Farm Machinery
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Lecture – 03
Tractor, implement and soil force consideration for tillage implement design

Dear students, you have seen the operation of the different implements in the field, in my previous class. Now we would like to let you know as to how the implements are attached to the tractor and what are the different forces which are acting on them, and what are the more details of those implements, which are responsible for various performance, attributes of the implements.

Now, so that is why I have named this lecture as the Tractor implement and soil force consideration for tillage implement design.

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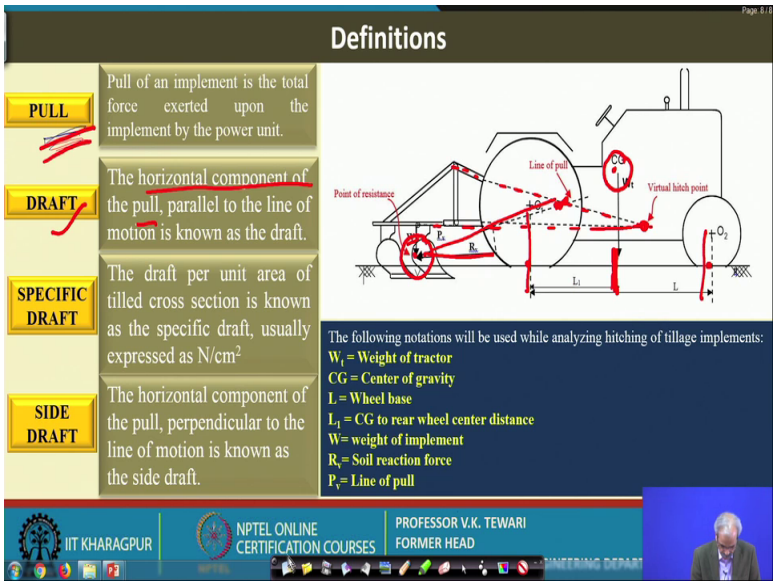

Now, let us have some of the important things which are there, well in this slide I have given a very simple diagram, which we will tell you as to how the tractor is connected to a two motor mold board plough. Certain forces which hare acting for example, the forces at the reaction forces at front axle and the rear axle I have not shown them purposely, I just want to show some of the important things which hare there and then subsequently when we will go to different slides and different analytical treatments we will know about more details of these.

Now, let us have first item when the implement is connected, what is the pull that we would like to know about the pull of the implement. So, if you can look at this, pull of an implement this is a total force exerted upon the implement by the power source this is the force which is, so pull source of this cut. [FL] [FL] [FL]. So, pull as described here is an implement pull of an implement is the total force exerted upon the implement by the power source, similarly the draft. Now as you we have connected the tractor to this particular implement or the vice versa we have certain aspects to be considered.

For example what is the line of pull; that means how the point is connected. See this is a point where we are talking up about the center of resistance the or the point of resistance; at this point the three forces you can see the W which is the weight of the implement, Px is the force along the line of pull and Rx is the soil reaction forces which are over there.

So, these are concentrated they are concentrated at this particular. Now when we add this point and the point of which now this is the point of which. In fact, here I have shown you that the line virtual he in case of a three point linkage, the hitch point is slightly different and it is not a one particular point. In fact, it keeps on varying.

For example the point obtained because of in a in case of a three point linkage is if you extend the top linkage by quartz, and similarly the lower links by quart it will meet at some point. Now this point is the point which is the hitch point. But now since it is an imaginary point we call it virtual hitch point and then this hitch point is in case of a real situation we will fall somewhere below, somewhere this point below the transmission line of the tractor. So, we take that point as the second point and then we draw a line imaginary line, which is this line and this is called the line of pull. So, the line of pull is the line which is drawn or which is obtained by joining the point of which to the center of resistance in this case.

