Fundamentals of Automotive Systems
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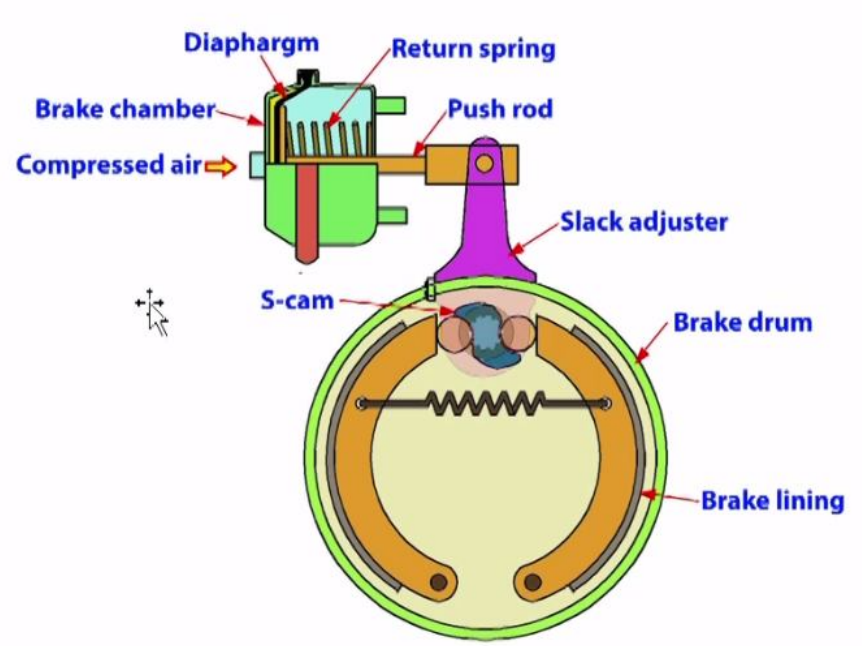
Module No # 10
Lecture No # 50
Air Brake System – Part 02

Now let us look at the next component we are going to look at or what are called as brake chambers. So let us look at what is called as a brake chambers?



BRAKE CHAMBER FOR DRUM BRAKE

If you look at the foundation brakes okay in most of the heavy vehicles once again they are going to use a drum or disc brakes. But for the time being let us look at a drum brake and then we will see what happens ok. So of course sorry there is a typo here this should be diaphragm alright sorry about that.

So what happens is the brake chamber is that this compressed air right. So let say we consider one of the brake chambers front or rear the compressed air comes through all these valves it enters the brake chamber right. The brake chamber is a diaphragm which is essentially support by a return spring. Now when the compressed air enters what happens? The air pressure is going to act on this side of the diaphragm. It is going to displace this diaphragm and the diaphragm attached to a component called as the push rod.

The push rod is nothing but the rod which is pushed out of the brake chamber when the compressed air enters the brake chamber and generates a mechanical force right. So when the push rod comes out of the brake chamber it essentially rotates a component which is called as a slack adjuster. So a slack adjuster is nothing but a lever ok so on which a force is applied by the push rod. So the lever is mounted on a shaft on splines. We have already seen what is splines are right.

So teeth like projections. So when this lever is pushed or the slack adjuster is pushed from the top what is going to happen? It is going to rotate about this axis or the shaft axis on which it is mounted. So the slack adjuster will rotate. When the slack adjuster rotates the shaft will rotate then on the other end of the shaft, we have a cam in the shape of an S which is mounted.

So that is why these brakes are what are called as S cam brakes ok. So if someone talks about S cam brake there are in essence talking about this heavy vehicle brakes where the foundation brake is a drum brake, which an S cam okay. So this is nothing but a drum brake with a cam shaped in the form of a S that is an S cam brake. So what is going to happen? The push rod will rotate the slack adjuster. This S cam will be rotated because it is mounted on a same shaft.

Now then what will happen these roller will rotate will move on the cam profile. When the S cam rotate the cam has a profile right. These rollers will move on the cam profile and they will push the brake pads out. So what is going to happen? The brake pads will move out, brake shoes will move out and contact the brake drum. That drum brake operation is same ok. Once you have an actuation force on the free ends of the brake shoes you know they are going to rotate about the pivot and go and contact the brake drum and generate the braking torque.

