Traction Engineering
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Lecture 29
Measurement of Contact Area of a Pneumatic Tyre on a Hard Surface

Hi, this is professor H Raheman from Agricultural and Food Engineering Department. I welcome you all to this NPTEL course on traction engineering. Today I will try to discuss how to measure the contact area of a pneumatic tyre.

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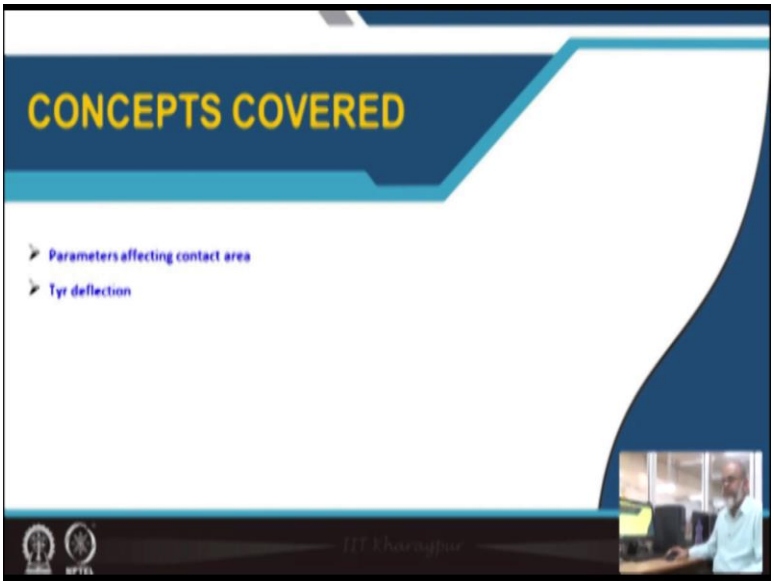

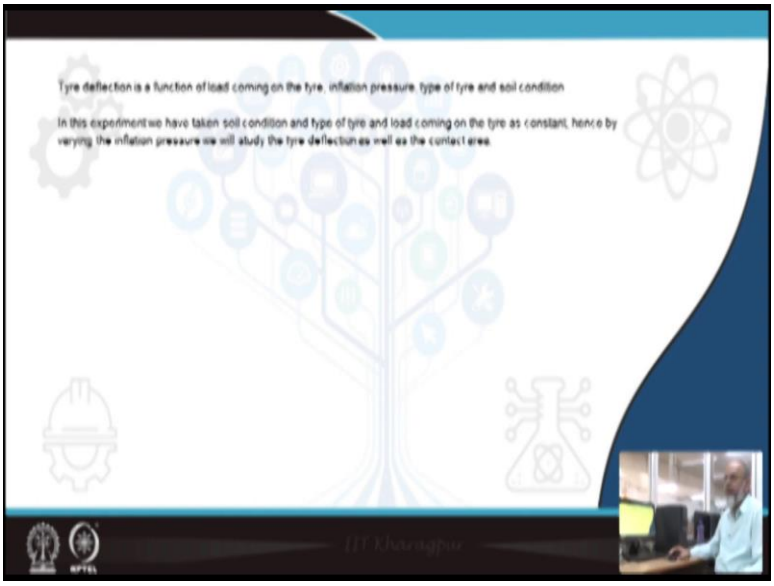

As I said contact area, so, first I will try to identify what are the different parameters which are going to affect the contact area and the tyre deflection. So, if I try to find out the parameters which are affecting contact area, it will be the load which is coming in the wheel, it depends on the type of tyre, it depends on the inflation pressure, it depends on the soil condition. So, in our experiment, we are going to find out contact area on a hard surface. And we will take a bias ply tyre at a maximum load of 1000 kg.

And what I will do is, I will vary the inflation pressure and corresponding to that inflation pressure, I will try to measure what is the tyre deflection and what will be the contact area by taking the footprint of the tyre. So, as I said bias ply, radial ply, obviously radial ply will give you more tyre deflection as compared to bias ply. So, that is known.