So, the draft is. So, the force which is acting along this line is the a speed P here and the horizontal component of this. So, the draft is the horizontal component of the pull which is parallel to the line of motion is the draft. So, we describe this as the draft similarly specific draft. When we generally when we want to compare particular implement the another implement, we would like to find we would like to compare certain specific failure which is independent of the weights etcetera of the equipment. So, we will talk with respect to specific draft; that means, what is the draft force per unit of area of cross

section of the soil handle, and generally this is expressed as just a Newton per centimeter square. So, this is specific draft.

Now, side draft well definitely when the implement is a being pulled by the tractor there will be a side draft which will come into picture. You might have seen in the field that we have a land site and on the second mold board plough you must have seen. So, the second mold board plough you had seen that there was a longer land side. Now the purpose of that land side is to take the side thrust. And here so, the side draft which we are going to sow over here is the horizontal component of the pull which is perpendicular to the line of motion is known as the side draft. So, this is the value which is shown here is Rx ok.

So, if we see in totality the definitions which I wanted to show over here are what where is this CG of the particular of a particular tractor, which lies somewhere here this point is also not exactly known, but then we find calculate depending upon the weight distribution on the rear axle as well as the front axle and the total weight of the tractor, by taking moment about this point as well as or this point, and then we try to find out what would be the approximate location on the CG of the tractor.

There are various methods of finding out the CG of this particular tractor, but then this is what we want to show. The second is the wheelbase I have also shown you the wheelbase in the in the field, but again I would like to say that this is the distance between the center to center; that means, this to this, this L is this wheelbase. And L 1 is given that the CG distance of the CG from the distance of CG from the center line of the rear axle. So, this is the value L 1 which is a value which will be required when we want to find out the total force required as well as we want to find out the total power required, in case of an implement which is connected to it.

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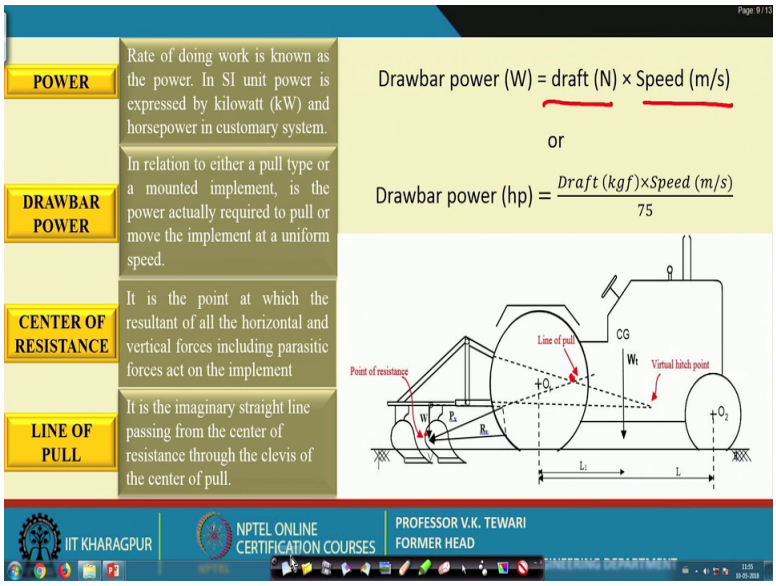

Well the second series of definitions here the drawer power. When I have already said the in tractor the drawer is the linkages particularly the single point link or the double point link or the three pointage link your linkage, and when generally those two point linkage are not so much used in our country as such. But then these are those are used for very large implements, which are child type of implement which are supported a portion of which is supported on the tractor and other portion supported on the ground. So, for that the second two point hitches are used.

For the three point hitches are very much used and so, we when we talk of drawer virtually we will be talking of the three point link only. So, the drawer power, what is this drawer power what is power by the way? So, power we know that rate of doing work is power we you are very much aware. So, here when we want to find the drawer or that means, if the implement is pulled by the tractor then how much is the power involved in that doing that task.

So, that is given in draft here yes. So, here this is the draft and the speed. So, if you multiply the draft with the speed you can get the drawer power, and drawer power when you see the draft is given as the kg of force and the speed here and you can get drawer horse power.

