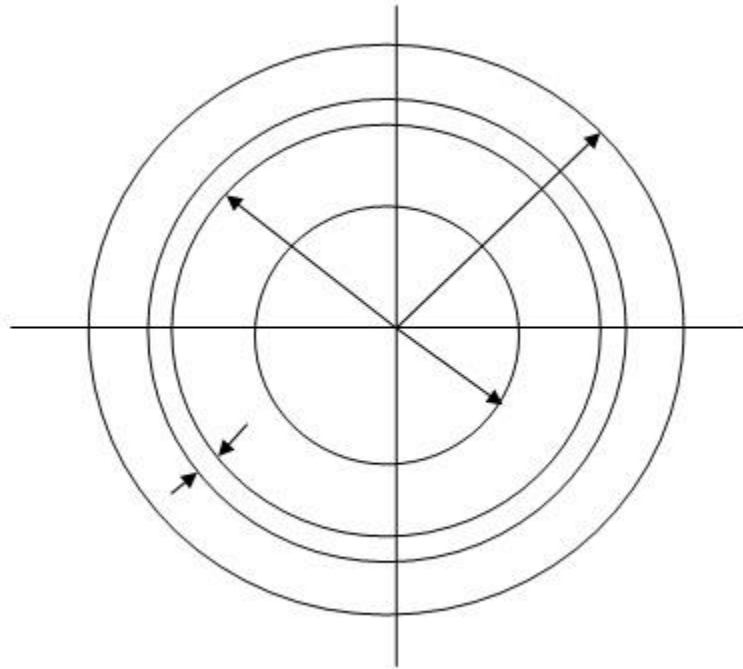
The number of contact surface will be $n_1+n_2- 1$

Analysis of Clutch – uniform wear, uniform pressure

- **Analysis of Torque Transmission**

In the figure, the frictional surface has an outer radius, r_o , inner radius r_i .

Assume an elemental surface area of thickness dr at a radius of r from the centre. If p is the pressure exerted while putting the two discs A and B together.



- r_o – radius of outer end of the clutch facing
- r_i – radius of inner edge of clutch facing
- dr – thickness of the elemental element of clutch facing at a distance of r from the centre

- Total axial force, $df = p \cdot dA$

$$df = p \cdot 2\pi r \cdot dr$$

The torque that can be transmitted

$$T = u \cdot df \cdot r$$

$$T = u \times p \cdot 2\pi r \cdot dr \times r$$

$$T = \int_{r_i}^{r_o} u \cdot 2\pi \cdot p r^2 \cdot dr$$

$$= 2\pi u \int_{r_i}^{r_o} p r^2 \cdot dr$$

Case I : If pressure is constant i.e. $p=k$

$$\Rightarrow F = 2\pi p \int_{r_i}^{r_0} r \, dr = 2\pi p \left(\frac{r_0^2 - r_i^2}{2} \right)$$
$$= \pi p (r_0^2 - r_i^2)$$

$$T = 2\pi u p \int_{r_i}^{r_0} r^2 \cdot dr = 2\pi u p \left(\frac{r_0^3 - r_i^3}{3} \right)$$
$$= u \cdot \pi p (r_0^2 - r_i^2) \cdot \frac{2}{3} \left(\frac{r_0^3 - r_i^3}{r_0^2 - r_i^2} \right)$$

$$\Rightarrow R = \frac{2}{3} \left(\frac{r_0^3 - r_i^3}{r_0^2 - r_i^2} \right), \text{ the mean effective radius if pressure is constant}$$

Case II: if wear is constant i.e. $p.r = \text{constant}$

$$\Rightarrow F = 2\pi p r \int_{r_i}^{r_0} dr = 2\pi p r (r_0 - r_i)$$

$$\begin{aligned} \Rightarrow T &= 2\pi u p r \int_{r_i}^{r_0} r \cdot dr = 2\pi u p r \left(\frac{r_0^2 - r_i^2}{2} \right) \\ &= u \cdot 2\pi p r (r_0 - r_i) \cdot \left(\frac{r_0 + r_i}{2} \right) \end{aligned}$$

$$\Rightarrow R = \left(\frac{r_0 + r_i}{2} \right), \text{ the mean effective radius if wear is constant.}$$

Dog clutch

- It is a simple clutch having square jaws which are used to drive a shaft in either direction.
- It is mostly used in power tillers.

PROBLEMS

- 1. A multiple disc clutch is composed of 5 steel and 4 bronze discs, the clutch is required to transmit 16 Nm of torque. If inner dia is 50 mm and find out the outer diameter if coefficient of friction is 0.1 and avg pressure 350 kN/m². assume uniform pressure.

- 2. A multidisc clutch, $n_1 = 4$, $n_2 = 4$, $d_o = 15\text{cm}$, $d_i = 11\text{cm}$. Determine the total load on springs power = 8hp, $N = 1000\text{rpm}$ $\mu = 0.08$, what is the load carried out by each effective contact surface (i,e 4). Assume uniform wear. (Ans= 40N)

- 3. A single plate friction clutch with both sides effective is to transmit 15Kn at 2000 rpm. The axial pressure is 0.1N/mm^2 .if the outer diameter of the friction lining is 1.5 times than inner diameter. Find the required outer and inner diameter of the friction lining. Assume uniform wear conditions. The coefficient of friction may be taken as 0.3.

- 4. One clutch disc is active on both the surface having inner and outer diameter of 6 and 14cm, respectively. The friction coefficient of material of the clutch is 0.3. If the clutch has torque of 10Nm, what will be pressure acting on the clutch plate?

- 5. A multi disc clutch has 4 steel discs and 3 bronze discs. The outer and inner diameter of contact surfaces are 250 and 180mm respectively. The coefficient of friction is 0.3 and axial force is 400N. What is the power in kW that clutch can transmit in 1000rpm?