Now the question arises why such an elaborate mechanism right because in a hydraulic brake system we essentially had a wheel cylinder that applied the actuation force. The wheel cylinder was fitted in this drum brake unit and hide fluid pressure came in and hydraulic pressure brake fluid pressure came in actuated the drum brake. Here why do we have such an elaborate mechanism there are multiple reasons to that right.

The first reason is that when you look at an, heavy vehicle compare to the passengers car its mass is more right. Then if you want to brake a heavy vehicle at the same deceleration the braking force will be should be should be larger I am sure all of us can agree to that because “m’ times “a” would be higher for the same a right for a heavy vehicle as suppose to a passenger car. So we need to essentially generate a larger braking force.

That translates to a larger braking torque or more output from the drum brake right in a heavy vehicle. So yes the dimension of, a brake are going in a heavy vehicle air brake system are going to be slightly larger than that in a passenger car. But it is not going to be as heavy sorry or as large to a have a huge increase in the brake torque. So for example let us say we take a car that weighs 1000 kilograms, we

take a truck or a bust which weighs 10,000 kilograms I am just taking a round number so that we can argue easily right.

So we need one order of magnitude higher braking torque. Do we have will we essentially increase the dimensions of the drum brake to such an extent that we get an order of magnitude increase in the braking torque unlikely alright. So what we may need to do? We need to increase the actuation force all the brake factor can be adjusted but then like we need to have more actuation force to get a higher brake output is it not that is point number 1.

Now if I need a higher actuation force, I need a bigger actuator. So and or a larger operating pressure is it not right. Actuation force in this fluid-based actuation system will be pressure times, area at steady state. So if I want one order of magnitude more actuation force I need higher actuation pressure or higher actuated area or preferably both right. Now actuator area is constrained by the dimension of the drum brake I cannot put a big actuator in the space available.

Actuation pressure in air brakes is one order of the magnitude lower than that of hydraulic brakes. See this is our maximum of order of 10 there you can have brake pressure in a hydraulic brake system the brake pressure can go up to 10 the order of 10 power 2 bars alright. So you can see that the maximum operating pressure in an air brake itself is 1 order of magnitude lower than that of a hydraulic brake. In fact we would have wanted the other way right.

So you can see that now I have a huge deficit right because the actuating pressure is smaller than that of a hydraulic brake. Then how do I generate higher actuating force? So for that we use this mechanism. So what we do is that we use a combination of larger actuated area and lever arm action to help us. So we put a

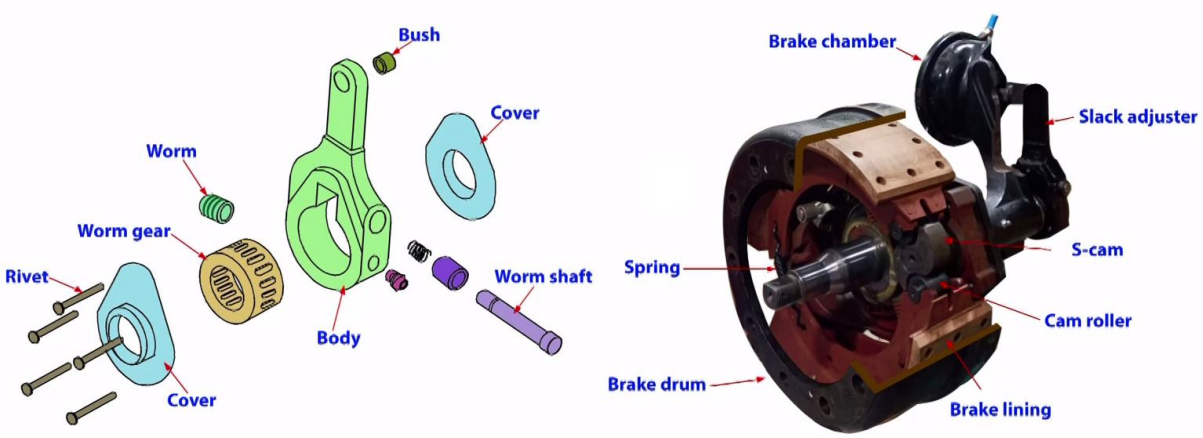
larger actuator outside the drum brake unit in the form of this brake chamber. So now I hope it is clear why we need a brake chamber outside the drum brake unit right.

