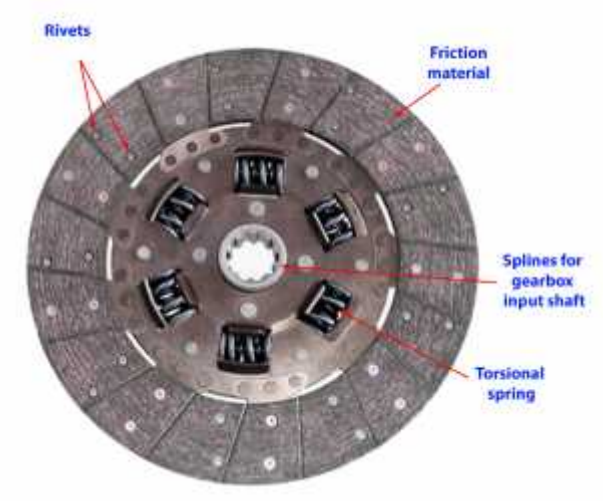
Fundamentals of Automotive Systems
Prof. C. S. Shankar Ram
Department of Engineering Design
Indian Institute of Technology-Madras

Lecture - 32
Automotive Clutch Part 02

So, the first component that we will look at closely is the clutch plate. So, if we look at a clutch plate we can immediately observe that it has friction material okay on it. So we can see that this is the clutch plate. So this there are what are called splines for mounting the clutch plate on the gearbox input shaft. So, you can see that splines are like teeth like to say projections on the inner surface, so that you can slide it on the corresponding splines on the input shaft to the gearbox, so, that any rotation of the clutch plate is transmitted to the gearbox input shaft.

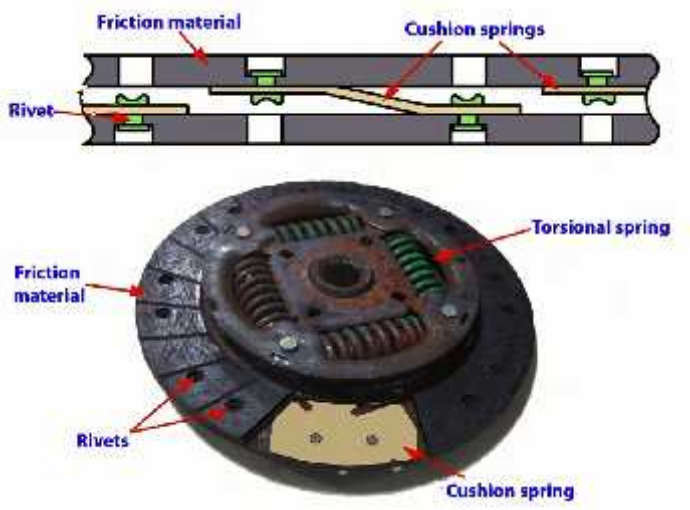


CLUTCH PLATE

So, we can see that this central hub of the clutch plate has a splined arrangement okay. We can also observe that a friction material is riveted on the periphery of clutch plate okay. So this friction material enables the what to say pickup of torque from the flywheels when the clutch is engaged when the clutch plate is initially pressed against the flywheel by the pressure plate and we can also see these coil springs which are mounted here along what to say along a circle right.

So these coil springs are mounted in cavities okay in the what to say core of the clutch plate and the main function is to ensure that they reduce torsional vibrations okay so they act as torsional springs. So when the clutch is initially engaged, imagine that the clutch is in between my hands the clutch plate, so let us say this is the flywheel and this is the pressure plate. So what is going to happen? The pressure plate is going to push the clutch plate against the flywheel.

So let us say the clutch is at rest. The clutch plate is at rest and the flywheel is rotating and some nonzero speed. So suddenly there is a torque that is transmitted right and there is a speed differential. So, there can be some sudden right due to the sudden peak of the torque. So these coil springs, serve to reduce the torsional vibrations that can result due to the engagement between the clutch plate and the fly wheel okay. So that is the role of the coil spring.



CUSHION SPRING – IN A CLUTCH PLATE

And a similar mechanism is also provided along the axis. So if you look at the cut section of this clutch plate, you can see that the central plate of the clutch plate when it goes to the friction material has a shape which is like this okay, it is a thin plate, but it is pressed like this. Why do you do we think is pressed like this because it cushions any sudden load that comes along the axis. So imagine that the clutch plate is in between my hands when I press the clutch plate, in between the flywheel and the pressure plate, there is also going to be force along the axial direction, so if when I suddenly press it there can be sudden shocks and vibrations along the axis.

So to reduce and absorb those forces, we have these cushions, springs, they are not springs persay, there is a they are not realized as typical coil springs, but then the clutch plate material itself has the shape along the periphery, so that the forces are absorbed by these cushion spring so, we look at this cut section.

