Farm Machinery

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Lecture – 05
Mechanics of Rotavator or Rotary Tillers

Dear students, in the previous lecture we had discussed about the different tillage equipment, particularly the mold board plough, disc plough, harrows and different types of harrows. These were all three point linkage mounted equipment. Now we will be talking of an equipment which is driven by the PTO of the tractor. You may recall I had told you that PTO is the one where maximum power is available out of the tractor and, but it is least used ah; however, this is an equipment there is an equipment now which is very much in use now and gives the and uses the power of PTO and this is the rotavator.

Of late in it has taken very much importance particularly among the farmers, because of the simplicity and because of saving in time as compared to other equipment. We may know that when a field is to be prepared the ploughs, the primary tillage, secondary tillage operation several operations and then planking has to be done before the seed seeding is done.

Now, in this equipment you do not need so, many passes of those equipment and hence we are saving energy, from that count this equipment is very useful. So, we will have an idea about this equipment or other rotary tillers. So, I have named this lecture as mechanics of rotavator or rotary tillers. Now in this we would like to know what are the details of a rotavator.

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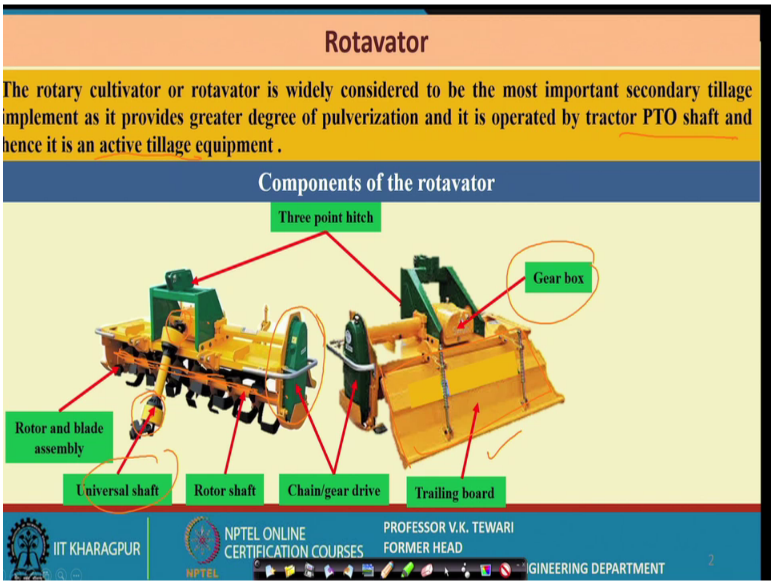

Well, what a rotavator is. You might have seen in the field its operation in the second class itself, but let me give you some more details of this particular equipment. This is a equipment which is which is operated by PTO of the tractor, and it is a active tillage equipment it is an active tillage equipment, it has certain basic components which are essential from the point of view of the designer or the user you must be have a look at it. First is the universal shaft why I say universal shaft initially? Because this is the shaft to which the power is taken from the PTO. Now this has the components for example, it has a universal hook joint on this side, there is a another hook joint over here and there is a cordon shaft in between.

This total is the one from where we are taking power from the tractor and giving it to the rotavator. Now in this rotor then we have a gear box we have a gear box here now this gear box you can see that when the power from the PTO is coming this power is rotating in one direction, and we would like to give change the direction of rotation to 90 degrees, because then the rotavator the axis of the rotavator is perpendicular to the direction of operation of the tractor. So, in order that we get this rotation we have to have a gear box which should give will change the direction of this, and here I will give you more details of this in the next slide.

Now, there is an another aspect which is in the how the power from the this gear box is connected given to the shaft to this shaft. Here is the chain or gear drive we will show you this also how it is connected. Because once the power is taken from the gear box to the shaft, there is a reduction in the speed because the PTO returns at about 540 rpm, but they are aim of this is much lesser than that about 210 to 20 to 30 in that range it varies revolutions per minute.

