Farm Machinery
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Lecture – 28
Estimation of Draft in Farm Machines – I

Welcome, students to my lecture number 28, in the series of NPTEL lectures on Farm Machinery. Well, Estimation of Draft in Farm Machines we would like to know whenever we are interested to measure the performance of an equipment or a an implement which is drawn by tractor. Now, what are the parameters which need to be measured under field conditions which is important to know as to how much of power of the source is being utilized.

We had discussed in my previous lecture one of the parameters which is the wheel slip and which is very important and it keeps on varying depending upon the soil and depending on the type of the implement you have, and the type of the lugs of the try to tires they are. We had discussed about another parameter about measurement of draft. You may recall my previous lectures in which we are talked of what are they what is a draft and how the whole process of utilization of power takes place whenever in implement is connected to a the tractor. Let us go through this short lecture and learn, how do we measure this draft.

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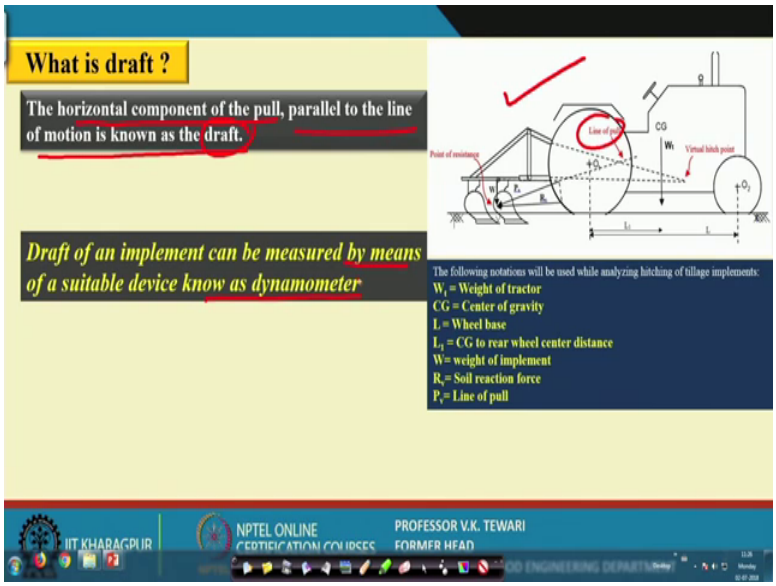

Well, I as I told you earlier that we had discussed about this, but then it is very imperative and very logical to have what is draft here in this particular lecture as well. You may recall that that this is the arrangement of tractor with a with an implement and this is the point of resistance which has been marking over here, this line of pull which is connected over here, we have shown the weight of the tractor.

Now, and the wheelbase etcetera all details are given only to understand that what happens to disrupt? What these draft is? As I told you recall that we had described this draft to be the horizontal component of the pull, the horizontal component of the pull and pull is between the center of point of resistance and the point of each.

Now, well we will not talk a point of each has because have dealt with this quiet earlier, but then we will talk that this line of pull or the force pull force is along this particular line, line of pull along this line is default and the horizontal component of this is the parallel to the line of motion is known as the draft. So, this is the draft.

Now, we would be interested to measure this draft. How this draft can be measured? There are various implements for measurement of this draft and we know them as dynamometers, we call them as dynamometers. Now, let us see what are the different types of dynamometers, what are the different ways by which people have been measuring and are measuring and what are the advanced ways by which we can measure the draft of an implement when it is connected to the tractor.

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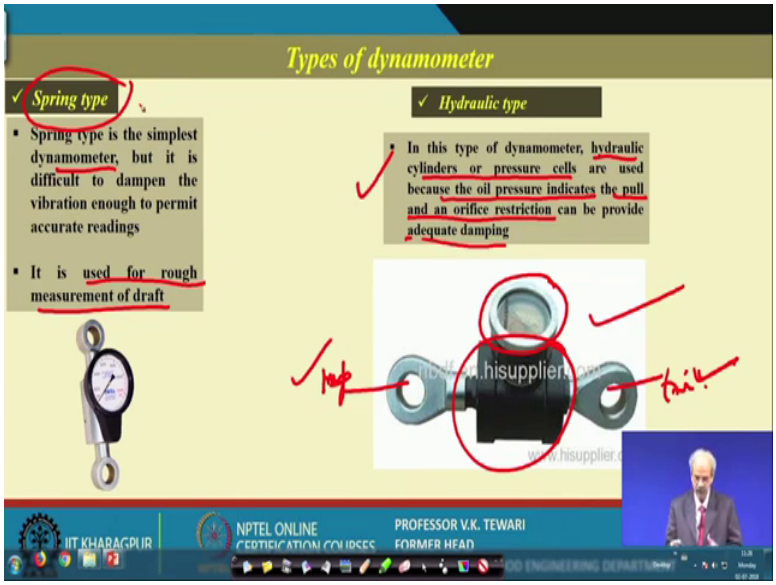

