Fundamentals of Automotive Systems
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Lecture – 43
Components of a Brake System and Drum Brake – Part 01

Okay, yeah greetings, so welcome to today's class, so quick recap of what we discussed in the previous lecture, so we were looking at braking, we just looked at you know what are the functional requirements of a brake and then we briefly looked at you know how brakes evolve from very simple mechanisms to where we are today particularly, with respect to the drum brake and a disc brake.

And we discussed certain important attributes that is required of what is called as a friction brake system which is what we are discussing you know like, and those the attributes were in terms of stopping distance, stability and reliability, okay.

So, let us continue from here, so the first topic that we are going to discuss would be to identify in general, what are the various components of a brake system, okay so that is something which we will start off with. So, if you look at any general brake system you know like, how can we enumerate, you know like the various components that constitute the; okay. So, the first broad component is the source of energy, okay.

So, if you look at sources of energy in a brake system, we can immediately realise that most commonly in any vehicle that we will be driving, right let us say, we start from a bicycle to a two wheeler and a four wheeler and so on, the main source of energy would be the human effort, of course which gets magnified and then transmitted down the line to the wheels but as it stands you know the main effort or the energy source comes from the human being, right.

So, essentially if we look at the sources of energy, the human effort is a primary source however, you know like in many scenarios, this human effort is augmented by what is called as an assist system or a boost system for example, we would look at what is called as a vacuum booster,

when we look at hydraulic brakes, so the pedal input or the force that is provided by the driver is magnified or augmented you know like by assist systems, okay.

And in some cases, what we call as power brakes, we have a separate source of energy for example, let us say we take heavy vehicle brakes you know like trucks and buses, what happens is that like in them you know like we have compressed air, you might have seen these tanks on the side of a truck with air written on them, right. So, those tanks essentially stored compressed air; pressurised air.

And air is taken from the atmosphere and a compressor pressurises and stores them; stores the compressed air in them, right. So, then when the driver presses the brake pedal in a truck or a bus, what the driver was actually doing is not to transmit that force to the wheels directly however, the driver is only regulating how much compressed air is taken from those tanks and given to the brakes on the wheel.

Such brake systems are what are called power brakes, okay so, where the driver is only regulating or metering out a source of energy, okay. So, in a power brake the driver input is used to model it the source of energy, okay. So, in example is an air brake which we will discuss in detail later on, so those are typical sources of energy in a brake system.

The second component; broad set of components you know like in a typical brake system is a mechanism for applying the brake, so typically if we look at how we apply brakes right, so all of us are familiar with how we apply the brakes, typically we use let us say, hand levers, right or foot pedal, correct, so for actuating the brake or applying the brake. So, typically these mechanisms take the form of foot pedal or hand levers, right.

So, that is a mechanism for applying the brake, third broad set of components in a brake system is what is called as an energy transmitting medium. So, the question is; how is the energy transmitted from the source to the wheels, right, please note that we are dealing with friction braking that means that on the wheels you know we have these brake units which essentially convert the kinetic energy into thermal energy, right.

So, from the source of energy or the; from the point of the driver actuation, how is the energy for braking transmitted, so we have once again different possibilities. In a purely mechanical brake for example, you know like in bicycles and also like most like two wheelers right, so we would have seen that the energy transmitting medium from let us say the hand lever would be in the form of cables, some levers, rods and so on, right, so that is purely mechanical, right.

So, mechanical brakes essentially utilise levers, rods, cables etc., to transmit this energy okay, so that is a mechanical brake, so most passenger cars, SUVs, certain class of light commercial vehicles, certain class of motorcycles you know like so, would use a hydraulic brake which uses an incompressible fluid, an almost incompressible fluid right, so what we call as the brake fluid, so to transmit the energy, okay. So, that is what happens in a hydraulic brake, right.

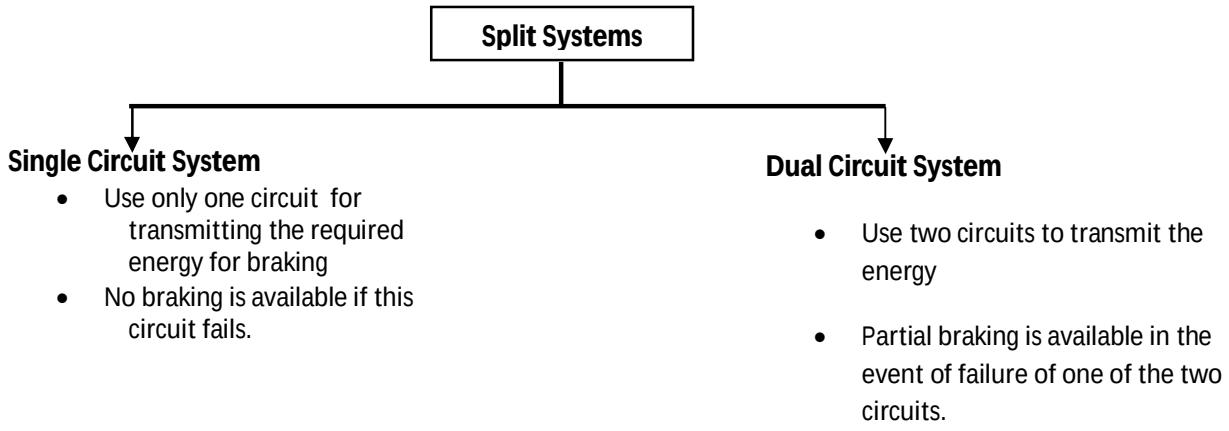
So, then we have air brakes which are used in trucks and buses, they utilise; uses compressed air as the energy transmitting medium, right. So, we can also have combination of this, so we can have a combination of these energy transmitting medium also so, for example we can have what are called air over hydraulic brakes, okay, part of the energy transmission is done by compressed air and then like then part over brake fluids and so on, right.

