Fundamentals of Automotive Systems
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Module No # 15
Lecture No # 73
Tyres - Part 01

Ok greetings so welcome to today's class so in today's class we shall look at another important component hidden automobile which will be the pneumatic tyre ok. So we shall learn what is an expected out of a pneumatic tyre. And also how it is constructed and how it operates ok. So that is something which we are going to learn.

So if we look at tyres you know which are used in automobiles they are very critical component because all the forces you know like between the automobile the vehicle and the road are transmitted to the tyre road interface. So let it be for braking or drive or steering and even the vibrations due to the road perturbations right all the forces are transmitted to the tyre road interface. So hence tyres become critical components that are responsible for the transmission of forces along the longitudinal lateral and vertical directions ok at the tyre interface road of course.

So if we look at the pneumatic tyre you know which is used in today's automobiles there are multiple expectations from multiple perspectives right so as far as their functional requirements are concerned. So let us look at what these requirements are?

So if we consider what are the expected; requirements from tyres? So broadly you know like if we classify them into a few categories right. So let say first we look at

what is typically called as driving safety. So one requirement is that the tyre should be seated safely on the wheel rim right and the retention of the tyre on the wheel rim is very important right because please note that there are significant loads that are transferred at the tyre road interface and the tyre is also loaded right.

And when we travel at high speeds you know like the tyre is subjected to stresses right along different directions. Then it is very important to ensure that the is retained on what is called as a wheel rim right. It should not come out of the wheel rim ok. So that is very important and the tyre must also be tightly sealed see this is important particularly in the case of a tubeless tyres right so where we do not have a tube right inside the tyre cavity.

So air is filled directly in the tyre cavity the space between the wheel rim and the tyre. So then what happens is that like we need to ensure that there is a hermetic seal between the tyre and the seat where it sits on the wheel rim. We are going to see what are the different components that enable these requirements right? And it should also be as less sensitive to overloading and be puncture proof right. So these are expected requirements of a tyre right from the point of view of driving safety right.

Of course there are going to be once again like conflicting requirements as we will shortly realize right when we go through the complete list so this from the point of view of safe driving safety from the point of view of vehicle operation so if you look at vehicle operating characteristics. So we would want from the perspective of vehicle operation very good traction be available at the tyre road interface along the different directions right let it be longitudinal or lateral directions.

So we would want high traction coefficients that we have encountered before when we studied about drive and braking right. So we want the best possible traction coefficient so that like whatever force or torque that is applied by either the power train or the brake is transmitted to the vehicle right through appropriate forces at the tyre road interface. And we want these traction coefficients to be good under you know like various road conditions you know like dry roads, wet roads, snowy roads, icy roads and so on right.

It should be the best possible you know whatever we can aspire for right. So that is going to be a important requirement and we should also enable good cornering characteristics. So what do we mean by cornering? That is what happens when a vehicle takes a turn right? So when a vehicle takes a turn we need forces to be applied along the lateral direction. So a tyre a good tyre must also enable the fast generation of this lateral forces and ensure that we get very good cornering or steering characteristics right from the perspective of operation right.

So from the point of view of comfort when we looked at suspension right one two important attributes or functions related to a suspension were ride comfort and road holding. So, ride comfort essentially dealt with the fact that we do not want to transmit the road perturbation to the occupants of the vehicle right or the vehicle body. So a tyre also plays a very important role and also the tyre should maintain a good contact with the road.

So that the variations in the normal loads are minimize that is what we call as road holding characteristic. So a pneumatic tyre should have good stiffness and damping characteristics ok. So to enable good ride comfort right, and also road holding characteristics. And we should try to achieve the minimum possible

vibrations in the vertical and lateral directions. So see ideally you know like we would want a tyre to be a perfect circle of course that is not going to happen right.

So due to either manufacturing defects or when the tyre is being operated we are going to have a shape which is not going to be a perfect circle. So if you go along the circumference of a tyre the radius from the center of the axis of rotation is going to be different that can result in vibrations along the vertical direction when the tyre rotates ok. That phenomenon is what is called as a radial run out ok.