Generally we get a present in terms of horse power or kilowatt as you wish, this can be done now the line of pull. As I have already shown you this line of pull; it is the

imaginary line straight line passing through the center of resistance and the point at which this hitched. I have explained already that this is the location which is there and then this. So, between this is a line of pull. So, the center of resistance is definitely the point as I said earlier at which, we have the total weight of the implement then the horizontal and vertical forces including parasitic forces are acting at that in this particular location.

So, joining this two points is the line of pull, and I talked about the vertical hitched point and the weight of the tractor now we go to the next yes.

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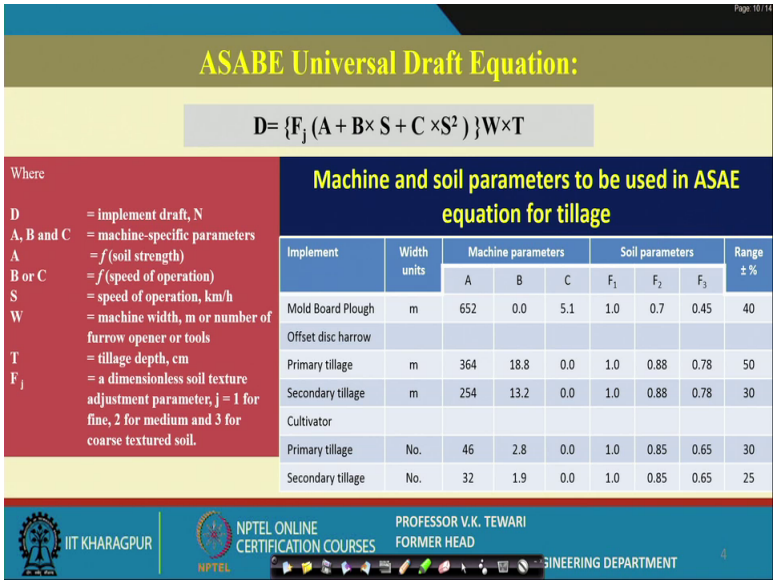

When well now I just stopped off the draft, because the moment we want to find out the force requirement and how much is the power involved, all these jugglery is important because we are interested to utilize the maximum power on the tractor. The tractors are 35 to 40 horse power tractor, 50 horse power tractor, but the implements which are being attached to that are not in a position to utilize that much of power. And that is why we would like to find out and design and have methods by which we can utilize the maximum as much possible the maximum power of the tractor.

Particularly this happens particularly because the soil is a viscous restrict material and then it changes with this moisture, it change with the structure and many other things with the climate it changes. So, you would require all these considerations to be taken while you want to design a particular matching implement for a particular tractor.

Now, there has been various methods of finding out the draft, particularly if you have a draft in case of the single point. Yes it is easier because the single the tractor is pulling the either trailer or a small implement just pulling it. So, we have just the horizontal force and that draft is known, but when we have the three point linkage of this implement, there are complications rise where we need to consider several aspects. Example we need to consider the type of the soil which is there the width of the implement and then we would like to see what is the depth that which this implement is operating and in different considerations are given.

So, the American society of agricultural biological engineers, they have devised or they have obtained a very universal draft equation which is given in front of you here. The various parameters D is the implement draft which is which has I have already explained to you by the way that the draft is the horizontal component of the pull, and pull is along the line which is joining the center of resistance to the point of hitch. So, this draft represented in Newton N is equal to the way F j F j A B C these are the machine in soil parameters and S is the speed of operation, W is the width of the you implement or the number of tools or times which may be there in some of the cases and T is the tillage depth at which the whole thing is the implement is operating.

So, using this equation it is possible and all over the world scientist and engineering agricultural engineers are trying to find out the draft. Now these are umm predictions and these are analytical values which have been found out over large experimentation, with respect to different types of soils you can see the soil parameters and the machine parameters.