So, well there is another important component of this rotavator is the board; now this board you can you can have a look at this board, which we call as the trailing board. Now this board a has two main purposes you know when the equipment is operating, many a times there could be stones etcetera and if they are people around may be the a person who is operating and there could be another helper etcetera. Some of the stones that may get thrown and hit the person or even some other may be dust etcetera, which may come and disturb the persons around. So, for that this cover helps us in covering that and give gives a safety cover to that.

Second usefulness of this is that it gives planking purpose; that means, you do not need to plank the feeds after so, rotavator has been operated. So, this is one of the very useful part of this particular equipment, then the rotor and the blade assembly. So, you can see here that this is the rotor shaft here and at that shaft, there are several discs single discs are there and each one of this discs there are blades.

We will talk of this slightly later, but then there are certain blades. Now these blades help us in cutting those soil as well as stresses which are there when the equipment moves. So, this talks of the total and this is connected to the three point hitch. It is connected to three point linkage, but the power is coming from the PTO only. For lifting and lowering only we are using the three point linkage let us go through the next slide.

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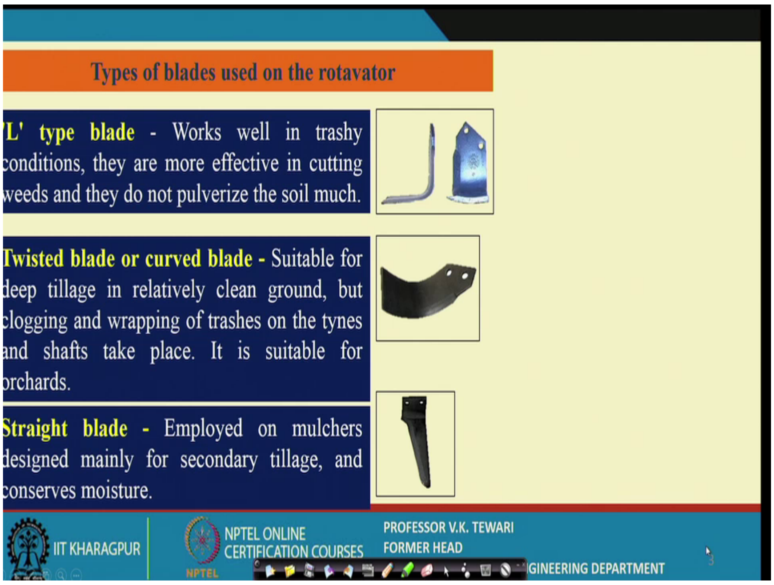

Yes types of blades well I have shown you the blades and how they are connected how they are fixed into the shaft of the rotavator, now see the types of blades. There are three main types of blades which are used; the L type of blade L type of blade. Now this blade works very well for trashy conditions this works very well for trashy conditions, although do not pulverize the soil very much it does not pulverize, but then when your trashy etcetera are there I think this type of blade L shaped blade will cut it and then put those things on the field and virtually try to conserve the moisture of the field.

The next one is the twisted blade or curve blade type twisted or curve blade type. This is suitable for deep tillage relatively clean ground when the ground is clean or may be in the orchards also, but it has a problem. Now the problem is because of the short length of this you can say the short length of this particular blade, that the trashes etcetera they get entangled or get wrapped into this the shaft itself. So, that way you can say that this will create load onto the tractor.

Although it must be tolled here that the rotavator is a negative draft implement, because when it rotates in fact, the total draft it should have been there that draft gets reduced by the amount of power that the rotoring element takes. So, although that is there, but then it will help it will not help if this particular blade is used, because it may have clogging and wrapping of the trashes on to the shafts. So, this is one of the you can say the problems with this, but then it has its own advantage which can be used in a orchard.

Straight blade when straight blade these are employed in mulchers as I said even while talking of the L type blade, because many times when after the way say wheat harvesting. Then this equipment is operated the stubbles are about 6 to 5 to 6 inches high and then they need to be cut and then left in the field itself. So, that they will conserve the moisture and then you can have the operation and you can have even seeding because there are equipment available for say like zero till drill you can use this thing and after that you can show the equipment immediately show the seed immediately because you will save moisture and also timelines of operations you will not lose more time in that as well as the weather, which will help you in next crop. So, these are the three important blades which are used with the rotavator.