Spring type, this is the one which is this is the one which is very primitive and in fact, when nothing was available we used to have this spring type of simplest dynamometer which is kept in between when the in when a the tractor between the tractor and the implement at the place where which is hitched, this is this dynamometer is kept and depending upon the pull that is coming onto the a spring we were in a position to measure the draft.

It is a you have been is it is used for rough measurement of draft. Yes, we now we can call that this is a rough measurement of draft, but then earlier this was the only method long back this was the only device available to us. Later on, then hydraulic type of dynamometer also came into picture which became slightly better accurate as compared to the spring type.

Now, in this as you can see in this particular drawing over here in photograph, these are the two locations where we have to connect the implement one to the tractor site and the other is to the implement site, implement site here this is to detector site and we have in between here the hydraulic system in which we have seen that the cylinder or pressure cells are there, because of used because the oil pressure indicates the pull through an orifice restriction which can be provided for adequate damping.

Now, we have put the hydraulic system if you if you have learnt about hydraulic system you will know that how we create pressure with the oil. So, the same concept of the hydraulic cylinders have been used for creating pressure and the tension which we get from when they implement when they tractor is here and the implement is connected to this and this dial will indicate the value of the draft because it is in the horizontal direction.

Mind you, we have all except him that this is a horizontal connection we are not giving any inclination to it at this point of time, but then this is one which is slightly better as compared to these spring time.

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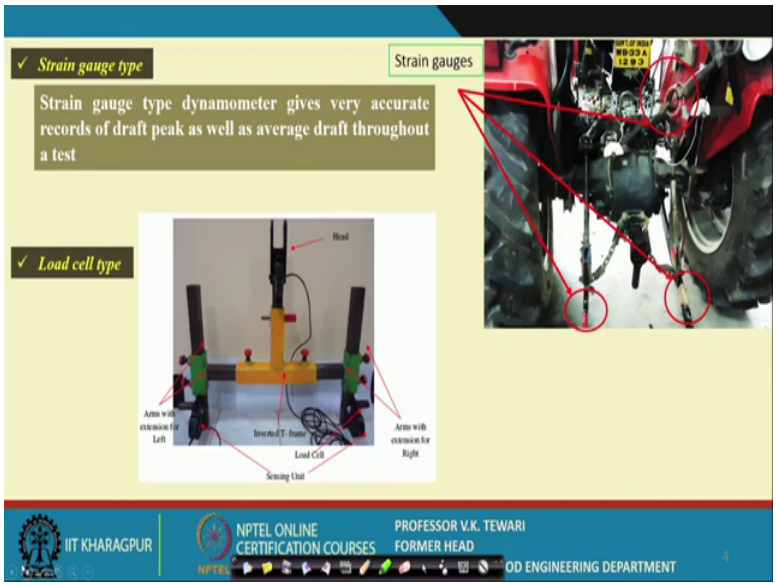

Now, let us see what are the other ones strain gauge type. Well, the strain, yes, the strain gauge type we have seen the two types the springtime and the hydraulics in dynamometer.

Now, a strain gauge type strain gauge type ones are the ones which have been used and supposed to be the most accurate one here the strain gauge is a strain gauge type dynamometer gives very accurate and records draft peak as well as average draft throughout a test whenever we are using.

Now, what are these strain gauges we will know at a later stage, but then at this point of time let us only understand that yes a strain gauge type is the one which is very accurate as compared with the two types which we had considered earlier. Then, came because then the strain gauges you will require wires and sometimes it is very difficult to have so much of wires connected together etcetera and there many a times it is not possible to have those wires put together.

So, the new way which has come up is the load cell type, this load cell type. Now, so, we have this is the one which we have developed at IIT, Kharagpur will discuss about this in detail and then once these strain gauges are fitted a this is also the load cell type is also a strain gauge type, but then the strain gauges are fixed inside in such a way that you are you are getting a very compact small unit which can be fitted anywhere and you will have very less wires etcetera coming out of this.