The machine parameters here A B C and the soil parameters F 1 F 2 and F 3 here. Now they will come depending upon see F j talks about a dimension of the soil structure the j is equal to 1 is for fine soil, 2 for medium and 3 for course structure soil now for the machine parameters A B C. So, a suppose mold board plough was width is may assumed in meters, then the value is 652. Now if the for a offset disc harrow if it is being used for a primary tillage, then the value is 364, secondary tillage it is value is this similar for cultivator if you it is the primary tillage, secondary accordingly the values are changed.

Now, the soil parameters are more or less same you can have a look at this that is more or less. Now what has been found out and what has been said by the researchers and the

scientist who have devised this formula the equation is that, there is a percent variation if you find because of the take they have taken soil from various tribes and locations. So, we will find that this value varies from as low as about 25 percent to as high as about 50 percent both ways plus and minus. So, this will be the variation you will get; that means, this although which is said to be a universal draft equation this need not be one which will give you exactly the draft of an implement and it is has to be a tractor.

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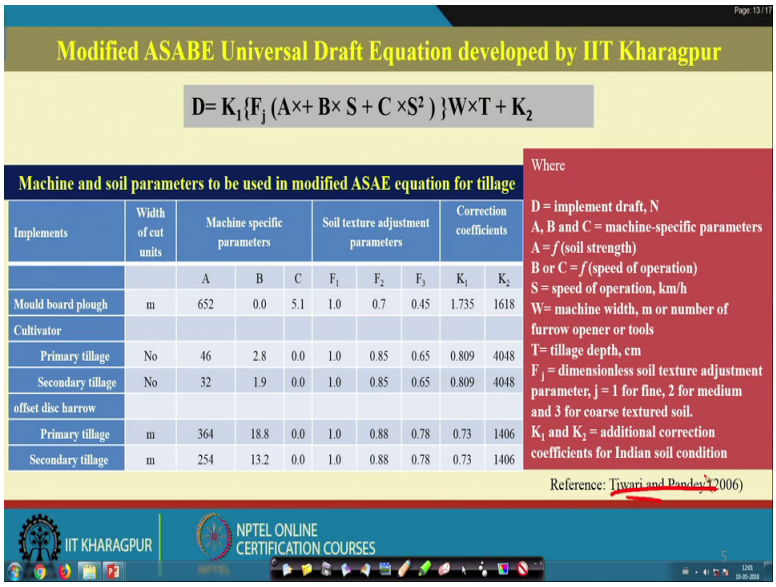

Well a similar equation has been developed a IIT Kharagpur some of our colleagues in the department of agricultural tool engineering have developed, a similar equation which we call that s modified ASAE inverse draft equation, and which has been published and the authors Tiwari and Pandey that deals you deals you can get if you look through for this particular paper.

Now, here also you can see that the equation is more or less similar except that certain parameters have been added here. For example, there is a factor K 1 which has been added over here, there is another factor K 2 has been added. Why so, because when wanted to actual measure the draft of a particular equipment, and then use this equation we found that there was a large difference this was not protecting as close as was the actual value. So, that is why the after a large number of experimentation in lateritic sandy loam soil, sandy clay loam soil they found out that there is need for adjustment of this

particular ASABE equation to suit to Indian conditions and therefore, this K 1 and K 2 were added.

Now, these correction factors K 1, this correction coefficients K 1, k 1 is these are the values for K 2 these are the values. Now they have accordingly as per the equation which remains same initially we need to add this K 1 and K 2 to suit the conditions of hours valve. We can see here that we have written K 1 and K 2 are in the additional correction coefficients for Indian soil conditions.

That means the value which will get for draft using the ASA AB equation is not necessarily the value which will be there in a condition for Indian soils and that is why this is has been made now it remains to be a question as to whether this will be can be called universal or whether this will be suited to any other country or not that is the question mark. So, we will leave it to at this state itself saying that a modification has been made at IIT Kharagpur by large number of experimentation, and these values depending on the Indian soils the value is K 1 and K 2 the factors or the coefficients K 1 and K 2 had been added to this equation which is given like this.