That is reasonably large so that is going to generate some force and then we have this slack adjuster that is going to provide a magnification. And then like the torque on the slack adjuster shaft is going to be converted to an actuation force by this S cam radius alright. So important parameters are in the order I will just write so brake chamber area these are all important design parameters that allow us to regulate what is the magnification obtain right brake chamber area is one.

The slack adjuster arm length is another because that helps us in figuring out what is the torque that we get for a what, to say provide given push rod force output right. And the S cam radius because the S cam radius dictates what will be the force on the brake shoe that actuation force for a given torque right. Torque divided by S cam radius will give me the actuation force.

So these are important design parameters that help us in meeting the actuation force requirement for a heavy vehicle drum brake to match the expected increase brake force output as oppose to a hydraulic brake. Is it clear why we have this mechanism? But we also use disc brakes today in heavy vehicle disc brakes are also becoming popular. Once again, the actuation medium is compressor air but the mechanism will be slightly different to account for the fact that we are using the air disc brake ok.

So that is the main difference but the concept of the disc brake remains the same right. So this the S cam brake so if you look at a picture or a photograph of that just to give a perspective so this is how it look like



SLACK ADJUSTER

So essentially we can observe that the air enters into the brake chamber ok. So this is the push rod so we can see the slack adjuster that is going to be rotated and that is going to rotate the S cam ok. So this is the S cam and when the S cam is rotated the rollers are going to be displaced on the profile of S cam and the brake shoes are going to be pushed outside right. They will go contact the brake drum and generate the de decelerating force alright. So now this is what is called as a service brake chamber ok.

So what happens in normal operation ok? Shortly we are going to look at what happen under emergencies you know and what happens when we have when we want to park a heavy vehicle ok. So we are going to come to that. So if you look at the slack adjuster parse this is just a simple schematic to show what, are the components in a slack adjuster? So as we that is an important component because, it is going to convert the force applied by the push rod into a torque right.

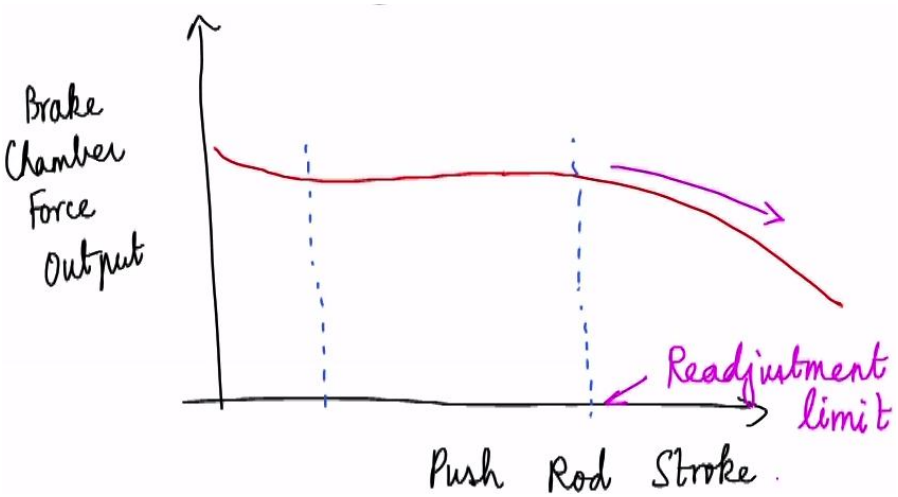
So we can observe that the slack in the slack adjuster body we have this warm gear you know like in which essentially has this splines on the inner side. So this, splines are a used to fit the slack adjuster on a splined S cam shaft right. So S cam

shaft this is the S cam shaft right the shaft has one end as a S cam the one is S cam the other end the slack is connected on splines. So then there is a worm gear with an adjustment mechanism and the slack adjuster has a hole where we can mount the push rod right. So the push rod is mounted at this point ok. So if you look at the slack adjuster arm length it is the distance between the center of this mounting hole and the center of the splined shaft ok.

So that is that is slack adjuster arm length. Now why do we require this worm shaft and why do we require the adjustment because as we discussed with the operation the drum brakes will wear out. Now what happens is that if you look if you go back to this schematic if the gap between the brake drum and the brake lining keeps on increasing what is going to happen is that? This stroke which is required for the push rod to enable the brake lining to contact the brake drum will increase.