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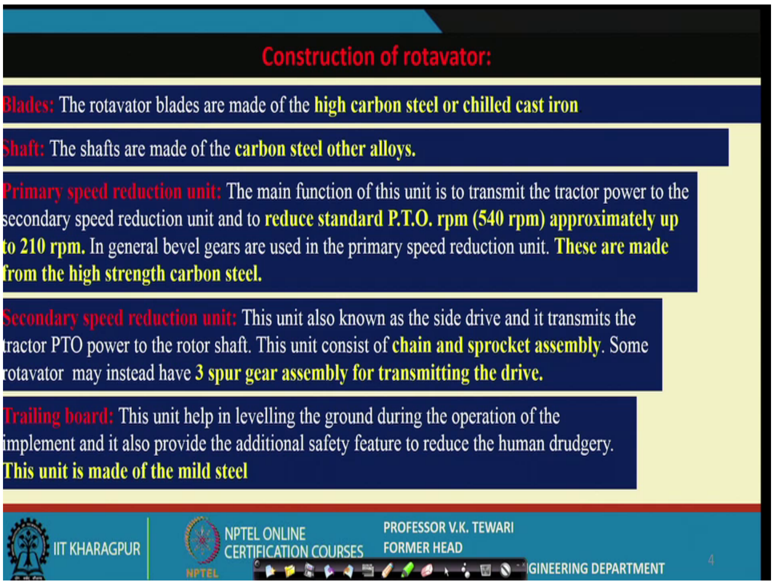

Well certain further information about the construction of the rotavator. Well we have talked of all the components how the components look like, where they are placed now we will talk about these component slightly in detail about their construction about their material of construction etcetera.

For example the blades the rotor blades are made of high carbon steel or chilled cast iron because we know that these blades are the most important component on the rotavator, because of these blades they do not last more then the then the farmer will have lot of problem in each time changing these blades. So, the blades must be made of a good quality material and the sharpness of the blade must be maintained for a longer duration of time to get more output.

Shaft; the material of the shaft these materials are the normal carbon steel materials or its alloys are used for the shaft of this rotavator. Now after these then we have the reduction units, I discussed in the previous slide itself. The primary speed reduction unit we will see what happens is we know that the PTO is operating at 540 rpm approximately, and the rotor is not operating at 540.

So, how to reduce this and for reduction of this you have to have a two stage reduction process. In the first stage what we are doing is we are in fact, having the rpm approximately ok. Bevel gears are used now what we do is first stage is in the gear itself which is there directly when we have connected the tractor PTO through the cardan shaft, you must have seen through cardan shaft to the gear box, and that gear box as we have seen in the previous slide that the gear box is just on top of the whole equipment.

So, there we have a bevel gears sometimes worm gears, you know that worm gears are also used for non intersecting shafts, and for giving a 90 degree power transmission. So, you can use any one of these. So, these are used. So, there also we have a reduction by using this spare of the gears and change in the direction of rotation. So, this is one state.

The second speed reduction takes place because this you have seen that this particular shaft is connected to a gear mechanism I had shown you in the earlier one may be in the next slide I will show you more details of that, but then there are chain and sprocket somewhere. This I will show you the chain and sprocket assembly here chain and sprocket assembly. So, this chain and sprocket assembly we know that chain and sprocket do not allow lot of loss of power and that is why it is easier to use them, rather than using gears or rather than using belts.

So, some rotavators may instead have three pear gear assembly for transmitting this drive also. So, the you can have gears, you can have this. Now depending upon the requirement, depending upon the type and depending upon the size of the rotavator which the manufacturer wants to make, I think we will have to decide on these. Then the trailing board I told you about this trailing board, usefulness of this trailing board I told you already I must emphasize once more here that, with this the unit this unit is made of mild steel and it helps in particular safety feature as a safety feature and hence that this is the human drudgery.

So, these are important points and of course, it levels the ground or levels the field once the it has been come it levels the field also. So, these are the different components and their construction and including the material of that. I mean that tell about the material of the gears etcetera which is well known, but then we have talked of the wave materials of the blades materials of the shaft, then we have talked of material of the trailing board which helps us in leveling the ground as well as the safety feature.