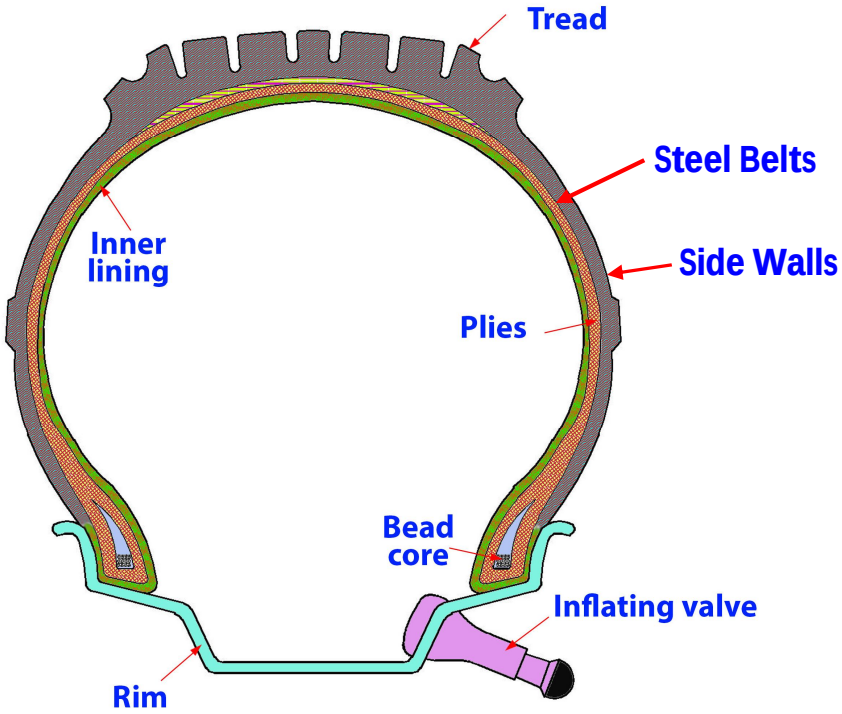
Then we can also have non uniformities along the lateral direction which can create vibrations along the lateral directions ok. So those should be ideally eliminated but of course we should try to ensure that there are at the lowest possible levels.

And then we should also have good long-term durability and high speed stability. So we can observe that you know there are so many requirements which are placed on a single component right which cover a wide range. So we require high speed stability right so because modern vehicles are designed for increasing speeds. So when they are operated at that speeds you know like the tyres should operate properly ok. And another important requirement is as for as economy is concerned from different perspective one perspective is from the point of initial cost.

So we should try to have as less initial cost of the tyre as possible what to say as possible and also operating cost right. So we should have good mileage so mileage in this context essentially refers to how many kilometers or miles that the tyre can provide you know before it needs to be either replaced or repair right. So that is mileage in this context we should consequently have as less wear as possible as far as the tyre is concerned right. So that like we get better mileage and also better traction from the tyre.

And it should also try to result in as less rolling resistance as possible right because rolling resistance is once again a resistance that is going to affect the fuel economy right when the vehicle is being driven. And this becomes more important in heavy road vehicles because trucks and buses which are operated for extended periods of time on highways you know like that having less rolling resistance becomes a very important requirement because that is going to have a direct impact on fuel consumption and thereby operating cost ok.

So it is particularly important in heavy road vehicles ok. So in heavy road vehicles another important requirement is what is called as a re-treadability right. So we will see what is called as a tread of a tear tyre ok sorry. And then like we should be able to what do what is called as a retreading ok of the tyre right. So, that becomes important in heavy road vehicles right typically. So that is from the perspective of economy.



COMPONENTS OF A TYRE

Now there are, also other perspective so there is a perspective from the view of environmental requirements. So what do we mean by this right. So, one thing is that like tyre noise should be as minimum as possible ok. So that is becomes a very important requirement. Another requirement is that the raw material and the energy consume during both tyre manufacturing and disposal ok become important considerations ok.

So we can see that there are different perspective, which essentially place constraints or requirements on a single component right. So not only do we need to worry about the materials and the energy required for manufacturing but once the tyres fail or you know like or wear out or their life is over right how do we dispose them you know that is also becomes very important right. So there are environmental perspectives.

So, one can clearly observe that there are going to be multiple requirements which need to be satisfied by a tyre designer. So the natural question to ask is that like what are the broad components of a typical pneumatic tyre that achieves the above functions right. So if you look at a simple schematic of a pneumatic tyre so we can observe that there are several components that perform these functions ok.

So this is a simple schematic where we can observe that a tyre you know like sits on this wheel rim ok. So we can see this wheel rim and we can see that the tyre is seated on the wheel rim ok. And there are components what are called as treads ok which are the components of a tyre that are in direct contact with the road surface ok. And below the tread there is what is called as sub structure of the tyre.