I am sure all of us can appreciate it right with a as a brake lining wears out the stroke of the push rod required to displace the brake shoe and press the brake lining against the drum would increase. But however please note that there is constraint on the stroke of the push rod right that depends on the dimension on the brake chamber. So this stroke of the push rod cannot keep on what to say increasing forever right without a limit.

So at some point or at some limit the push rod stroke will reach a state where in this diaphragm may start hitting the brake component of the brake chamber components and the force output from the push rod is going to go down or decrease ok.



So if we plot the brake chamber force output this is push rod stroke what is going to happen is the following. We are going to see a drawing a diagram something like this for most operating pressures ok so some characteristic curve like this. So typically if you install a new brake lining we are going to have some base line stroke let say around half an inch right that is a typical stroke such that the drum brake is properly apply.

Now what happen is that like as a stroke keeps on increasing right as the brake lining get worn out or the brake drum expands due to the thermal expansion is so on. So if the push rod stroke reaches what is called as a readjustment limit alright. Then we can see that the output from the brake chamber starts falling down right because the diaphragm is going to go and hit the other surface of the brake chamber.

So that is going to take up some of the force out from the brake chamber right. So the stroke of the push rod is an important parameter that provides us with information on both the health of the air brake system. So it is a very useful diagnostic and prognostic parameter which tells us what is the state of this air

brake system right. So that is a very important point ok. So let me write that so please note that the output force from the brake chamber reduces significantly once the push rod stroke exceeds the so called re adjustment limit.

So once the readjustment limit is exceeded the brake force output reduces rapidly alright and that is something which you and I do not want. So the readjustment limit is specified by the manufacture ok. So that is why this slack adjuster has a an adjustment mechanism in the form of this mechanism.

So what happen is that there is what is called is an adjustment nut and someone has to go underneath the vehicle and check out this stroke of the push rod if it is very high what the mechanic does is that they rotate this adjustment nut so that the initial position of the worm gear itself is rotate right. So that the even with the brake being released the initial position of the brake pads are closer to the drum. Of course, this has to be done carefully right. We do not want the brake linings to be excessively worn out.

Then even if we use the adjustment mechanism we would not get proper brake force output right. So it has to be used judiciously this mechanism for adjusting the initial position. So there is an adjustment nut which can be turned to rotate this worm gear such that the initial position of the brake shoe relative to the drum itself is brough closer right. So that is the purpose of the adjustment mechanism. So based on the adjustment mechanism which is there if someone has to do it manually we have what is called a manual slack adjuster right.

And if the adjustment happens automatically when the vehicle is in operation there is something called an automatic slack adjuster ok. So this is these are 2 mechanism that are available ok for enabling this adjustment operation right ok.

There is another point you know like which is important as far as air brake systems are concerned in the presence of a leak in an air brake system the sensory feed back available to the driver is lower than in a hydraulic brake system.

As we discussed in the hydraulic brake system if there is a leak in the fluid circuit what is going to happen we will see that our pedal is going to become softer right to apply what is called as a pedal sinkage effect right. So that is going to be a result of the fact that we are losing brake fluid there right and we are losing that fluid pressure. So the reaction that comes to the driver is reduced. What was the physics behind it?

The physics behind it was due to the mechanics by which the hydraulic brake, system function's there the brake fluid is pressurized by the human force. Of course, the human force is magnified by mechanical and other means through a vacuum booster but ultimately the human effort though magnified is ultimate is finally used to pressurize the brake fluid. So if the pressure drops, that is going to directly influence the human or the reaction force provided to the driver.