Now, where on these strain gauges fixed? Now, to have an idea let me tell you that the strain gauges are generally fixed at the lower links because you know that we are talking with respect to three-point linkage dynamometer when we have tested in equipment. So, the on the top link this is the location at which on the top link which is connected, then at the lower links this and then this you can see that these are locations where we do it. We will discuss this slightly in detail about where and how they are connected, but at this point I just want to show you that the all the and all the three locations in the links we have these strain gauges come connected.

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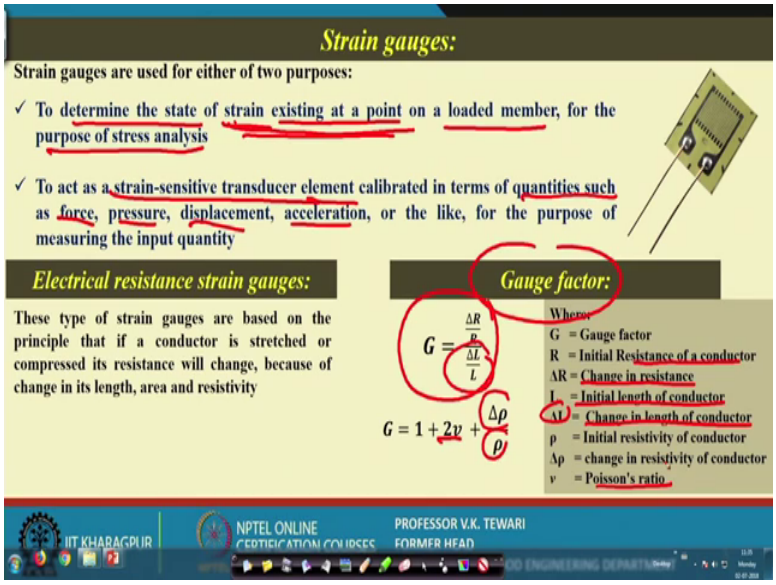

Strain gauges now, strain gauges are used either for two purposes. I would thought it is a it is very essential to let you know something about these strain gauges because they have been used world over and found to be the most accurate one so far and that is why it I felt it is imperative to let you know about these strain gauges and what are their types a bit of theory about this. So, these are the types which are strain gauge the existing at a point on a load member for the purpose of stress analysis. These two determine the state of strain existing at a point on a loaded member this can be done.

To act as a strain sensitive transducer element this act as a this now there are basic two purposes to find out the strain existing at a point on it load member and the other is strain sensitive transducer element in terms of quantities such as force, pressure, displacement, acceleration or the like. So, this is the way we use the strain gauges um.

These are electrical strain gauges and the gauge factor of these now the there are certain features of this particular strain gauge and there are certain parameters their own values by which we know these strain gauges and we try to classify these strain gauges and we try to select the strain gauges and out of them the most important is the gauge factor. This the gauge factor over here. This gauge factor is very simply given here as delta R by R that is change in resistance there will be a when they are connected. There will be a change in resistance per unit resistance divided by change in length per unit length.

So, you can see here delta R; R is the initial resistance of the conductor delta R is the change in resistance. Similarly, initial length is L and the change in length is delta L. So, this G is given as this and it is also explained just like in a different fashion like 1 plus twice sigma or nu by plus delta rho by rho, where nu is [passion um/poisons] Poisson's ratio.

So, in terms of the Poisson's ratio, how we can get and change in resistivity of the conductor? There is a change in the resistivity of the conductor and initial resistivity of the conductor is known. So, once you know this thing you can also find out the G factor or the gauge factor of the strain gauge.