So, this definitely gives as close as possible to the data or the drafts measured by implements which are used in India here with the tractors well.

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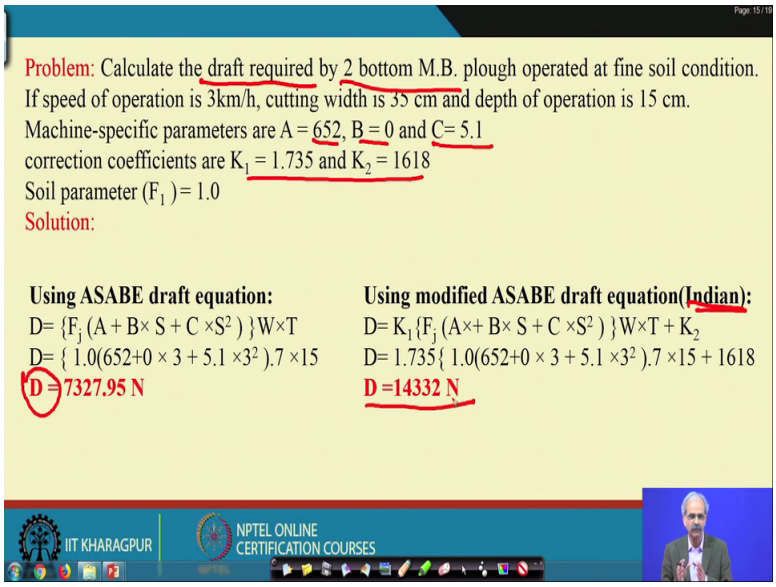

Now, we have seen that the two equations, I would like to place in front of you a problem which we will talk of how these can be used and what will be the difference. In fact, it is very amazing that you will get if you use the original ASABE equation you will get a value virtually half the value which is there for Indian conditions.

Well you can see that the draft is to be calculated for a two bottom mold board plough, it is operated in fine soil conditions. So, we know about the soil condition and the machine parameters have been taken from the table, the table which I showed you earlier. So, it has been taken from the table as 652 beta is 0 B is 0, C is 5.1. According the coefficients also now the researchers Tiwari and Pandey have also given this for the different machine parameters K 1 and K 2.

So, using this we find that the value of D for two bottom mold board plough operating in soil with all conditions this value will be there, but if it is used with the modified equation we find the value in this. So, virtually you can say that more than about 50 percent increase in the value. Now this remains to be questioned if somebody wants, but otherwise if we have to say that under Indian conditions we would take these values. Because then when we want to design the implements or decide the power source for these we will have to take this value itself and that is why we would like you to understand that this equations for Indian conditions you may use this equation and then does not matter the value is some high, but you can use this for design of the equipment.

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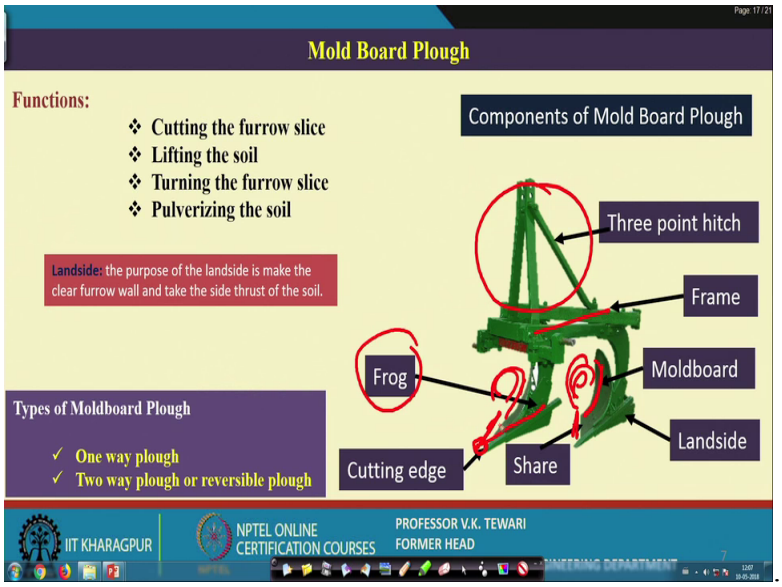

