Automotive Vehicles
AEL ZC441

BITS Pilani
Pilani Campus

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Lecture 1 - Recap

- Introduction to Automobile
- Development of Automobile (1769 to 2005)
- General Classification (Type I & II)
- Basic Structure &
- Components of Automobile (Basic Structure, Power Plant, Transmission System, Auxiliaries, Controls, Superstructure)

Lecture 2 - Recap

- Chassis & Body
- Classification
- Conventional Construction
- Sub frames
- Frameless Constructions
- Classifications of Body

Lecture 3 - Recap

- Cylinder Block and crank case
- Cylinder Head
- Sump or oil pan
- Intake and Exhaust Manifolds
- Gaskets
- Cylinder Liners
- Piston
- Piston Rings
- Connecting Rods
- Piston Pins
- Crankshaft
- Main bearings
- Valves and Valve actuating mechanisms
- Mufflers

Lecture 4 - Recap

- Need of Cooling system
- Variation of Gas temperature
- Theory of Engine heat transfer and co-relation
- Parameters affecting Heat transfer
- Air cooled Systems

Lecture 5 - Recap

- Water Cooling system
- Types of Water cooling
- Components of Water Cooling system
- Other coolants & Anti-freeze solutions
- Intelligent cooling system

Lecture 6 - Recap

- Causes of engine friction
- Function of lubrication
- Mechanism of lubrication
- Journal bearing lubrication
- Lubrication system types
- Lubrication of Engine systems

Today's Topic

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Lect No.	Learning Objectives	Topics to be covered	Reference to Text
1	An introduction to automobiles	Overview of the course and evaluation scheme Development of automobiles, General classification, Basic structure and components of automobile	1TB1,1TB2
2	The chassis Construction and Body	Classification, Conventional construction, Sub frames, Frame less constructions, Classification of body, Numerical problems on chassis member bending.	11TB1, 1 TB2
3	Reciprocating Engine Construction and basics	Constructional details, Calculation of displacement velocity and acceleration of piston and connecting rod, Working of 2and 4 stroke engines. Numerical problems on the above topics	3TB1
4	Cooling systems	Need. Variation of gas temperature. Piston temperature distribution. Theory of engine heat transfer and correlation. Parameters affecting engine heat transfer. Air-cooled systems.	8TB1, 12RBa
5	Cooling systems	Types of water-cooling systems. Radiators. Fans. Correlation for the power required for engine cooling. Numerical problems on the above topics	8TB1, 12RBa
6	Lubrication systems	Causes of engine friction. Function of lubrication. Mechanism of lubrication. Journal bearing lubrication.	7TB1, 11RBa
	Lubrication systems	Types of lubrication systems. Lubrication of engine components.	7TB1, 11RBa
7	Clutch	Definition of clutch, requirements, classification, principle of working of friction clutches, Driving system and Plate clutch (uniform pressure and uniform wear).	14TB1, 3TB2

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Automotive Vehicles
Lecture 7

Clutches

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- Definition of Clutch
- Requirements
- Classification
- Principle working of Friction Clutches
- Driving System & Plate Clutch
- Design Details (Uniform Pressure, Uniform Wear, Energy lost)

https://www.youtube.com/watch?v=devo3kdSPQY
https://www.youtube.com/watch?v=pqF-aBtTBnY

Clutch - Definition

- A Mechanism enables the rotary motion of one shaft to be transmitted , when desired to a second shaft the axis of which is coincident with that of the first.
- A Mechanism designed to disconnect and reconnect driving , driven members

<u>To Engage and Dis-Engage:</u>

- To obtain smooth engagement, clutch engages and torque transmitted from engine to propel the vehicle.
- For change of gear, clutch disengages the Engine from transmitting torque to other component

Clutch – Functions

1. Smooth transmission of rotary motion of Engine crankshaft to Gear box shaft
2. To transmit maximum engine torque
3. Enables rapid engagement and disengagement of the engine from transmission for gear changing, Emergency stop, one or both in motion

Clutch - Requirements

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1. Torque transmission (To transmit maximum torque)
2. Gradual Engagement (Without Jerks)
3. Heat dissipation (Rubbing surface should have sufficient area and ensure proper ventilation)
4. Dynamic Balancing
5. Vibration Damping (Elimination of noise during transmission)
6. Size (small to occupy less space)
7. Inertia (Minimum inertia to avoid spinning)
8. Clutch free Pedal play (To reduce clamping load wear)
9. Ease of operation