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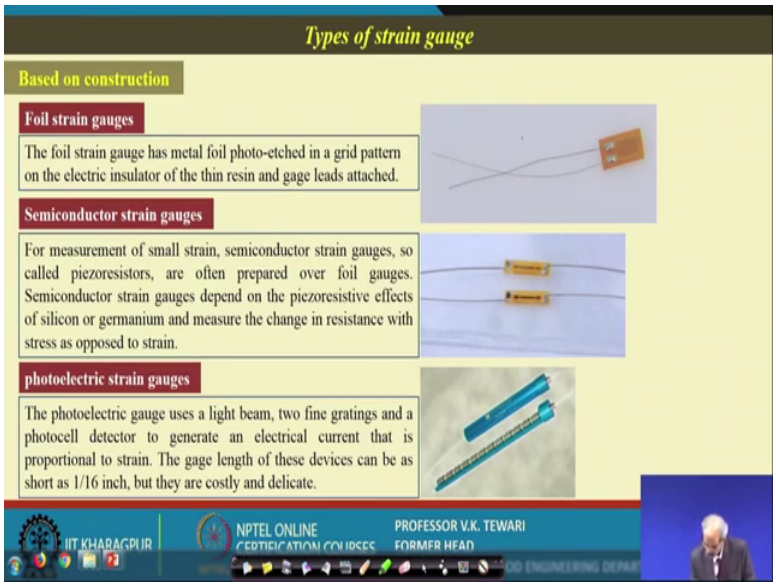

Types of strain gauges, where little bit more about this there are different types of strain gauges depending upon how they are connected and what are their locations, where they are used and all that. So, it is well it is it is very logical to have an idea about this as well.

See, foil a strain gauges, foil strain gauges has metal foil photo-etched you can see this over here, so, very simple one here. Then semiconductor type strain gauges, this is locations given over here. Now, these are ones both these semiconductor strain gauges and the foil type ones are the one which we very rarely used and where you we use for a long time we have been using these for a long time.

The photoelectric strain gauges are slightly different slightly different, but gauges use a light beam they will use a light beam and to find a gratings and a photocell detector to a generate electrical current that is proportional to the strain which has been measured. So, this has slightly an application which is slightly different than the ones which are there at these two, semiconductor type strain gauges and the foil type.

These ones which we have been very extensively used in our uses, wherever, we have used for measurement of strain and hence measurement of draft or pressure force etcetera, as I told earlier.

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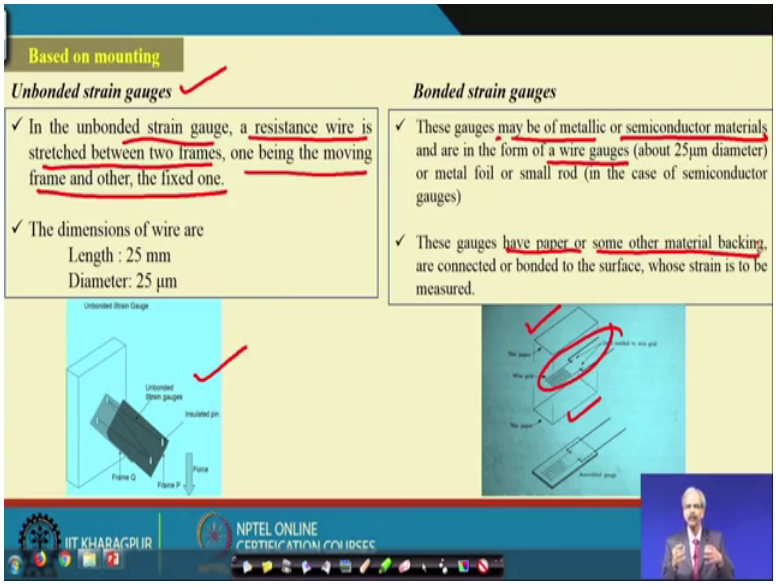

So, now let us see what is further is there in this. Based on mounting, yes how is the mounting of these? It is also essential to understand that on the basis of mounting how they are known. So, see unbounded a strain gauges unbounded strain gauges a resistance wire is stretched between two frames, you can have a look at this and one being moving frame and the other fixed one you can have this arrangement which is shown over here.

Now, bonded type strain gauges, the bonded type of strain gauges are may be metallic or semiconductor materials, where or in the form of a wire gauge. Now, you can see here that these are things there then this is the thin a paper here and this is thin paper and in between then they are bonded. So, you can see here that the gauges have paper or some other material for baking as if a they are kept in between these two.

So, based on the mounting you can have a unbounded type strain gauges and bounded type of a strain gauges. These are the different types when I have what I wanted that it is very essential and imperative I felt to give you some introduction about this particular a strain gauges and the types and their features etcetera and that is why I wanted them to be here in this lecture.