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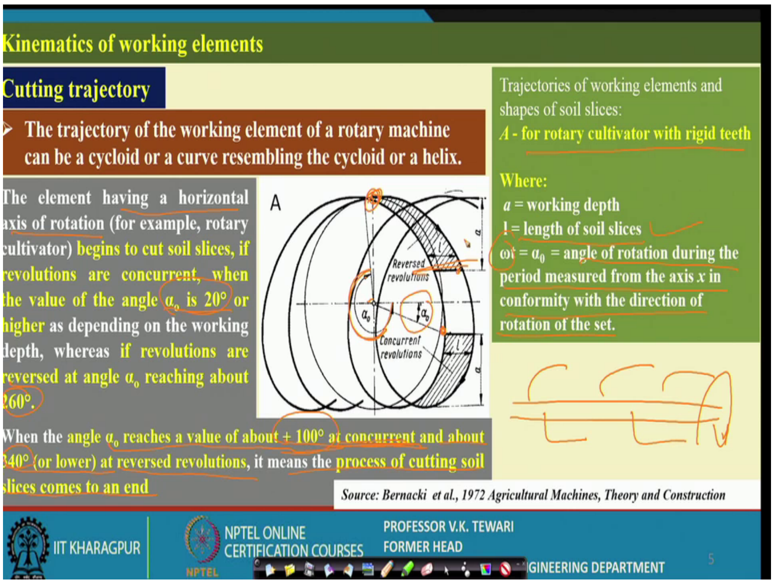

And now we will go to the next slide. Well once you have seen that the equipment has shaft and therefore, several blades and then the power is coming from the PTO, now what happens to this particular power how the power is being utilized in cutting the soil? Particularly when we want the manipulation of the soil for preparing a seed bed so, we will it will very essential to know the trajectory of this cutting elements, we call here the kinematics of working elements, the blades are the working elements here what is the trajectory here.

Now, you see that you we have the rotor here, we have the rotor and then the blades are onto that the blades are on that. So, now, these blades now these blades when the rotation takes place, they will be moving forward and once they move forward they will definitely cut a certain section of the slide section of the soil, then when it goes further there will be another section cut.

Now, what happens is that there is there are two important things to be considered here, one is the speed of the tractor and the second is the peripheral speed of the rotator shaft. There has to be a good relationship or a or a designed relationship between the speed of the tractor forward speed of the tractor, which we designate at say v and the speed of the speed of the rotor shaft the peripheral velocity of this.

So, there has to be the these important relationships, now when we talk of this relationship then only we get what is the amount of soil which has been cut or what is the amount of cut of the soil or width of the soil that we have cut, how it cuts while in rotation let us have a look at it. See when rotary cutter when a rotary cutter rigid teeth or when the say any one of the blades which we have shown earlier anyone of the blades, what will happen is, is the center over here. So, from there when the when the element is having a horizontal axis of rotation during horizontal axis of rotation it is seem that when the blade moves at an angle alpha is this value at this particular point, where value is say about 20 degrees.

So, at this point you can see that at this point the cutting starts, at this end somewhere this goes and it ends somewhere when the angle is about 100 or so. Now when the angle alpha reaches the value of over plus 100 at concurrent and about 340 lower at reverse revolution it means the process of cutting soil so, as coming to an end; that means, now concurrent and this must be told to you.

Now, see what concurrent means; many a times when the when we have the blades put in such a way that the direction of movement of the tractor, the cutting is taking place. Many times in those in that case of course, we do not get that much of pulverization, but when we reverse the blades and by changing the these the transmission which we had discussed earlier, the transmission as well as the orientation of the blades with respect to the discs which are there on the shaft.

So, when you do that, you will find two types of operations one is the upper cut I mean the up cut the other is down cut. So, in case of the down cut actually when we are talking the forward direction, this which is called as concurrent; that means, it is in the same direction when the tractor is moving in the forward direction the cutting is also taking place in the same direction.