Clutches - Types

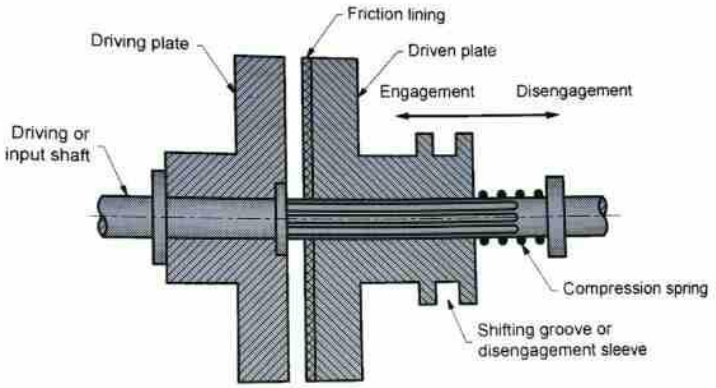
1. Friction Clutches
2. Fluid Flywheel

Friction Clutches – Friction is caused when two rotating discs come into contact with each other

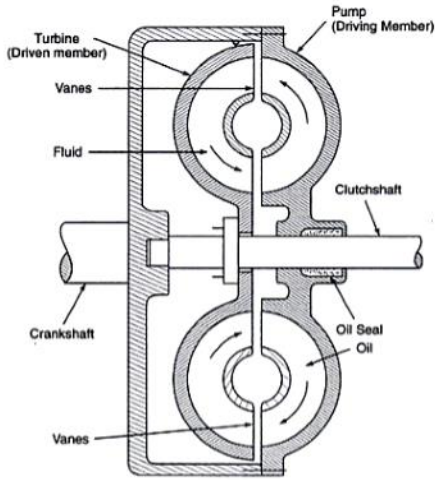
Sub-classification :

- Dry clutch (commonly used)
- Wet clutch (operates in oil)

Fluid Flywheel – Works on the transfer of energy from one rotor to the other by means of some fluid



Friction clutch



Fluid flywheel

Friction Clutch – Working Principle

Working Principle of Friction Clutch

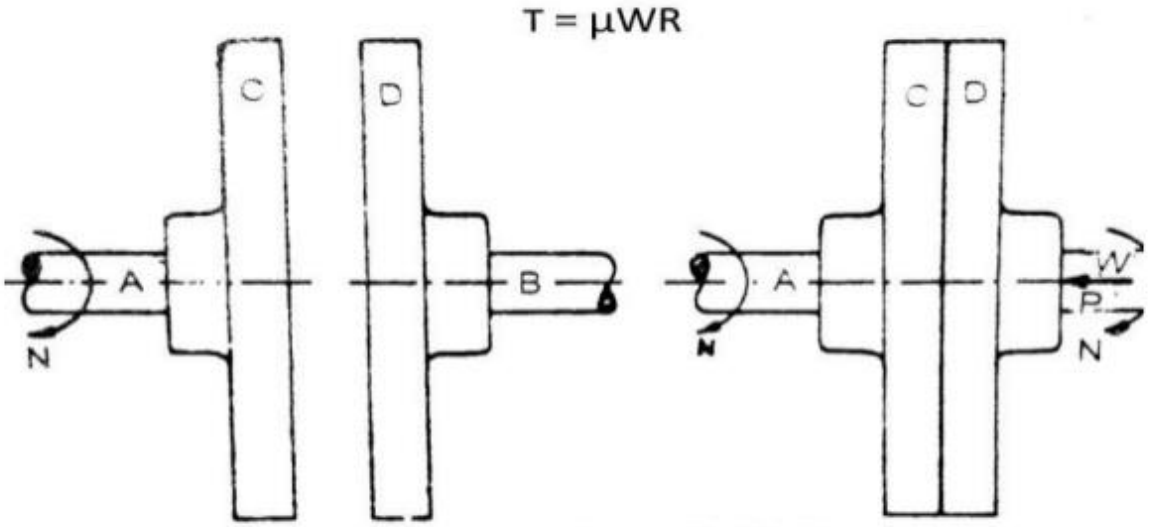


Fig. 2.1 (b) ***Principle of Friction Clutch***

W – Axial load applied
μ – Coefficient of Friction
T – Torque transmitted
R – effective mean radius

$$T = \mu WR$$

Friction Clutch – Working Principle

Coefficient of Friction, μ

- Depends on materials comprising friction surfaces
- Varies with temperature, pressure and rubbing velocity