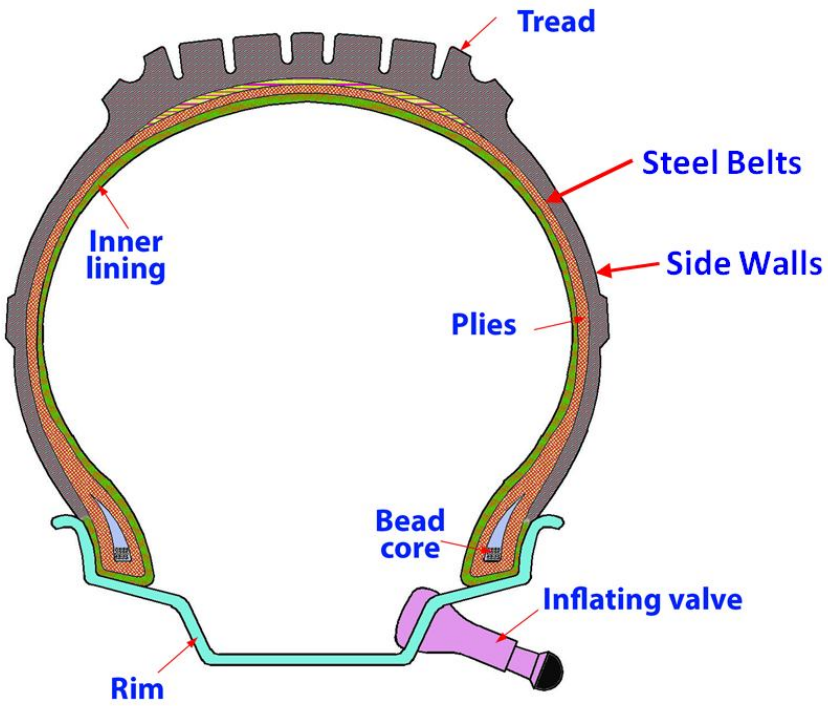
This sub structure typically can consist of what are called as steel belts we will shortly see what is the roll of these belts which are typically made of steel right.

And then you know like we have what are called as plies ok. We will look at different types of plies and the roll ok shortly. Then we have what is called as inner lining which is on the innermost surface you know like that is a lining of a rubber which is provided on the innermost surface.

And one of the important components is what is called as a tyre bead you know like that is essentially you know like rings of steel wire you know like which run around the circumference of a tyre ok. And ensure that the along with the plies you know like ensure that you know the tyre is seated properly on the rim and it does not come out. So bead is very important component you know like it satisfies that function.

And then like we have what are called as a side walls which essentially is the structure which goes from the bead assemble to the tread ok. Then we have you know like an inflating valve through which we can pump in air into this cavity and then to maintain the necessary operating pressures ok. So broadly these are the main components of a pneumatic tyre. So let me write down each component and its characteristics.

So, the first one is the tread so the tread is the ridged or the profiled or the patterned surface that is in contact with the road ok. So that is the tread ok. So this obviously you know like now we can immediately understand what is called as retreading right. So that is if the tread is in contact to the road you know like as a tyre keeps on operating alright. So the tread is the component which is going to wear out fast.



COMPONENTS OF A TYRE

So obviously you know like when we when the tread wears out fast you know like retreading is the operation where we essentially address that issue right. So that is what now I hope the term retreading is clear okay. So that is the tread and below the tread we have various other components. So let us look at beads which are here so we can observe that we have these beads here. What are beads? Beads are nothing but rings of steel wire which are embedded in rubber ok that run along the circumference of the assemble in the inner edge of the tyre right.

So they are along the inner edges of the tyre ok so that is a bead. So we have what is called as core of the bead which are essentially steel wire right so which essentially run along the circumference ok and this steel wires are embedded in rubber material ok stiffened material.

So those are beads then we have what are called plies ok which are nothing but layers of fabric and cords that are wrapped around the beads. And these piles are located below that tread ok so below the outer surface of the tyre right. So they and extend over the inside of the tyre ok. So the ends of the plies are wrapped around the core of the tyre beads on both sides.

So what do I mean by this? So we can see that if you look at both sides you know like that the core of the tyre bead and the plies which are wrapped around them you know they form the main structure or main connection with the wheel rim ok. So that is a bead.

So essentially we can immediately observe that the (refer time: 21:34) bead is critical in the sense that should provide a good seating of the tyre on the rim and transfer the drive torques and the brake torques from the wheel to the tyre right. So that is another important function of a bead assembly ok. So and it should also enable a good seal particularly in tubeless tyres right. So to prevent any leakages, so these beads become very important right ok.

So the next component is what is called as a sidewall as we discuss what is a sidewall? Sidewall these components ok so the external surface of the tyre which go from the lower end which will be the bead assembly to the treads ok. So that is what is called as a sidewall ok. So the sidewalls are attached to the what are called as the shoulders ok on either ends of the tyre assembly and that leads to the treads ok.

So what are these sidewalls? Sidewalls, connects the bead to the tread through shoulders what are called as shoulders right. So that is an important role of an sidewall. And today you know like in most tyres we have what are called belts

which run below the tread and they provide stiffness and support ok. So typically we have belts that run around the tyre below the tread to strengthen the body plies and the tread ok.

So we can see that the pneumatic tyre (refer time: 24:29) has so many components of a what to say not only varying materials and also but also which perform various functions right. So the last one is what is called as a liner it is nothing but a thin it is the inner lining it is a thin layer of rubber material on the inner tyre surfaces ok. So that is what is called as a liner. So these are the typical components of a pneumatic tyre.