Well now we will talk of mold board plough, now I wanted that you should have some idea about, we have seen the mold board plough in the field and you have seen its operation also and you have seen that how it was operating in inverting the soil. But then, you must know what are its components many times the students not aware of the different components as the purposes of those elements or the components are there in the tractor it is just for your knowledge, which will help you in appreciating the size and appreciating the design of mold board plough.

Now, you see that we have cutting edge here. Now this is the cutting edge, but this. Now this is the cutting this is the shear point, but the depth is the cutting edge is through this here now the cutting edge furrow slice for the purpose of this the type or the this is the shear here now you can see this portion or this portion is to ca cut the furrow slice.

Then lifting the soil and turning the furrow slice is done by the mold board, now this is mold board here. So, this is this portion in job is to lift and turn this. So, it goes like this and then falls like this falls on the. Now a three point hitch you we have discussed that this is the attachment for the implement this tractor 2 the tra the implement to the tractor these are the three points, you will require to be attached then this is the main frame of that.

Now, we have a and a component which is frog, now this component is very important. In fact, we have said that we have this share here this is the shear, now we have the mold board and then we have the the share and the cutting blade and the mold board. So, and the and the land side. So, in order to connect these we have a frog over here, we have a frog over here. So, this frog this frog is the one which attaches these three together, and the purpose of this land side is very important. You can see that in the front one this is the slightly smaller as compared to the real one.

The purpose of this is the land side is make the clear frog wall and take the side thrust of the soil this is very important.

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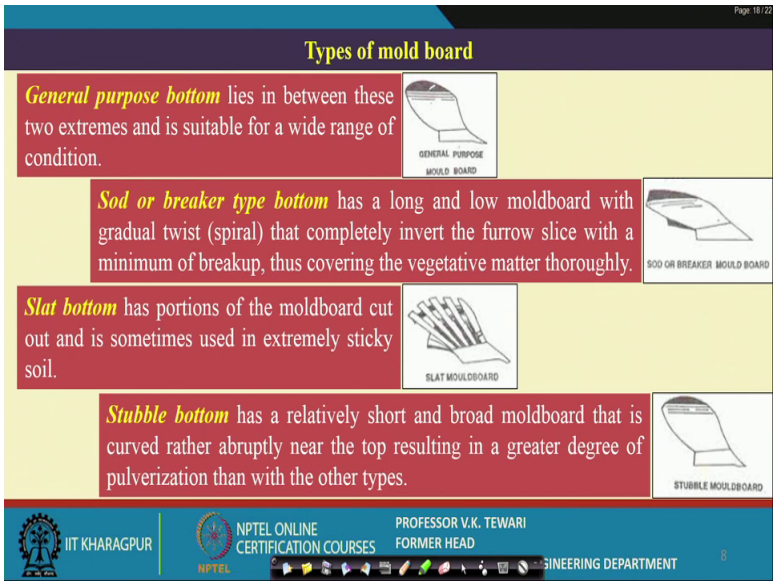

Well different types of mold board actually although these are not very much used in now a days you might have seen that the mold board itself is not very much used, because of other types of equipment which has been available and the farmers are farmers are using mostly even the cultivator is most of the time used as a primary tillage equipment. Because we are trying to conserve the soil moisture and that is why do not go to first opening of the tract by the by the mold board plough.

So, but we would like to just tell you that these are the different types in general purpose type, then the sod or breaker or sod mold board plough then the stubble mold board plough and the slat mould board. These have their requirements particularly the general one purpose is mostly used for all sorts of operations is to find here then the breaker type is for able for.