Axial Pressure, W

- Maximum value of W, limited (100-120N) to the driver can exert without strain

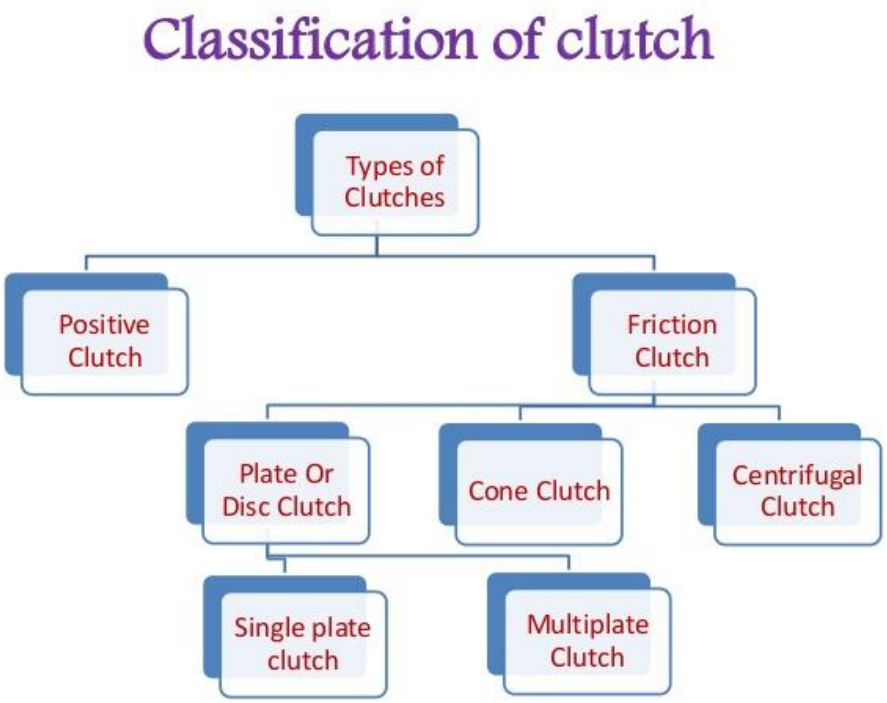
Effective Mean Radius of contact surfaces, R

- Maximum based on the space of the vehicle

Clutches – Dry Friction type

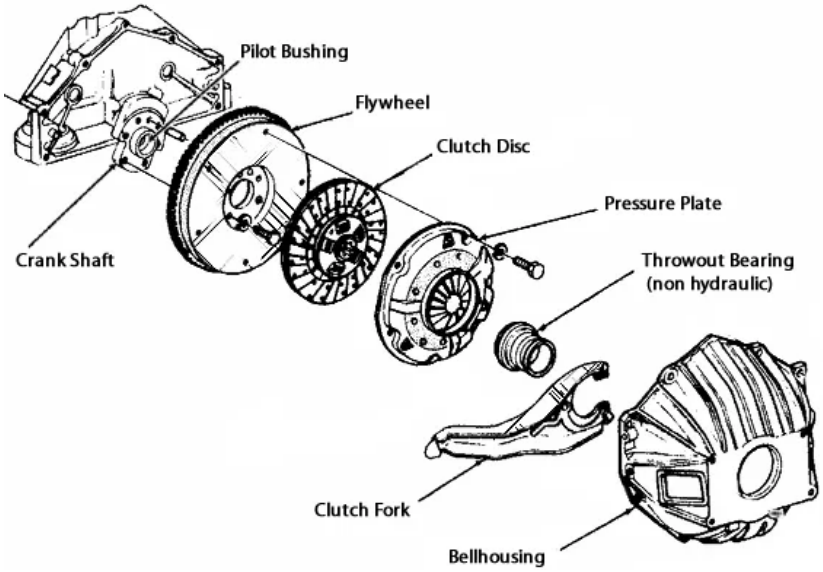
Types of Dry Friction Clutches

- Cone clutch
- Plate Clutch
  - Single Plate clutch
  - Multi Plate clutch
- Semi Centrifugal clutch
- Centrifugal clutch



