Fundamentals of Automotive Systems
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Lecture – 48
Hydraulic Brake System – Part 02

Now, if you look at a hydraulic brake right, so we have discussed the components but there are two more important components right, one is the brake fluid itself, it is because the energy transmitting medium is a fluid right, which we consider to be almost incompressible, right that is the fluid which is pressurized and it transmits the energy to the foundation brakes. So, the question arises you know like what can we say about this brake fluid itself right.

So, if we are looking at what are some desirable properties of the; of a brake fluid used in hydraulic brake systems, so the first one which strikes our mind is that the brake fluid should have a high boiling point, right because we are dealing with friction brakes, so the brakes are going to get hot with application, right. So, as the brakes get heated up, then what is going to happen; so are the brake components.

And we do not want the brake fluid to vaporize, right because the mechanism of operation of the hydraulic brake is debut; is tied to the fact that the fluid remains as a in a liquid state right, we do not want it to be transition to the vapour state, so the first one which we desire from a good brake fluid is a high boiling point, right. So, building on what we just discussed a brake fluid should also have low compressibility right, is not it, just building on what reasoning we just thought; discussed, right.

So, why low compressibility because like once again, you know like, the transmission mechanism is depends on the fact that you know we are having an almost incompressible fluid, right, it gets; if it gets compressed, then the driver may provide a pedal input you know but we will not be able to get the same pressure increase, right if the fluid is compressible, right.

So and of course, a good brake fluid should not corrode metal parts that is important because it is going to flow through very small metal pipes and also flexible hoses, right with lots of

metallic connections, so it should not corrode those metal parts and a; I am just completing here, a good brake fluid must also have good lubricating property because the hydraulic brake per se does not have a separate lubricant as such you know like the brake fluid also needs to act as a lubricant.

And of course, should not be harmful to human beings right, so because we need to replace the brake fluid from time to time, right and when human beings handle it, it should not be toxic to result in a health hazard, right so that is important. So, based on these requirements, there are some common brake fluids which are used okay, so they are broadly classified into two categories what are used today.

The first one is a class of glycol based fluids okay, glycol based fluids as the name indicates you know like they have glycol as the base right, so typically these are commonly used in most road vehicle applications that here at least currently, so the more popular ones are what are called DOT3 and DOT4, okay. So, what is this DOT? DOT stands for Department of Transportation.

Because the United States Department of Transportation came up with these specifications okay, so DOT stands for Department of Transportation okay, so they came up with specifications on what the properties of these fluids are, right and essentially, they are being used. So, we will not worry about the numbers per se but we will look at the qualitative aspects of these properties.

So, what are some good properties about glycol based fluids; they are most commonly used in vehicle applications right, so one good attribute or feature of a glycol based fluids is its low compressibility and that is good, right because like we want the fluid to be as close to being incompressible as possible right, so although so, it has very low compressibility, so that is why it is quite popular.

But an issue with glycol based fluids is that it is hygroscopic, so if you look at brake fluids, there is something called a dry boiling point and a wet boiling point. What is dry boiling point? You use a fresh brake fluid without any moisture right, then what is the boiling point of that fluid, it is what is called as a dry boiling point but with usage invariably, water or water vapour is going to seep in right through the various components.

And it is going to mix with the or it is going to try to mix with the brake fluid, the glycol based fluids are hygroscopic, so what does hygroscopic mean; that is it can mix with water, so hence its effective boiling point or what we call as a wet boiling point reduces if it gets or if water gets mixed with it, right so, that is a limitation of a glycol based fluid but it is okay for normal applications, right.

So, essentially in most day to day users in passenger cars and so on right, so this is fine, okay. So, what is the other category of brake fluids we have; silicon based fluids, so typically this takes the form of DOT 5 family, the reason I am saying family is that like I think there have been a few versions after 5.1 and so on right, so the DOT 5 series belongs to a silicon based fluids.

As the name indicates you know like the base, what to say is silicon right, so and then like the fluid is non-hygroscopic, which is a very good attribute and that addresses a limitation of glycol based fluids, it has more stable boiling point as a result, right but the limitation with silicon based fluids is that it has high compressibility, okay. So, that is an issue in silicon based fluids, right.

And another limitation is that since it is non-hygroscopic, if water gets mixed; water is added to it, would not mix, right and then water pockets will form and that is going to affect the performance of these fluids, right.