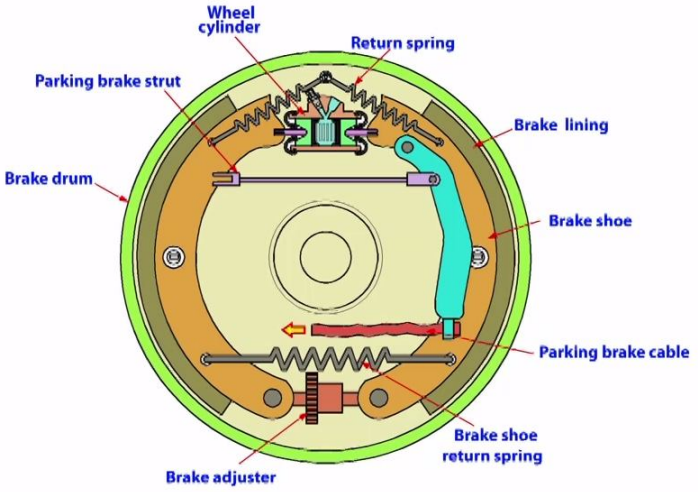
In an air brake system, the human effort does not pressurize the operating medium. So consequently, what happen is that the tactile feedback or the sensory feedback available to the driver in the presence of a leak in an air brake system is smaller. And that makes it a challenge for human beings to detect this ok. So that is another challenge with air brake systems ok. So the tactile feedback available to the driver is lower in an air brake system in the presence of a leak.

So obviously we can observe that a leak and an air brake system not only reduces the force output from the brake chamber why? There is a leak a pressure will drop right the particularly under even if we see braking condition the maximum pressure

available will drop in the brake chamber if the maximum pressure drops then the maximum force output also would be lower in the brake chamber.

Now another point is that like if there is a leak what is going to happen the brake system is going to try to pump in more air into the brake chamber consequently in the treadle valve and relay valve the connection between the supply and the delivery will always be open even if you have medium brake applications because why there is air leakage right. So that is going to bleed more air from the reservoir.

So we are going to waste energy right is not it because we are using more air from the reservoirs and to maintain a certain pressure. So those are 2 detrimental effects of leaks. The operating force or the output force reduces and also we end up using more compressed air source right. So that is something we do not want to do in a air brake system right. So the last component, which I am going to discuss are parking brakes.



PARKING BRAKE

So let us look at what happens in a hydraulic brake system. So I am calling as a mechanical parking brake first. So, as we mention when we discussed this

configuration of disc brakes in the front and the drum brakes in the rear right. So I also told that in addition to the reason that we discuss there is also one more reason why drum brakes are still popular in the rear and that is due to the easier integration of parking brakes in the rear.

So if we take a typical passenger car how do we will engage the parking brake we pull the hand lever right which is available next to the driver. So the parking brake is mechanical in nature in most passenger car brake systems right. So what happens is that when I pull the lever this cable you can see the parking brake cable is going to be pulled. So when the parking brake cable is being pulled you see that this element to which the parking brake is connected this lever arm is pivoted about here and that is going to generate the magnified force on this parking brake strut is it not?

Because this end is going to move like this right once I pull the cable. So this pivoted this lever arm is pivoted about this pivot so consequently at this point the force will be magnified. So the magnified force will be applied on this parking brake strut. The parking brake strut lies on this brake shoe. So what is going to happen this going to push the brake shoe against the drum and because of this self-adjustment mechanism it will also rotate this and press it against press this brake shoe against strut right it will try to push it.

But anyway parking brake is only a relatively smaller output brake right you just want to ensure that the vehicle does not move when there is a disturbance on it or when the vehicle is parked on a slope W Sin theta does not make it move down the slope right. So it is provide enough brake torque alright to enable that it is stationary that is the function of a parking brake. So obviously we cannot expect a

parking brake to replace a service brake. So I hope now the subtle difference between the parking brake and service brake is clear right.

Service brake is used for a normal brake application parking brake has a specific functionality right. But you can immediately observe that the parking brake also uses the same components as that of the service brake. There are some more components this, what to say the basically the arm which is used by the parking lever which is used by the driver, the cable and the lever arm and the strut those are additional component which are there.

But then please note that one uses the same drum brake to enable this parking brake functionality. The parking brake and also can be used as an emergency brake. The case is that the service brake fails let say you have fluid pressure loss in a hydraulic brake system we can still enable the parking brake to generate some brake output right. So this also acts as an emergency or secondary brake. Of course, it cannot replace the service brake please remember that right ok.

So we can observe immediately that this one important advantage of using a drum brake in the rear because the parking brake is easily integrated with a drum brake on the rear using simple mechanical components right. Now what happens with a disc brake so that I will leave it you as an exercise. How is, this achieved in a let say a car where the disc brakes on all 4 wheels? Ok. So please find out right. So we will discuss about parking brakes in heavy vehicles in the next class and then we will move further. Thank you.