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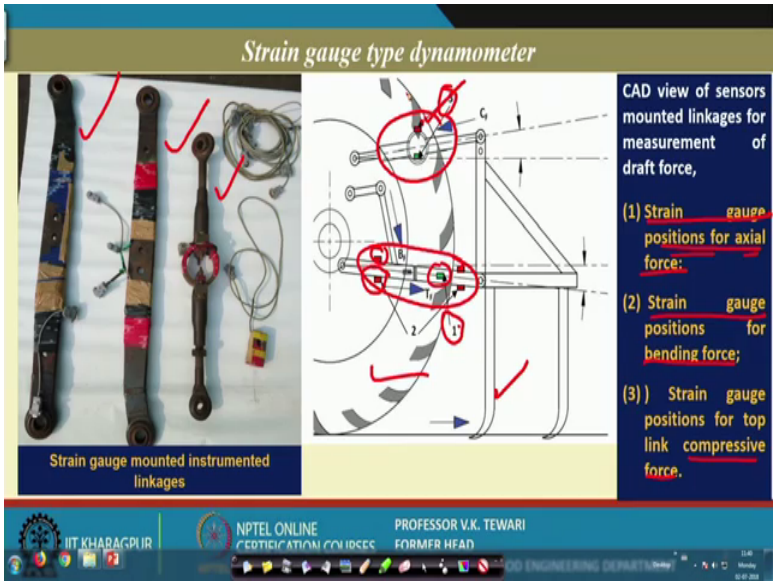

Well, how they are connected? I have shown you already that these are connected to our links the two lower links of the tractor and the top link. So, I will you show you here that how they are how they are connected. You can see here that this is a lower link this is another lower link and this is our top link.

Now, these are the ones which are connected here in our and the arrangement in the tractor is if you can see that this is our tractor wheel and this is the implement here connected. So, these are connected at the locations where you can see here. These are location and at this location. So, this is this is the actual thing which we which we have

done and this is the in the diagram we are showing how it looks like when you see a elevation side elevation which you look how it appears.

This is the CAD view of these sensors mounted. In fact, a CAD view of a sensor which are mounted. This a strain gauge positions for axial force 1, you can see here 1, this one he talks of this strain gauge position for axial force then strain gauge is position for bending forces this is 2. So, this you can see for the bending forces strain gauge positions for top link which is compressive force and this is the one which is connected over here this number 3. This is probing ring which is used we will discuss slightly later about this. But, then this is how it is connected with the three-point linkage in the tractor.

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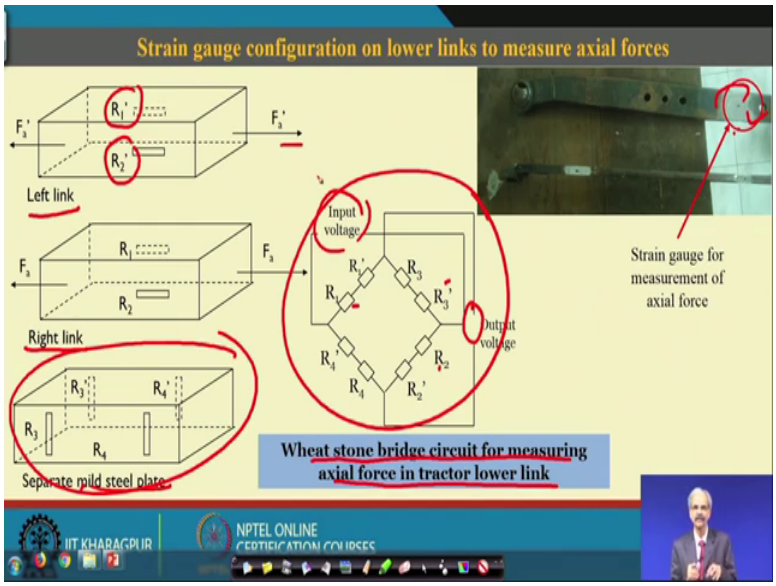

Configurations of the strain gauges on lower links to measure axial force now. How they are measured? In fact, see the a strain gauges for measurement of axial forces you can see this is where it is for axial forces how they are connected over here and you these are the locations see left link, these are the forces these are the strain gauge positions R 1, R 2 dash these are the forces which are acting.

Similarly, the in the right link we have same arrangement and then separate mild steel plate on which these. These are the ones which are which are dummy gauges. So, at this now how they are connected in the circuit? So, the curtain just wheat stone bridge you have must have heard about wheat stone bridge circuit measurement of axial force in tractor link.