Clutch Assembly - Components

1. Driving Member
2. Driven Member
3. Operating Member



Driving Member :

- Pressure plate assembly and flywheel

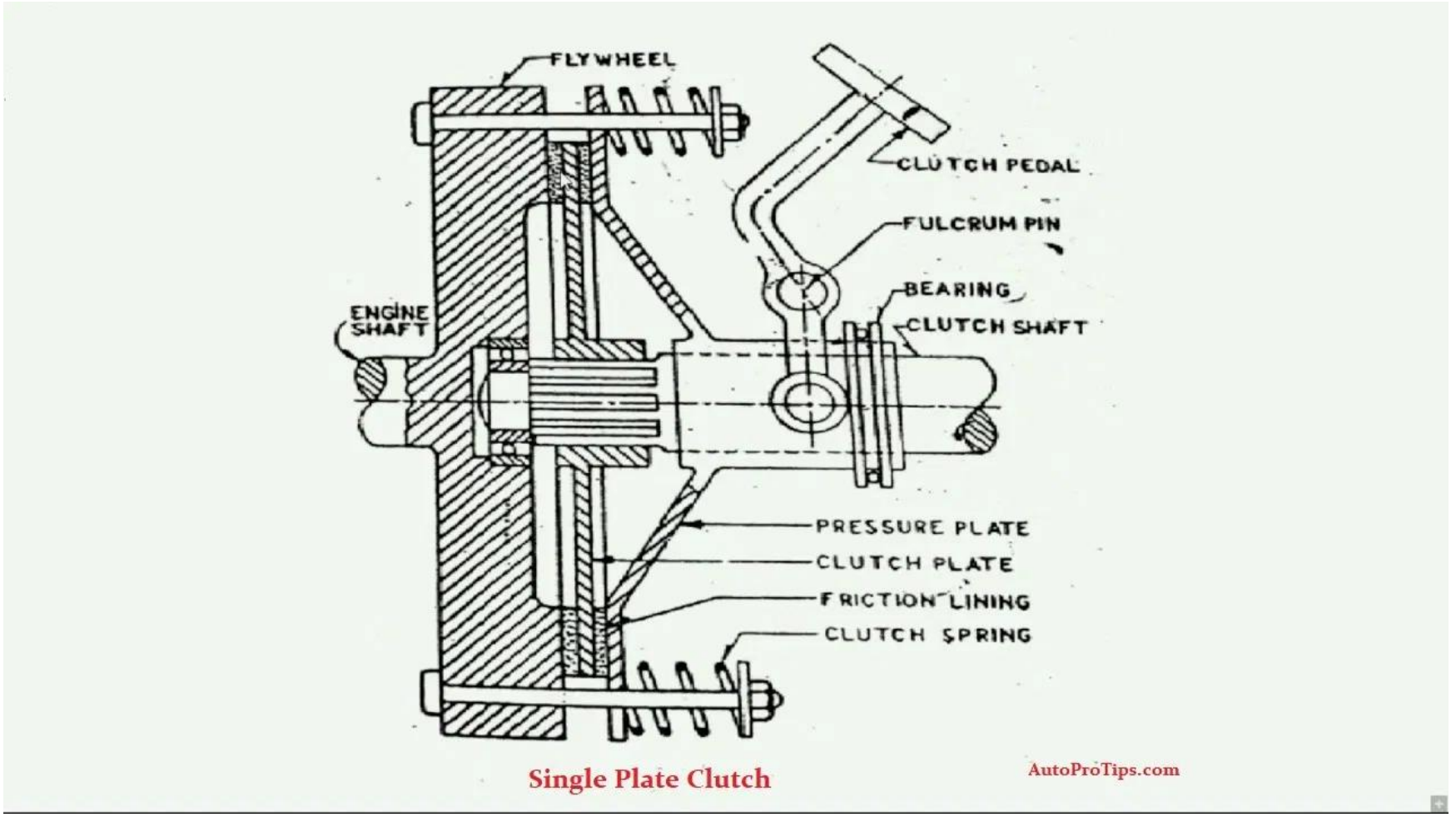
Driven Member :

- Disc or plate assembly and clutch shaft

Operating Member :