So, only my aim is to find out how to measure the contact area. So that is why whether it is radial tyre, bias tyre does not matter, the procedure remains same. So that is why, I have restricted my study to only one kind of tyre, at one inflation at one load and at 1 soil condition here the soil condition is hard soil.

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Today, I am going to explain how to measure the contact area of a tyre. Contact area of a tyre is important from the point of view that tractive effort is developed by a tyre. So, it is the contact area which is directly controlling how much force or the tractive force will be developed. So,

contact area is a function of different other parameters like what is the inflation pressure, what is the strength of soil, what is the load which are applying and what is the type of tyre.

So, in today's class, what I will do is I will restrict this study to a particular tyre, particular tyre means I have taken a 13.6-28 bias ply tyre and I will try to measure the contact area on a hard surface. So, we try to apply a load and then we vary the pressure. So, since I told in the beginning that contact area is a function of load, is a function of type of tyre, it is a function of inflation pressure, is a function of soil condition.

Now you have fixed the soil condition here the soil condition will be on a hard surface that means the soil condition is hard. Now, the other variables I will try to restrict the load to the maximum load carrying ability of the tyre that is 1400 kg. And then what I will do is, I will try to vary the inflation pressure. So, I will get different contact areas. So, I will measure those contact areas by following a certain procedure.

In addition to that, we will also measure the deflection of tyre because when you are going to calculate the tractive effort developed by a tyre, there we are utilizing Brixus equation, where we require the deflection. So, when deflection is more, obviously, the contact area will be more. So, deflection will be more means either we, for a given soil condition, if we increase the load and keeping the inflation pressure constant, then deflection will increase.

In other words, if we keep the load fix, vary the inflation pressure, contact area will be changed. That means is the tyre deflection, which is a function of load as well as the inflation pressure for a given soil condition. So now, I will show you the procedure which will follow to find out or to measure the contact area.

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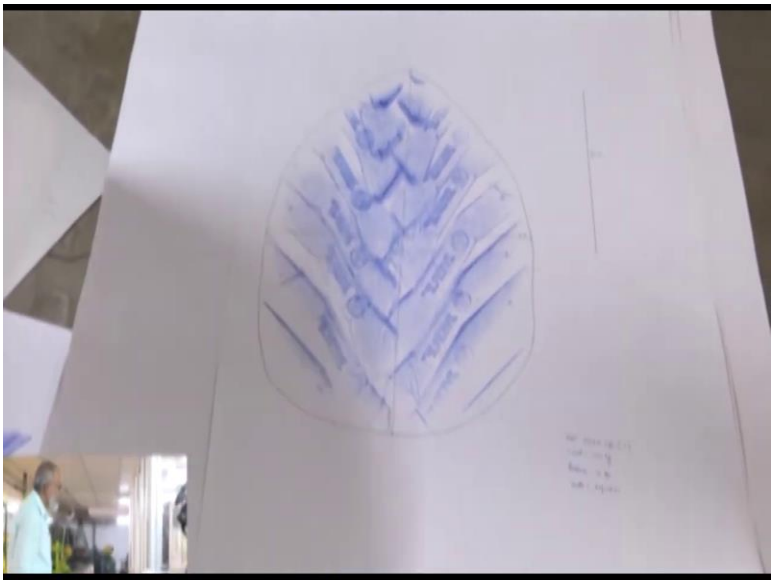

As I said that the contact area will be measured on a hard surface. So, I have put this blue plate this is a MS plate over which I will try to take the contact area. So, what I will do is, I will put a sheet, white sheet, this white sheet is very interesting in the sense, I have to take the footprint so, I have taken a carbon sheet in between that means the lower sheet, the footprint will come. And to protect this carbon sheet from damage, we have to put a white sheet on the top.

So, this is the sandwich of two drawing sheets. With a carbon sheet, this has to be put below the contact, below the tyre footprint. So, what I will do is, I have to raise the tyre, so you can see here, the there is a gap between the plate and the tyre low surface. So that gap will help us to put

the sheet where I will take the footprint of the tyre. So, I will try to, I will now try to put the sheet then I will slowly release the tyre so that it will rest on the sheet.