Yes, but the this is for in inverting the furrow, then slat bottom type this is for extremely used for sticky soil conditions, and the stubble bottom is for mold boards that is curved and rather abruptly near the resulting near the top resulting in a greater degree of pulverization, is increased a the pulverization this type of the mold board plough. Well these are the different types, but generally they are not very much used now.

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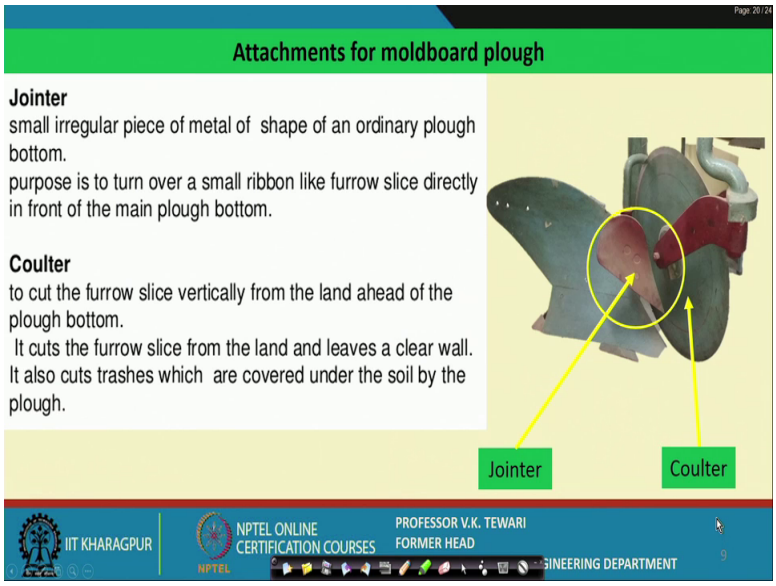

Yes attachments to the plough where there are important attachments when you have might have seen this jointer and coulter, the purpose of jointer is a small miniature plough just like that, and it cuts the soil top portion of this slice, and coulter is also cutting the soil and it moves ahead of the plough bottom, it moves ahead of the plough bottom. But you may not find this a in the that tractors which are there now, adjustments in the mold board plough.

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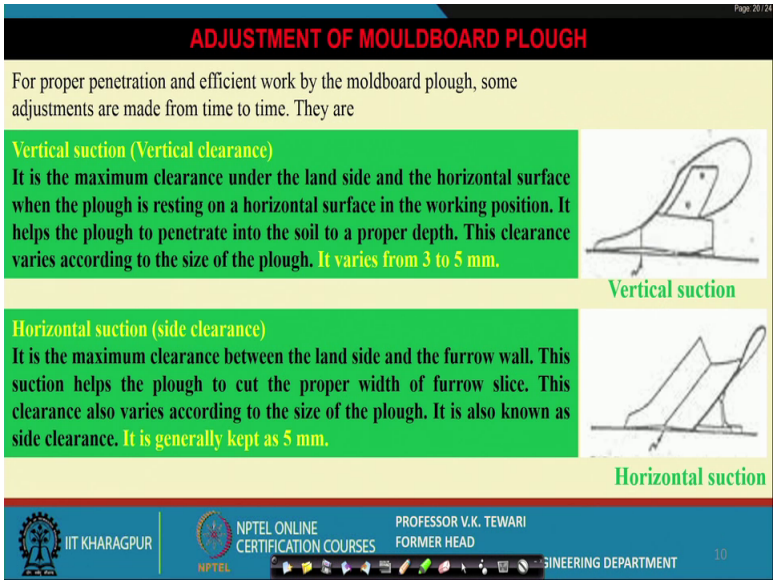

These are two very important adjustments sometimes when I want to increase the depth then the adjustment is vertical section which is over here.

Vertical section here and then horizontal section at this place. So, the horizontal section vertical section which is about 3 to 5 millimeter is helpful in increasing the depth and this is one which is important for giving a proper width of the furrow slice, this is important for that.