- Release earing, Release lever, Foot pedal, linkage and spring with adjuster

Single Plate clutch



Single Plate clutch working

- Friction Linings or Facings – To provide better Friction coefficient property
- Pressure plate with Studs, forced by means of Springs
- Withdrawal sleeve to push the plate away from flywheel
- Adjustable link to provide full force over driven plate
- When pedal is pressed, clutch forks push pressure plate away from Flywheel : Disengages from Engine transmission
- When pedal is released, driven plate can follow either transferred directly from flywheel face to driven plate : Engages from Engine transmission

Single Plate clutch : Design Details

14.2.1. Torque Transmitted

Referring to Fig. 14.3, let

r_1 and r_2 = internal and external radii of contact surface respectively, m,

W = axial load exerted by actuating springs, N,

and μ = coefficient of friction between the contact surfaces.

Though the value of μ varies from point to point on the contact surface as it depends upon the relative velocity and the intensity of pressure, it is assumed to be constant for simplicity in calculations.

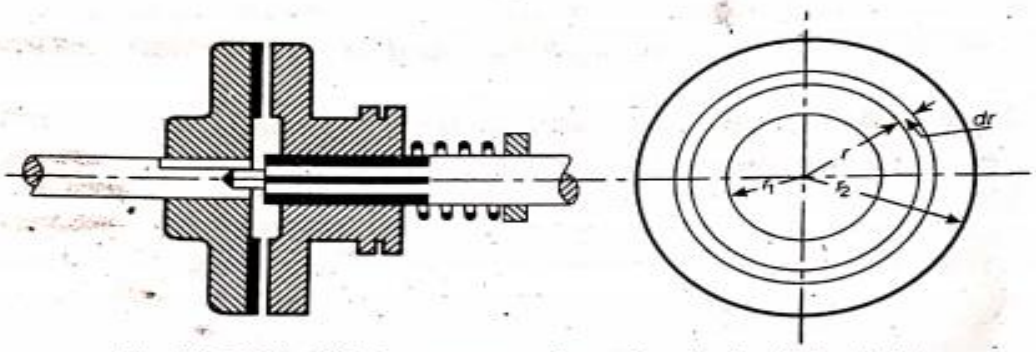


Fig. 14.3. Simplified representation of a single plate clutch.

Elemental area of ring at a radius r, of radial width $dr = 2\pi r\, dr$.

Let p = normal pressure, Pa.

Then, total axial, $W = \int_{r_1}^{r_2} 2\pi r\, dr\, p$,

and total frictional torque, $T = \int^{r_2} 2\,\mu\pi\, r^2\, dr\, p$.

Single Plate clutch : Design Details (Uniform intensity of Pressure)

Uniform Intensity of Pressure. When the two surfaces have perfect contact, the pressure p is uniform over the entire surface. The intensity of pressure becomes,

$$p = W/\int_{r_1}^{r_2} 2\pi r\, dr = W/2\,\pi\left(\frac{r^2}{2}\right)_{r_1}^{r_2} = W/[\pi\left(r_2^2 - r_1^2\right)].$$

Therefore, total frictional torque, $T = \int_{r_1}^{r_2} 2\,\mu\pi\, pr^2\, dr$

$$= 2\,\mu\,\pi\, p\left(\frac{r^3}{3}\right)_{r_1}^{r_2} = 2\,\mu\,\pi\,\frac{W}{\pi\,(r_2^2 - r_1^2)} \times \frac{(r_2^3 - r_1^3)}{3} = \frac{2}{3}\,\mu\, W\,\frac{(r_2^3 - r_1^3)}{(r_2^2 - r_1^2)}, \text{ Nm.}$$

Single Plate clutch : Design Details (Uniform Rate of wear)

Uniform Rate of Wear:

$$W = 2\pi C \int_{r_1}^{r_2} dr = 2\pi C (r_2 - r_1).$$

or $$C = W/[2\pi (r_2 - r_1)].$$

Total frictional torque becomes,

$$T = 2\pi C \int_{r_1}^{r_2} r\, dr = \mu\pi C(r_2^2 - r_1^2) = \mu W (r_2 + r_1)/2, \text{ Nm} = \mu W R, \text{ Nm},$$

where R is the mean radius of the friction surface $= (r_2 + r_1)/2$.

For a single plate clutch having a pair of contact surfaces, $T = \mu W (r_2 + r_1)$, Nm.

For multiple clutch having n pair of contact surfaces, $T = \mu W n (r_2 + r_1)/2$, Nm.