Then I will repeat that exercise by rotating the wheel 2 to 3 times so that I can get a clear print of the tyre footprint. Now I have put the drawing sheet below the tyre and the sheet has to be clamped. Because good amount of weight is coming in the sheet that is why it will be disturbed. To prevent the sheet from disturbance, we have clamped this sheet which is put on the MS plate on both the sides, then I will slowly put the tyre over the sheet.

This raising and lowering of wheel is done by a hydraulic arrangement. So, everything will be done very smoothly. Now on both sides you have clamped, so the paper is almost flat. There is no crease in between. So next procedure will be I will try to lower this plate, this wheel over the sheet. Now when I lower the tyre, I should see that the tyre does not rest over that sheet, because that will give you something some error results.

So, what I will do is, I will try to see whether the tyre is just touching or resting. To verify that one, I have put a sheet of paper, you can see the person can easily remove that paper that means the tyre had just touched, touched the sheet. The entire load is not transferred on to the sheet. When the tyre is just touching the drawing sheet which I put below the tyre I should know that that is the 0 condition.

So, what I have done is I have measured the depth of that one with respect to the rail which is provided here over this rail and one end of this rail is supported this depth gauge is there the other end is fixed. So now, if the tyre is going down when it is transmitting the load onto the drawing sheet, then there is a deflection. So, I will initially take the zero condition.

And then finally whatever reading comes, the difference will give you what is the tyre deflection. Now I will lower the tyre to touch or to transmit the entire load onto the drawing sheet. Now the tyre is almost resting on the drawing sheet, that means the entire weight is transferred. So, I will get a footprint to make that more clear. What I will do is, again raise that tyre, rotate it, then do the same exercise that means again lower it so this way I will continue for 3 times so that there will be a clear cut print of the tyre footprint will come on the drawing sheet. Initially, the reading was, that means it was just touching the driving sheet, the reading was 24 centimeter now, the

final reading is coming as 32 centimeter that means the tyre has deflected by 8 centimeter. This test was carried out at a pressure of 14 psi and a load of 1400 kg for a 13.6 bias ply tyre, now the tyre is rotated to a different position.

So, another surface will come in contact with the drawing sheet. Now, we have removed the clamp and then I will remove the, the upper sheet that is upper drawing sheet and the carbon sheet which is present. Now we have removed the upper 2 seats that is drawing sheet and the carbon sheet and the lower sheet where the footprint has been taken, you can see very clearly some print has come on that sheet.

Now I will remove that sheet and show you how what is the shape of that footprint which you obtained. Now, the footprint which I got, I have removed that sheet you can see very clearly the same. The very good shape which I have got, I will show you what will be the length of that contact area.

So, this is 48 centimeter, 49 centimeter is the length of their contact and width will be 31 centimeter. This not a square, this is nearly parabolic type of thing. So, 31 centimeter is the width and 48.5 centimeter is the length. I have drawn the outline of that footprint area. And I measured the length and width. So similar exercise I will carry out for different other pressures, as I said deflection has to be varied. So, I will try with a different inflation pressure.

And the footprint which you got is this one, this is at a pressure of 10 psi inflation pressure load remaining same. In this, I have also reduced the load so that we will get more deflection that means we will get less a deflection because we are reduced the load, inflation pressure we have decreased, so we will get another set of data then we increase the inflation pressure, it was 10 psi now we have increased to 18 psi.

So, we will get this is the footprint of the tyre. This is a 12 psi 1000 kg. This is the shape of the tyre, footprint of the tyre. So likewise, we have carried out different exercises for different pressures and load combinations to get a set of data. And then from there, we will try to find out how contact area is changing, changing with load and changing with inflation pressure.