So, we can have a mixture of them but as we discussed in the previous class when we talked about reliability; we typically introduce a redundancy to prevent failure in the component of which we deem to be more susceptible to failure and if you look at the brake system per se, we are going to look at one more component in a very generic brake system right, so the weakest link is going to be this energy transmission circuit, okay.

So, the energy transmission circuit is going to be the; is going to be more prone, it is not still what to say good but then like chances of failure creeping in, false creeping in are relatively more right. So, then we look at by regulation now, we need to use what are called as dual circuit systems you know like to essentially protect against failure.

So, consequently there is what is called as this notion of split system, okay, so what do I mean by split systems you know like so, the energy transmission circuit or the path you know can be

design to be a single circuit system or a dual circuit system. So, what do we mean by this; you know like single circuit means as the name indicates there is only one circuit for transmitting the energy.



So, imagine that you know like we had only one point of control for the driver and there is only one essentially circuit you know like let it be hydraulic, mechanical or compressed air that provides this energy to let us say all the wheel; the brakes on all the wheels, right. So, use only one circuit for transmitting the energy required for braking, okay and obviously, if there is any failure in this or fault in this circuit that is going to be very detrimental, right.

So, no friction braking or no braking would be available, if the circuit fails, right, obviously, so that is a limitation of a single circuit system. Now, almost all brakes are dual circuit systems, you know like we are mandated to be dual circuit systems, so you can see that this is seen very naturally in let us say in bicycles or certain class of two wheelers, right. So, for example if you look at two wheelers you know like our left hand lever would typically actuate the rear brake.

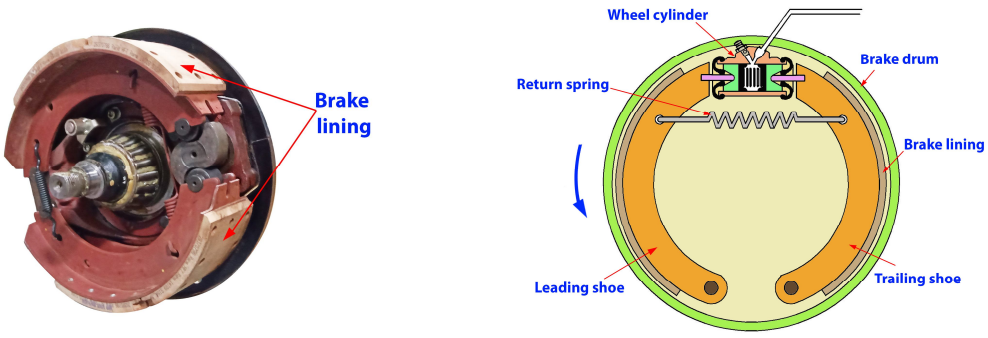
And the right will actuate the front, okay in bicycles and certain class of two wheelers, where you have the left hand lever in a two wheeler connected to a clutch, your rear brake is going to be actuated by a foot pedal, right. So, you can evidently see that there are two control points for the driver and there are consequently there will be two separate circuits, so that is very clearly visible you know from the outside.

In a passenger car you know, there is only one control point typically, or one point for actuation which is a foot pedal but as we will see that when we look at the hydraulic brake system internally, there is going to be a split, we will see how it happens, right, when we discuss a hydraulic brake system, right. So, dual circuit systems use two circuits to transmit this energy and the main advantage as we would have realised a partial braking is available in the event of failure of one of the two circuits that is a big advantage, is it not, right.

So, we still have partial brake capacity or braking capacity even, if one circuit fails, right, so that is an advantage of a dual circuit brake system, we will see how they are realised in hydraulic and air brakes as we go along, okay, so that is the energy transmitting medium and circuit.

So, the 4th broad set of components in a typical brake system essentially, takes the form of foundation brakes, so what are foundation brakes? These are essentially, the brake units of the wheels, so that essentially act on the wheels, right then use the energy that is transmitted by the energy transmission circuit and then convert the vehicle kinetic energy into thermal energy and dissipated.