So, in that case it this cutting the cutting width actually the length of the soil slice, starts here at alpha is equal to say 20 degrees and ends at plus 100 degree in case of the concurrent. Now when this is there in case of a up cut situation where we have changed the direction using the same shaft I mean the same shaft, but change the direction in that case we find that the cutting starts, the cutting starts at 260 degrees. So, 260 degrees here somewhere here. So, this is alpha 0 become 260 degrees. So, it starts here and then it ends up to this at 340. So, this comes somewhere about here and then the takes 8 inch. So, this soil slice is changing.

Now, here only it is the mechanics of how the soil slices are cut in the two different situations of the motion of the blades. A whether it is a up cut or a cut down cut in the case of the concurrent movement; that means, movement in the same direction where u is in the same direction and v is also in the same direction then we have this thing.

Well this we have taken from source over here to explain the details you may have more more details you may see there itself now. So, alpha 0 is the angle of rotation during the period measured from the axis x, in confirmatively direction of rotation on the set. So, with this is what omega t gives us our alpha 0.

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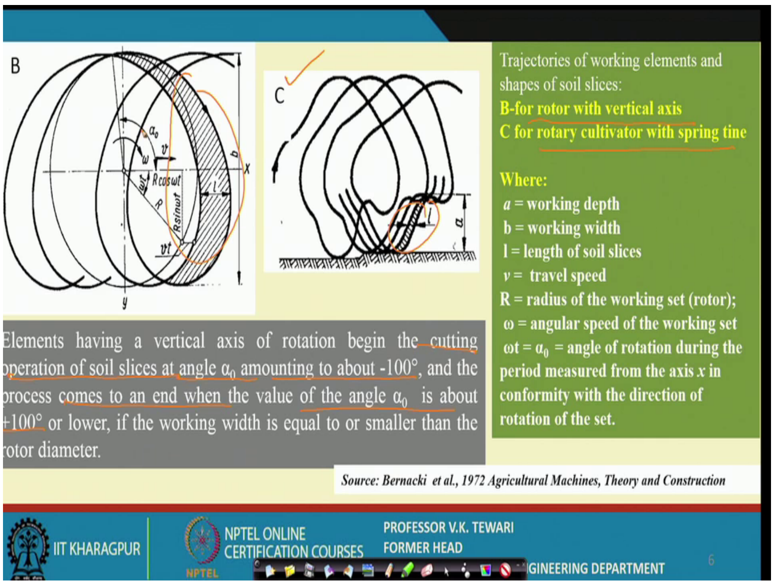

Now, another situation where now we talked of the blades where the axis for its horizontal, where the shaft was horizontal; now there could be a situation where the shaft is not horizontal and is vertical axis of rotation. Now although these are not in vogue now a day, but I thought work having a look at this for your information that, if these are in a in a vertical axis how the length of the soil size changes and if it is rotary cultivator in the spring time, then how it will change. So, these three situations have been explained here.

You can see that rotator with vertical axis and the rotator cultivator with the spring time we had talked of the horizontal axis in the previous slide. So, in case of this you can just have a look at this that same angle omega t which was there earlier, now the l starts here. The soil slice at an angle the cutting operation of the soil slice at an angle of alpha amounting to about minus 100 degree, and the process comes to an end at the value alpha 0 about plus 100 degree.

It is it is very simple because then since it is in the vertical direction, it is easier to understand that where it starts and where it will end. So, it is a let starts at about minus 100 degree and then close that plus 100 degree or lower than that depending upon the size of the blade that has been used over there.

In case of see the rotator cultivator will spring time here, you can see that the length of the soil slice is so small so small here although, this is a very good amount of soil slice which has been cut even in the vertical axis, but in the rotary cultivator it is times with spring type times here, this is the slice the width of the slice or you can see the length of the slice this is very very much low and I would say that this would not be preferred very much for the operations.

You can also have a look at the total work in, which here total work in which this in case of a vertical one this is in the total working with. And radius of the working say total radius of the working state is shown over here. Now these are the details of the two three types of the shafts connections with the blades. Now let us go to the next portion is to what happens to the blades and how we use the element these elements in design yes.