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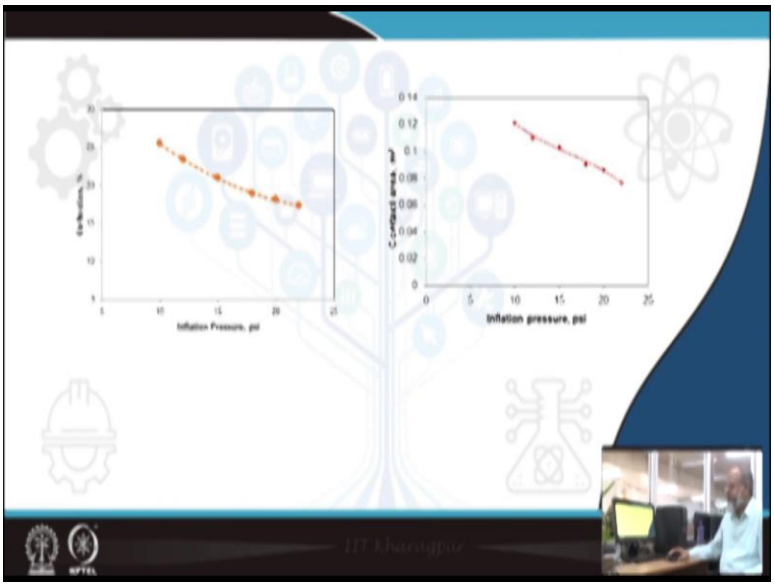

The tyre deflection which you measure that is converted into deflection percentage, how I converted it whatever deflection I got that had to divide it by the section height minus the flange height into 100. So that means that the numerator is the parameter which you measure that is the deflection and the denominator is the difference between the section height of the tyre and the flange height.

The section height of the tyre is calculated from the tyre specification, the tyre specification which we use is 13.6-28 tyre. So, the section height is aspect ratio into section width. So, 13.6 is the section width and aspect ratio is 0.75. So, we can multiply and find out what will be the section height. So, in the denominator, we have section height and flange height that is the difference.

So, numerator and denominator, then we multiply the ratio with 100 to find out deflection percent. So, what I have done is, for different inflation pressures starting from 10 to 22 psi, what is the deflection percentage which you obtain that I plotted. So clearly, it indicates that with the increase in pressure, the deflection percentage is reduced is obvious because when you are putting when are increasing inflation pressure that means you are putting more air into the tyre.

So, it is the air which is carrying, which is supporting the load that means load is not transmitted to the tyre carcass, so, that is why deflection is reduced. So, more the pressure more is the air

into the tyre and air will carry the sufficient amount of load which you are putting and it will not allow the load to transfer it to the tyre carcass. So, that is why deflection is reduced.

Now, coming to the contact area, the footprint which you obtain that were transferred to a SolidWorks and from the SolidWorks, we could be able to calculate the contact area. The other method simplest method is put it on a graph sheet and then use a Planimeter then you can find out contact area.

So, we have done the first part that we have transferred the image into SolidWorks then from the SolidWorks we calculate it, what is the contact area. Now, that contact area is again plotted against inflation pressure starting from 10 psi to 22 psi. So, what you observed is, a trend which is similar to the tyre deflection that means with increase in inflation pressure, the contact area is reduced is obvious. Since deflection is less.

So, contact area will be less that means is the area which is resisting, resisting the load which should come onto the platform where we try to measure the contact area, it is not allowing that load to come onto the drawing sheet or the platform. Now, since load is not transmitted to the tyre carcass, so, obviously, there will be less a deflection and there will be less contact area.

So, contact area is important that is why I have demonstrated this procedure how to measure contact area and that you have taken on a hard surface you can carry out similar exercise on a soft surface, but in the soft surface, the contact area will be varying, varying from what we observe on hard surface, because the resistance which is coming from the soil, it will not be there, in case of hard soil whatever resistance we are getting, we will not get that resistance in soft soil.

So, obviously, the contact area will change. So, in our study, since we have limited our study to a particular condition that is the hard soil surface, then we are limited the study to a particular load which is the maximum load carrying ability of a tyre and then what we varied is and we are also limited the tyre to a bias ply tyre.

So, my aim was to just to show, how to measure the contact area so that you can have some idea and since contact area is the important parameter, which is deciding the maximum tractive effort or the tractive effort which is developed at different slip values. So that is why my aim was to

show you how to calculate the contact area. So, I have demonstrated this one. I hope you have understood how to measure the contact area and you can utilize these values for calculating the tractive effort. Thank you.