So, if water gets mixed, water packets can form that lead to performance degradation, so typically not used in most road vehicles but there are some applications in military vehicles you know like as for as silicon based fluids are concern, right. So, each brake fluid has its own pros and cons, right so but of course, you know like we want as high a boiling point as possible, right.

So, because we do not want the heat which is generated in the brake, right during the process of braking to affect their properties okay, so that is regarding the brake fluid, another important component of this brake system of course, not only hydraulic brake in general, any brake are the brake linings; the brake friction linings, right are they not, right, so a brake friction lining today is pretty what to say is composed of many components, right.

And lot of research goes on into getting the best possible brake lining with very desirable properties right, so once again what may be some desirable properties of a brake lining obviously, it should have as much friction coefficient as possible, right but the friction coefficient should not degrade very, very much with respect to temperature increase that means, brake fade should be low, low amount of brake wear, right.

And essentially, it should; performance or output should not degrade with varying operating conditions, so there are various requirements that places constraints, right are used as inputs to design and manufacture brake linings today, okay. So, what are the typical constituents of a brake lining, so that is what we are going to look at? So, if you look at a typical brake lining as I told, as I am telling you know like the actual composition can vary, right.

So, this is just to give us a general flavour, so if you look at the brake lining per se broadly there are four constituents, okay so, the first one are fibers, right. What is a fiber? A fiber in a brake lining provides rigidity and strength to the lining okay, so that is more like the backbone of the brake lining, right. So, if you look at brake linings historically, asbestos was used right, previously.

Because asbestos had some; what to say, very good properties like good heat dissipation, it also was; is fire resistant, right and inexpensive, right. So, but today it is not used because it is also carcinogenic, it can; the asbestos dust if inhaled can cause cancer, right so, it is not used today. So, what are being used? So, there are various organic linings you know like semi-metallic linings and so on, right.

So, in those lining you know like steel wool, aramid fibers are all used as fiber material, okay, the backbone of the fibers right, so those are commonly used, okay.

So, then there are materials called fillers, so of course we cannot fill the entire brake lining with fibers right, so fibers essentially form the backbone which gives rigidity and strength to the lining, so then we have filling material, right. So, what do these filling material do; you know they occupy the space in the lining and then they essentially wear out faster, so that they can protect the other constituents particularly, the fibers and the so called friction modifiers and so on, right.

So, essentially fillers extend lining life because we can afford them to be worn out right, so fillers extend the lining life, right and then like they fill space as the name indicates and minimize cost, so they are fairly inexpensive, right. So, what are typically used as fillers today? If you; there are various choices; barytes, clay, we can use calcium carbonate, so you can see that there are lot of choices.

And a typical break lining today is also a mix of many of these constituents right, so one can also have finely ground metal powders right, so to be used as fillers, right. So, a third constituent of this brake lining; it is a class of binders, okay because we have fibers, we have fillers, so we know, we need some glue to hold them together right, so yeah, so that is the role of a binder.

So, the function of a binder as the name indicates, it acts as a glue that holds the lining materials together okay, that is the role of a binder. So, if you look at binders today in brake linings, phenol-formaladhehydres are commonly used, right and then a fourth component of these brake linings are what are called as friction modifiers. So, once again you know, see the primary expectation of a good break; from a good brake lining is that like it should provide good friction properties, right.

So, a friction modifier essentially ensures that you know we get some desirable friction properties you know from the brake lining, so friction modifiers are nothing but Elastomers that improve the mechanical and wear properties, okay and then like curing agents and other substances that affect friction levels, right so that is a friction modifier, okay. So, what are typically used; brass, zinc, etc., are typically added to control the abrasive properties, okay.

So, you see that of course, there are a lot of choices here, you know like as we can see and brake linings you know like there are multiple varieties today, right so, to give the desirable attributes, okay. So, these are the broad components of a brake lining, so that in a nutshell in a provides us a overview of a hydraulic brake system. So, the next one that we are going to start in this lecture is the air brake system.