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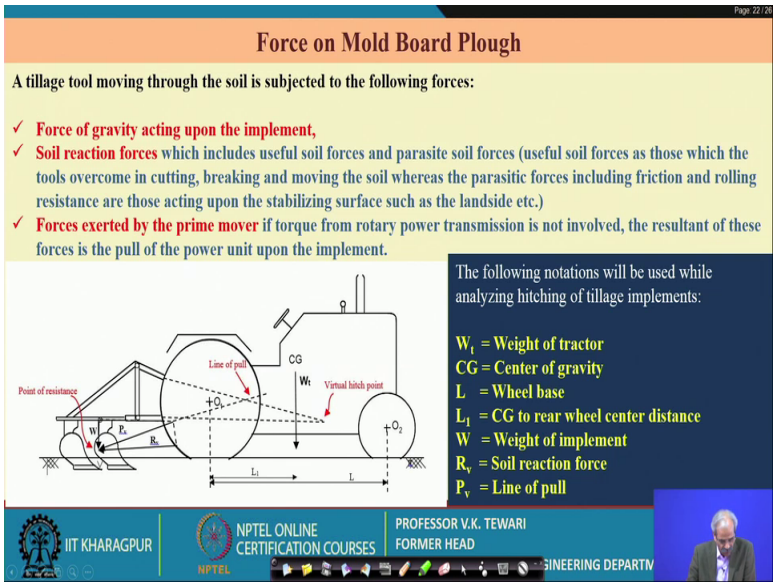

Forces on mold board plough well we have shown already these forces on mold board plough, generally as I showed that force of gravity or the implement which is there, the weight of the implement and the soil reaction forces and the forces exerted by the prime member in case of a rotary power source is the power rotary power source is not involved, the resultant of these forces is the pull or the power unit upon the implement.

Otherwise we have the soil reaction forces which talk of two items, the soil forces and parasitic forces. So, the useful soil forces those which are tool for cutting then for breaking and moving the soil. While the parasitic forces talk of the friction and rolled in resistance of this. So, these are the different types of forces which will act the when the implement is connected to a; well the problem has been also shown to you.

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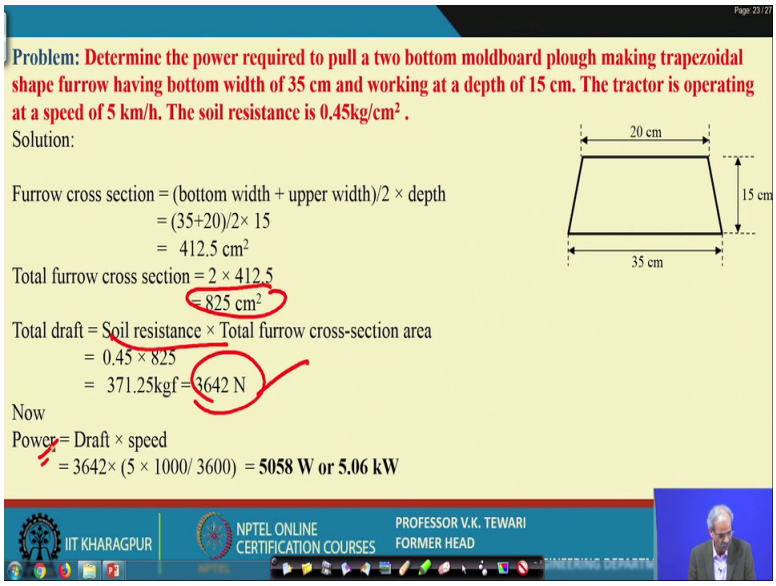

And the is a very simple problem, once you know what is the type of the cross section with a mold board plough goes through in this furrow, you should be in a position to find out what is the total cross section of this, and once you know the soil resistance you should be in a position to find out what much is the draft. And once you know the draft you should be in a position to find out power because we have already said that draft and pa and speed once multiplied will give you the total power here.

Well students I have now explained in detail about mold board plough along with a small problem, now I will continue with the details of other tillage equipment like this plough, cultivator etcetera in my next class.

Thank you.