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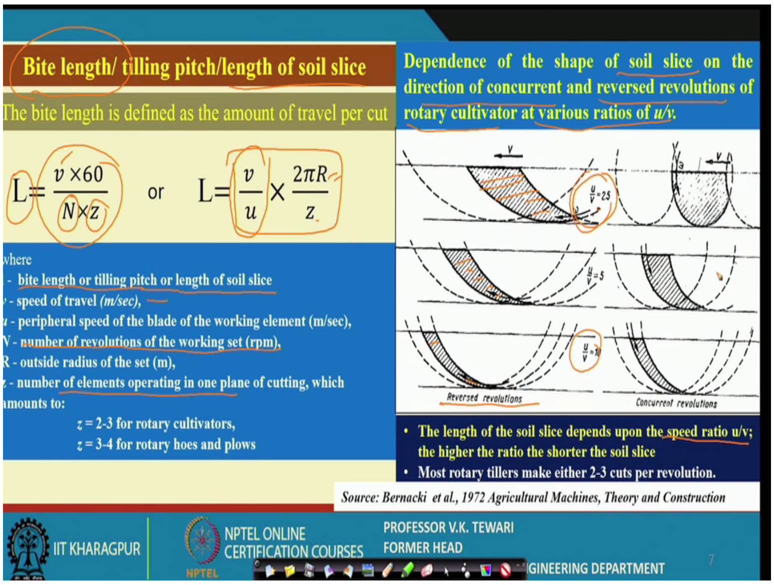

Now, we just talked of the length of the soil slice. Now how important is this length of soil slice? See definitely important because then we would know as to what is the total volume of soil which this rotavator is handling, because on that itself the power will depend and we will have to have the power source accordingly designed.

In later course of this particular lecture I will also let you know how to design the rotavator and what are the various other features which will come into play. The one which is coming to play at this point of time is the bite length here or the length of the soil slice. Now this it is it is very easy to understand once you are knowing about the rotation of the shaft and rotation of the blades, you can very easily compute what is the bite length here or the tilling pitch or length of the soil slice which we have shown earlier.

Now, you can have a look at this, that if N is the number of revolutions of the working set over here and if Z is the number of working elements in in a plane, then v being the velocity travel speed in the forward direction we can simply get L which is the bite length which is given as in this here. Or if we take care of the speed of the if we can take care of the speed of rotation of this; that means, speed of the peripheral speed of this, we will find that the relationship gets changed where a very regular one where we get the v and v by u. Now this is very important factor here R is the radius and z of course, I have said about the number of elements in one plane.

Now, v by u this is an important factor. So, far as l is concerned as well as this also talks of the total volume of soil which has been handled. So, when v by u you can have a look on this slice, we have shown you the dependence of the shape of the soil slice on the direction of concurrent and reverse which is very important. On the rotary cultivator at various ratios of u and v. Now you can see the length of the slice are depends upon the speed ratio u by v here. Now you can see here that as u by v is increasing for example, u by v is 2.5 this is the cut here this is what it is.

Then goes to 5 you can see the amount it has come. It come to 10 it has come much less, when you go to the this is when the case is when the situation is reversible issues in the up cut type of rotavator blades when they are pointed. When you take care of the concurrent revolutions, then you have a look at this. Here the c here that u by v when it is 2.5 see this is the amount which is cut. Now u by v which is 5 this is the amount and much compared to this. So, you will find that the concurrent one definitely gives a higher volume as compared to this even at a value of v as 10 this is higher than this value this value in case of reverse one.

So, we can say that u by v is a very important factor to be considered when we are considering the design of the rotavator or when we are considering finding out what should be the size of the blade and all other details of the design. Most rotary blades have two to three cuts per revolution yes, how many in a revolution how many such cuts will appear, now these it has been found about 2 to 3 cuts will takes place. So, depending upon the u by v ratio that you take, you will have these details known to you; now let us go to second slide.