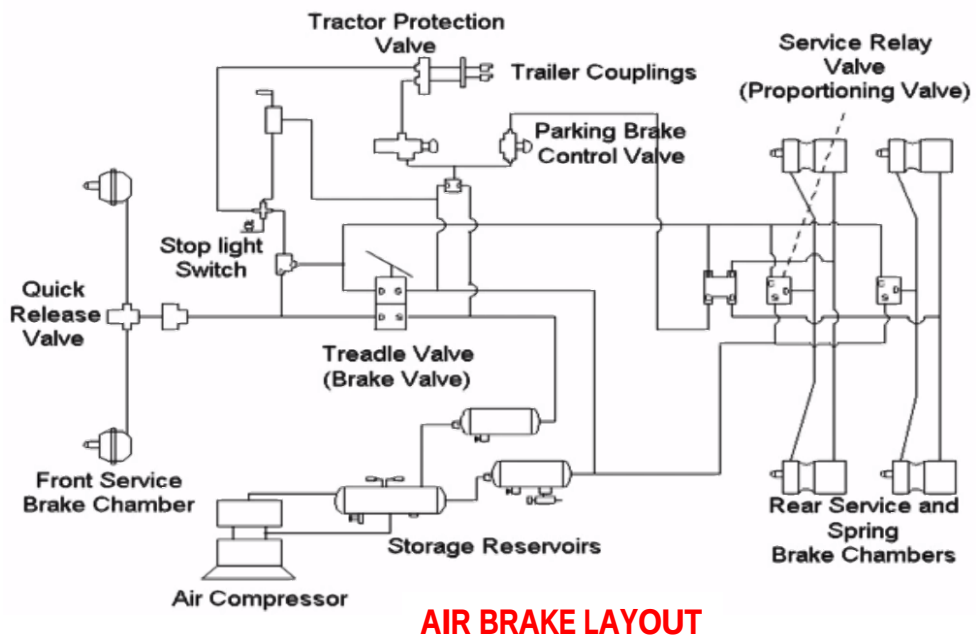
So, the air brake system as the name indicates you know like they use; uses compressed air as the energy transmitting medium okay, so that is the row that is the primary feature of an air brake, so we have air taken from the atmosphere, pressurized, stored in a reservoir used and

then like essentially given back to the atmosphere. So, the energy transmitting medium is kept on used and then thrown to the atmosphere, right.

Whereas in a hydraulic brake, the brake fluid is used repeatedly okay, so that is one attribute of an air brake system, it is typically used in so called heavy commercial road vehicles, okay. So, what are called as HCRVs, okay so, of course different people, some people will say commercial vehicles right, so some people will say heavy vehicles and so on. So, what are these vehicles?

So, essentially these vehicles are trucks you know like buses, tractor trailers, tractor semi-trailers, tractor trailer combinations you know that is what, okay, so those are what are called as heavy commercial road vehicles, okay. So, just to have a broad overview of this air brake system, let us look at a simple schematic.

So, when in an air brake, the application of the brake pedal does not pressurize air, okay meters out compressed air from the storage reservoir to the foundation brakes, so this is what is called as a power brake, okay, so that is you have a separate source of energy, the humans effort is not the source of energy, you have a separate source of energy and that source of energy is metered or regulated by the driver, okay.



AIR BRAKE LAYOUT

So that is one important feature of an airbrake, so please know that in an airbrake, when the driver presses the brake pedal, they are not pressurizing the fluid okay, in a hydraulic brake as we discussed today, the drivers pedal forces is used to pressurize the brake fluid but not so in an air brake. So, let us look at a broad schematic of an air brake and then like see how it works okay.

So, let me take a simple schematic, so this is just a layout, just the line diagram to show you what are the different components and manner in which this air is transmitted, okay. So, what happens is that like we in a typical heavy vehicle, we have this air compressor which is operated by the engine of course right, the air compressor takes an air from the atmosphere and pressurized air is stored in or compressed air is stored in the reservoirs.

Of course, there are multiple reservoirs because if you have a big vehicle you know like, you have multiple tanks to store the air, then what happens is that like the main valve which is under the control of the driver is what is called as a treadle valve, okay. So, the driver presses or applies this treadle valve, so once again there are 2 circuits; a primary circuit and the secondary circuits, so these are also dual circuit valves.

Once again, as usual P stands for primary, S stands for secondary, one important what to say attribute of an airbrake system compared to a hydraulic brake system, is it is relatively longer you know like time delay or like what is called as transmission lag you know like in transmitting the energy transmitting medium from the source to the foundation brake. So, what we typically do is that this primary circuit transmits air to the rear brakes.

So, this is the rear of the vehicle, right and this is the front of the vehicle, so we can see that the primary circuit transmits compressed air to the rear because the path is longer, right and then the secondary circuit gets actuated and the secondary circuit transmits air to the front, okay. How does this transmission happen you know, what are the intermediate components are some things we will learn in the next lecture okay, so thank you for your attention.