LOCATION OF CUSHION SPRING IN A CLUTCH

So, we can see that this material is like the blade of a fan. So, this comes from the you can see this what to say these arms attached here to the central hub of the clutch plate. So, what happens is that imagine that these are like some loops like this okay. So there are plates, which essentially project from the hub and they are depressed like this very small depression. So that the force get cushion so you can see one such thing here. So that is essentially attached to the core of the clutch plate okay.

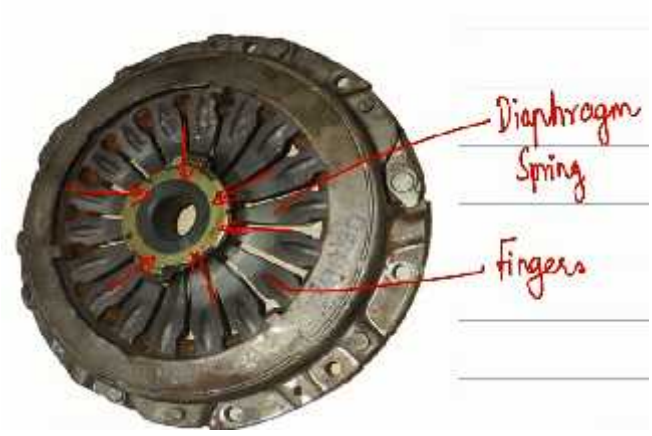
So, main some main features of the clutch plate are that it is essentially situated between the flywheel and the pressure plate okay. So the splines on the clutch plate mesh with those on the input shaft to the gearbox.

And if we look at the springs, coil springs these are these perform the role of torsional springs okay. So these are nothing but coil springs which are compressed in corresponding slots that are arranged tangentially right. So, the main function of these springs is that they reduce the torsional vibrations and similarly the cushion spring okay. So essentially reduce the sudden the effects for sudden engagement between the clutch plates and flywheel along the axial direction okay.

So that is the role of this cushion spring. And typically these clutch friction linings are riveted on both sides of the clutch plate please note that the clutch plate we can see that the friction material is riveted on both sides of the clutch plate. So, one side engages with the pressure plate another side engages with the flywheel okay so the friction linings are riveted on both sides of the clutch plates and commonly most automotive applications you know like vehicle applications you know these friction linings are mainly organic linings. So, organic linings essentially consists of yarns which are made up of glass, aramid and cellulose fibers embedded in.

So, these fibers provide the structural strength okay. They are embedded in a matrix of resins and fillers okay, so that is the typical lining which is used. So, there are metallic linings also used in some applications off road applications okay off road vehicles and in some applications you know like this organic linings are also realized as carbon linings. So, carbon linings form a subgroup of this organic linings and in carbon linings what happens is that like carbon fibers are introduced to increase stiffness of the lining material and temperature resistance.

For example, they are used in race vehicles you know like where we need to engage and disengage you know very more very frequently. So and temperature resistance also becomes important okay. So these are the clutch linings okay. So, this is a clutch plate. So the clutch plate is pressed against the fly wheel by the pressure plate. So, the pressure plate assembly essentially pushes the clutch plate against the flywheel.



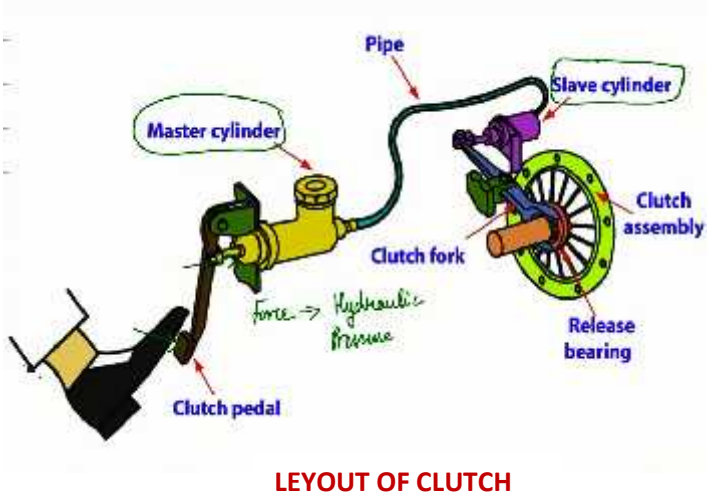
CLUTCH ASSEBLY

So how is this pressure plate realized let us look at that so, this essentially a pressure plate assembly, so called diaphragm spring okay. So, this core is what is called as a diaphragm spring okay. So what happens is that like these diaphragm springs have these so called fingers okay we can see these slender projections and slender metallic plates which are coming towards the center and these fingers are pivoted about the pivoted bearing and then connected to the pressure plate on the other side.