So, this is the in the wheat stone bridge which talks of and these are the locations where the different registers R are resistances are fixed. The output voltage is connected over here and the input voltage is connected over here this is the wheat stone bridge. You have learnt about wheat stone bridge in your you might have learnt and that is from where we are taking and connecting our the strain gauges in order that we should get the output and get the values of the parameter particularly the strains which are coming onto the strain the strain gauges as they are connected onto the links.

This is a another arrangement for showing these strain gauges for bending force. Well, this is arrangement showing for bending force. So, you can see here that for bending force this is the arrangement of the these are the two locations where is the strain gauges on the links which are fixed on the lower links. We had seen in the other one we had seen one face of it and this is another phase formatting the bending one.

The compressive one which we said is there in the top link. So, these are again similarly the left link and right link connections are shown here the connections of the different strain gauges are shown over here and similar arrangement as I explained earlier is given for the wheat stone bridge for the input voltage and output voltage and the connections which for the bending force in lower link.

So, these connections these wires will be there now this is what I was telling earlier that you have with the strain gauges although we are getting very accurate information about the load, but then these are the different types wires in fact apart from this there will be other Rs because measurement of angle as well of the lower links the two lower links in the horizontal plane and vertical plane. So, in fact, those things come. So, so much of wires come, that is only a drawback, but this is the type which has been used all over the world.

So, it is worth knowing about this particular type and in fact, the strain gauge type one is the one which has been put in a load cell type which will discuss after this.

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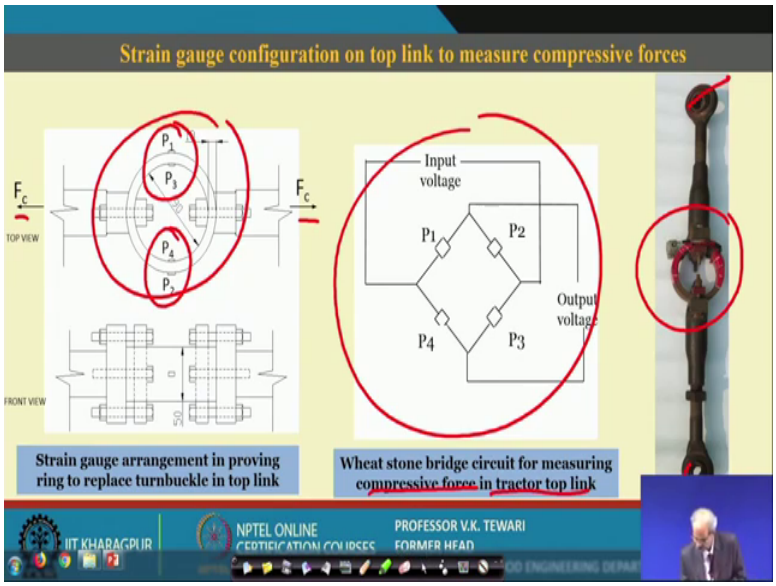

This is the arrangement for top link. So, for top link we had I had shown you here that this is the connection is a ring which is connected. They say this ring over which it is connected here we cannot you have seen that the connect type of the top link and the formation of the top link we have seen. So, it is very essential that we must have an idea about finding out the compressive force which comes onto the top link,.

So, that is why we have made a fringe and accordingly the placement of these gauges you can see here the gauge is on P 1, P 3 here and P 2 P 4 over rho a here and this is the compressive force which we will be experienced by this particular member when it is connected one side here, the other side to the implement and then the and as earlier explain this is the your wheat stones bridge here for measurement of the compressive force in the top length.

So, these are all which are taken together and then we are in a position to measure these different values of the strains which we get into the lower link into the top link and various positions well.

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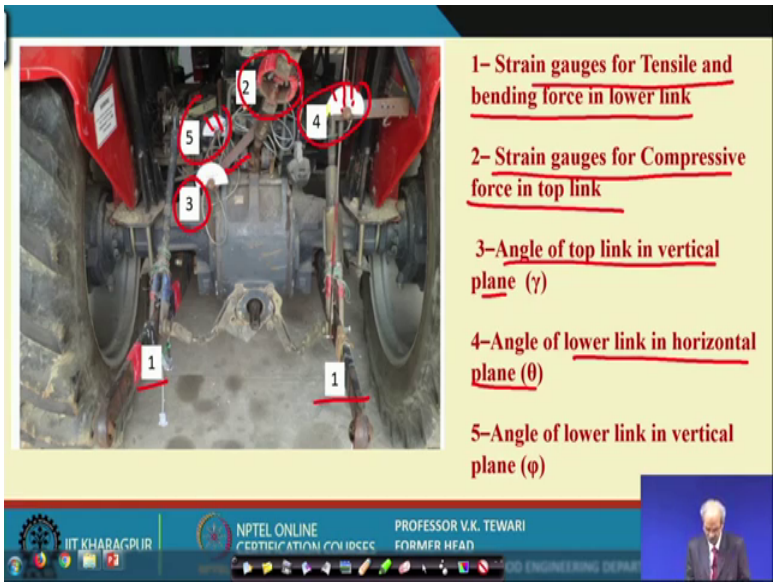