So, today you know like, if you look at foundation brakes, the two common brakes that are used, the drum brakes and the disc brakes, okay, so let us look at them more closely, okay, so these are the four broad set of components.



DRUM BRAKE

So, let us go and look at drum brakes first, so as we discussed in the previous class, the notion of drum brakes came over from the concept of this internal expanding brake, right so, where we

wanted to have the friction element within an enclosure and when the brake was applied, these friction pads moved outside and contacted the inner surface of a rotating element to generate the braking torque, right so, that is the basic concept behind the drum brakes.

So, let us look at various realisations of drum brake, so if; this is just a photograph of a drum brake that is used in heavy vehicles, we look at other what to say, configurations also, so what happens here right, so let me paste another diagram, so this is a schematic of a drum brake which is used in a hydraulic brakes like in cars and so on, right, okay. So, let us look at both scenarios, alright, so we will discuss them in more detail as we go to hydraulic and air brakes.

So, but the basic idea is the following, right so, you have these two what to say, brake shoes so, these are what we can label as a brake shoe and we have this brake friction lining right. So, what happens is that like when the brake is applied in the brake shoes are pivoted on a backing plate as you can observe here and the force is applied here, so this is what is called as a S-cam brake, we will come to this S-cam brake later on.

But the cam is going to rotate here and then like it is going to push the to this end of the brake shoe away from one another, so what will happen; these brake shoes will rotate about this pivot, they will go and contact the drum which is rotating along the wheel and if decelerating torque is going to be generated. So, here in a hydraulic brake, the same action right, so you can see these two brake shoes, right and essentially, there is something called as the wheel cylinder, we will discuss this later on.

So, that essentially converts this brake fluid pressure to a mechanical force which essentially is an actuation force and that actuation force acts on the brake shoes and these brake shoes essentially move and then rotate about this pivot and go and contact the inner surface of the brake drum and once the contact is; sufficient contact is made due to friction, a decelerating torque is produced, okay, so that is the mechanism for a simple drum brake.

And we have a return spring, so you can see this return spring here okay so, which essentially ensures you can see a return spring, right so, which essentially ensures that you know the brake

shoes come back to their original position, once the brake is released okay, so that the contact in the lining and the drum is are broken, so pretty simple in construction and operation. Now, before we go to its analysis, there are a few advantages and limitations.

Advantages is that like it is; we will look at one important advantage of a drum brake as we do the analysis but we will immediately realise that as we keep on operating this drum brake, what is going to happen; see the brake drum is going to expand, right with all the heat energy that is result in due to this braking; friction braking process. So, then what happens is that this clearance between the brake friction lining and the brake drum is going to keep on increasing.

Then, what happens; as the clearing; clearance increases, the brake shoes also have to move a longer distance to get applied, right so that is something we need to remember, so not only the clearance increased due to brake pad wear but also during the operation of the vehicle due to what is called as thermal expansion, the clearance is going to increase.

So, one what to say, issue we must be aware of is essentially, a thermal expansion resulting increased clearance; thermal expansion of brake drum, right which is resulting in the increased clearance, okay. So, the clearance also increases due to brake pad wear that is another issue. Now, another issue is that as temperature increases, not only would this clearance increase due to this thermal expansion, even the fiction properties of brake lining would change, right.

The brake lining material you know is also like sensitive to temperature, so what happens is that there is something called as brake fade, so what is brake fade? Brake fade is the reduction in the brake friction lining coefficient with increase in temperature, okay, so that is essentially what is called as brake fade okay, so that is also an important issue, right. So, because we want some baseline brake torque, right to keep the; to meet the design braking requirements right.

So, we do not want the coefficient of friction, for of the friction lining to fall too much, so that is an important aspect, right. So, now I am; what I am going to do is that like I am going to do a very simple analysis, okay of this drum brake, okay. So, let us consider this drum brake and then

like, we will use simple; even like dynamics to analyse how this drum brake response and what is the output from the drum brake.

So, and if in fact look at the schematic, you know like 1 shoe is what is called as a leading shoe, another shoe is called as a trailing shoe right, let us also figure out what do we mean, right so, I have not explained them yet, we are going to get a what to say, understanding of these terms, when we do the analysis, so but as indicated in the figure, we will assume that the brake drum is rotating counter clockwise without loss of generality, you can rotate the other way also.

But we are considering it to counter clockwise, let us consider this leading shoe and then like let us do a simple analysis, okay of this thing, so in this analysis, what we are going to do is that like let us neglect the weight of the brake shoe, when compared to the other forces, we are going to identify what other forces are going to come into play, right so, that MG component, right of the brake shoe is something we will neglect, okay.

We considered to be relatively small, we have also neglect the spring restoring force in addition to the weight of the brake shoe when compared to the other force components, right so that are acting on the brake shoe, right.