To have n pair of contact surfaces, there must be $(n+1)$ numbers discs or plates. If there are n_A no of discs on the driving shaft and n_B no of discs on the driven shaft, then the number of pairs of contact surfaces are $n = n_A + n_B - 1$.

Advantages and Disadvantages of Single Plate Clutch

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Advantages:

1. Gear changing is easier than other types
2. Pedal Movement is less
3. More Reliable

Disadvantages:

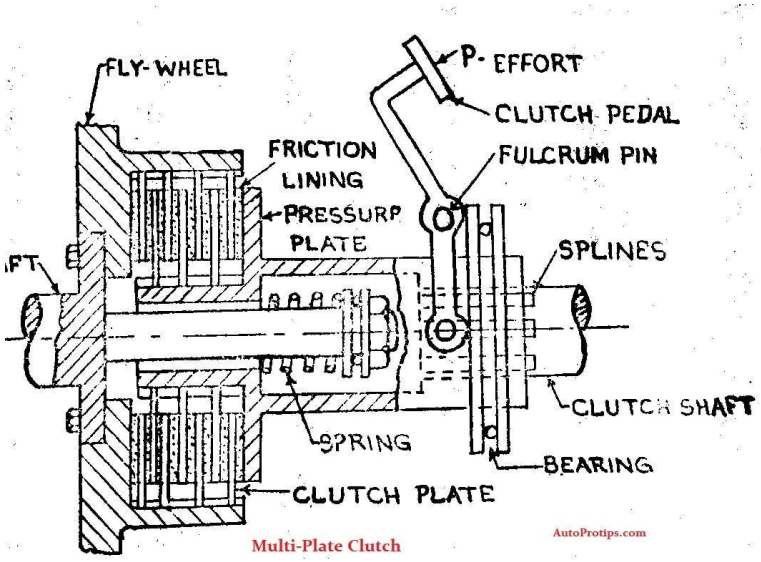
1. Springs are of Stiff and greater force required for disengaging
2. Undesirable noise due to release of levers in engaged position

Double Clutch

- Same as single plate except another driving disc and intermediate disc added
- Both driven discs are mounted on same or different hubs
- Driving disc and pressure plate are connected to Flywheel by parallel pins
- Operating Mechanism remains same

Multi Plate clutch

- Contains more than three discs
- This clutch has greater capacity to transmit power due to high frictional area
- Contains alternate driving and driven discs
- Driving discs connected to flywheel and driven disc to clutch shaft
- Used in heavy transport and Racing cars



Multi Plate Clutch: Design Details (Uniform Pressure and Rate of Wear)

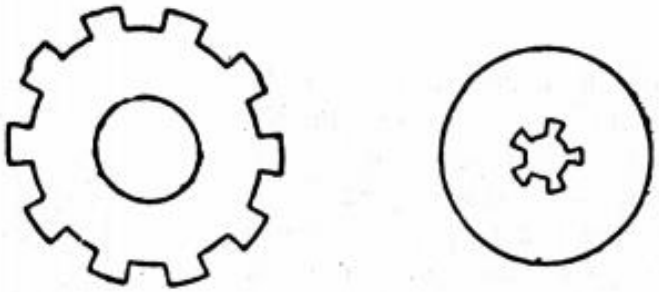


Fig. 3.22. Friction plates of a multiplate clutch. (*a*) Plates with outer teeth, (*b*) Plates with inner teeth.

Design details

If n = total number of friction plates in the multiplate clutch, then, number of pairs of contact surfaces $= (n - 1)$.

Then the torque equation, [Eq. (3.1)] is modified as,

$$T = (n-1)\,\mu\, WR \qquad \ldots(3.19)$$

Accordingly,

(*i*) For uniform pressure intensity,

$$T = (n-1)\,\mu\, W\,\frac{2}{3}\left(\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) \qquad \ldots(3.20)$$

(*ii*) For uniform rate of wear,

$$T = (n-1)\,\mu\, W\left(\frac{r_i + r_o}{2}\right) \qquad \ldots(3.21)$$

Clutches

Multi Plate clutch :

https://www.youtube.com/watch?v=TcYsV063lk8

https://www.youtube.com/watch?v=7L1cnYEOpDI

Revision

- L1 to L7 Slides
- Sample Format of Questions

Next Class

- Important Questions
- Numericals