Well, you can have a look at this then the where we are keeping or we have already shown to you that I have shown to you that we are we are attaching these into the lower link and the top link of the a tractor whenever we are connected. So, here you just have a look at this 1 and 1 here, this talks of the strain gauges for tensile and when you force it lower link these two locations here.

Then strain gauges for compressive force in the top link. This is the location here for toppling then angle of top link in vertical plane as I was telling you earlier that we do need to find out this angle also. So, angle of top link in vertical plane y, 3 here. So, how do we measure this angle? We are in a position to measure from here then angle of lower link in horizontal plane theta. This is at this position here. So, we are in a position to measure the angle this is the location from where we are in a position to measure the angle and this is the one here we measure the angle.

So, depending upon these 1 2 3 4 5 these locations, where we have put the strain gauges for measurement of the angle as well as measurement of the strains which are coming in the top link as well have the two or lower links for tensile forces, for compressive forces and for bending forces. So, this is the way we are in a position to measure.

Now, after this what do we do with this?

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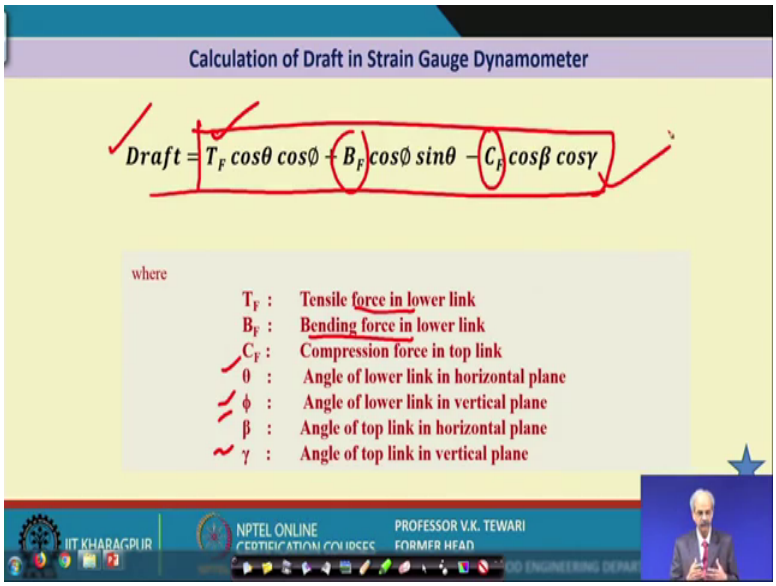

Well, calculation of draft, once you have got now, see this if you go into the details of calculations and details of the tensions and the forces which are tensile forces and the bending forces all these details and the angles we get equation like this. This is the equation which we get here where all these parameters we talked of the tensile force lower link, the bending force in the lower link, compression force in the top link and the various angles which are here. So, everything is taken into consideration and the draft which is the horizontal component in case of a three-point linkage this is how the draft force is given by.

Now, so, T f is T f is the tensile force and B f is the bending force and C f is the compressive force in this. So, because of the now if this is negative because this the direction is different and that is why we have these plus this minus this. Now, once you know that the draft is available now the we had discussed in this particular lecture that we have there are various methods for finding out the draft; one we talked of the simple stray simple spring then hydraulic and after that we talked of strain gauges and then we also said that there are strain gauges which as which are used in compact devices which are known load cells.

So, so, and how they are connected, where they are connected and what are the other parameters like angles etcetera which we are measuring, so that we get the complete value of the draft and this equation has been very widely used. So, now, at this point, we

can know we can tell you the draft is available with us when you have a three-point linkage connected implement or equipment with you and this can be used for measurement of the draft and hence the power required.

Thank you, very much.