So what happens is that like when we depress the clutch pedal, we are any way going to apply a force on the center of the structure through the release bearing. So when we apply a force, which essentially acts on this, this finger acts like a pivot. So, when we apply a force like this, what is going to happen to this iron it is going to be pulled up, but this end is connected to the pressure plate. So, what happens to the pressure plate, the pressure plate also moves up and the clutch plate is here.

Okay so, when the diaphragm spring is pressed in this way, the pressure plate is moved away from the clutch plate by the spring action of this fingers when the force is released, the motion happens in the opposite direction right, and the pressure plate then pushes the clutch plate against the flywheel okay. So this so called diaphragm spring is used to engage and disengage the clutch okay. So that is what that is the role of this diaphragm spring on the pressure plate okay. And the actuation of these diaphragm springs takes place through by means of the release bearing and what happens in when we engage the clutch pedal is following.

So when we actuate the clutch pedal there can be multiple what to say means so this clutch actuation can be mechanical it can be hydraulic okay. So please note that it is a good amount of forces needed to depress this diaphragm spring good amount of forces needs to be applied on the release bearing to essentially disengage the clutch and what is the source of this force the human pedal input please note that a driver typically presses the clutch very, what to say frequently when while driving a car. So, imagine driving in city traffic you know like, we have to press the clutch often.



LEYOUT OF CLUTCH

So, we need to provide enough mechanical advantage so that the force which is applied by the driver is sufficiently small and is magnified from the input to the release bearing such that the clutch is engaged and disengaged, approximately. So, early clutch mechanisms used a purely mechanical action where we had cables and leavers and the magnification of the force was due to lever arm action okay. So, nowadays you know like in most clutches, you know we use a hydraulic means of magnifying this force.

So, when the driver presses the clutch pedal, so, what happens is that like there is something called as a master cylinder in the clutch mechanism, when you come to brakes, we will see that there is a master cylinder in a hydraulic brake system that is different. So, in this master cylinder what happens is that this force is converted to a hydraulic pressure okay. And this pressure is transmitted through the fluid in the pipe and that then goes to what is called as a slave cylinder which is closer to the clutch assembly okay.

So, the slave cylinder, then actuates the clutch fork and the clutch for then goes in, presses the release bearing and disengages the clutch. So, that is how the action of this hydraulic system works. So, the magnification of the drivers input force is done both by using lever action because still even here there is a lever, magnification right one here and another action here there is a lever arm action right and by suitably adjusting the dimensions of the master and slave cylinders right because by suitably adjusting the sizes of the master and slave cylinders, we can adjust the magnification of the nodes. So that is how the clutch actuation takes place.

The torque transmitted by the clutch is

$$T_c = (\mu F_{axial}) r_m n$$

μ ⟶ clutch lining friction coefft. (0.3 to 0.45 for organic friction linings).

F_{axial} ⟶ Axial force applied on the clutch plate.

r_m ⟶ average radius.

n ⟶ number of friction surfaces.

n = 2, for a single-plate clutch.
n = 4, for a two-plate clutch.

So finally, the torque which is transmitted by the clutch at steady state is given by following. So let us say the coefficient of friction of the clutch friction lining is meu and let us say an axial force of F axial is applied, because the pressure plate pushing against this. So this is going to be the tangential friction force perpendicular, to the lump tangential friction force on the clutch plate. And let us say we lump all this force at a mean radius R of course the contact is over the face of the friction material.

Let us say we lump all these forces at a mean radius and multiply it by n, where n is the number of what to say clutch plates okay. So friction surfaces on the clutch plate. So this meu is the clutch lining friction coefficient. So typically around point three two point four five for organic fiction and linings that are used. So F axial is the axial force applied on the clutch plate or M is the mean or average radius used in this calculation and n is indicates the number of friction surfaces.

So, n is typically two for a single plate clutch okay and if we have a two plate clutch right they N will be equal to four okay and so on . So, typically we use a multi plate clutch when we want to transmit higher torques okay so that is when we use a multi plate clutch for example in heavy vehicles and so on where we want to transmit more work we go for the multi plate clutch. So, this is the, this is a broad overview of the friction clutch which is used in the automotive power train.

So, just to go back to the layout of the power train, so, in today's class we have looked at the clutch okay. So, tomorrow we will look at the gearbox, which is downstream from the clutch in the power train. We will see how they are realized, what are its features and so on. And then we will look at, you know how to put all these things together to match the specifications of the gearbox to the vehicle performance requirements is given a particular engine. So that is something that we will do. So I will stop here for today. Thank you.