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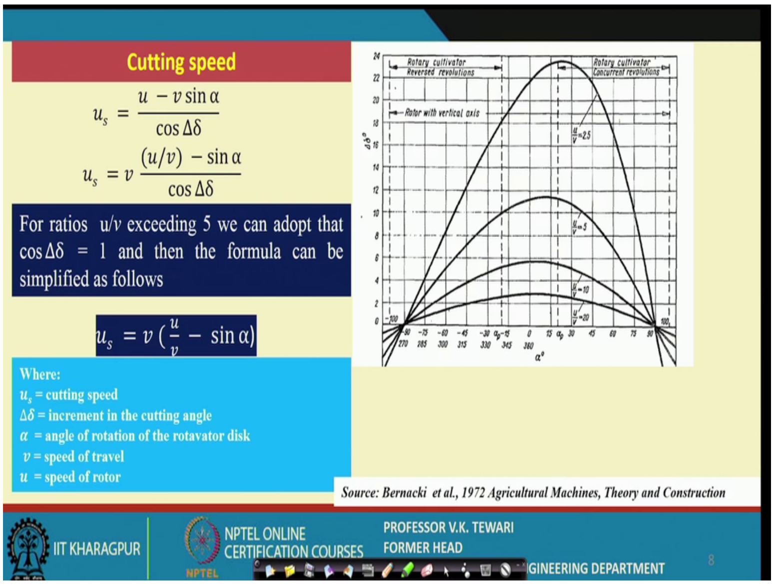

Well cutting speed. So, from there itself we can have an idea about what the cutting speed is. Now this is the cutting speed which has the ratios with u v and angle alpha. Now this angle alpha is the angle of rotation of the rotator and the rotator with a disc. So, with these you the cutting speed has been formulated to the u minus v sin alpha by this. Now you can see that v the speed of the rotor, and v the forward travel speed here. Increment in the cutting angle now delta t delta you can see the delta is the increment in the cutting angle. So, with this you find that u s is given by this here, and then u s if you for a ratio of u by v exceeding 5, we can adopt that cos delta is 1 very if you say that the value of cos delta, which is coming over here can we take it into v 1 for u by v is equal to 5.

Now, there are u you can have a look at this because this angle alpha has a variation with respect to its delta. Now when we want to consider this alpha this delta we need to look into this particular table. This data is already available and once we have this chosen for accordingly, we can look at the value of alpha and take the value and from here we can find out the cutting speed of the yes forces of cutting.

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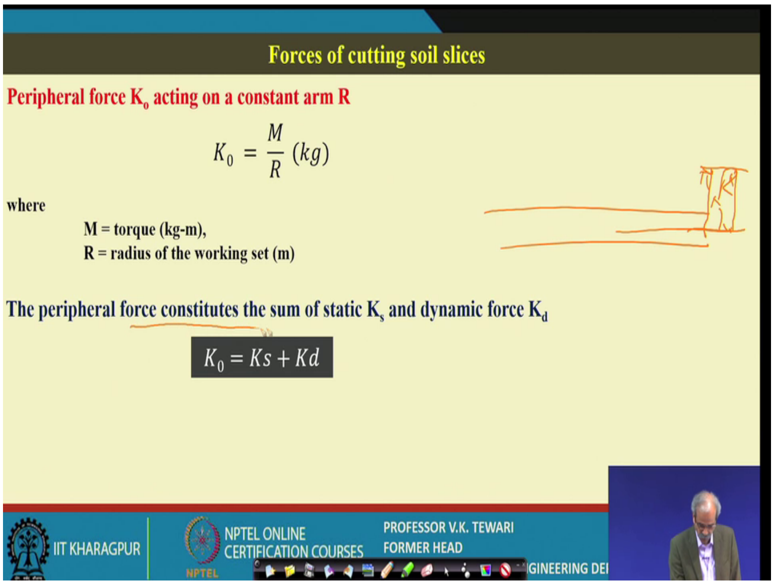

So, immediately there you can also know what is the cutting force on the blade, because then ba blade will have a certain torque the radius of the set is known because we know right from the center right from the center of this is this we can find out what is the total radius here. So, this radius you can find out and M is the torque coming on to it.

So, we need to find out the total torque. See peripheral force constitute these two things one is K s and the other is dynamic force K d. Well arrangement of the working elements on rotary disc, how they are arranged. It is very important to know once you know the details it is very important to understand as to how they are arranged.

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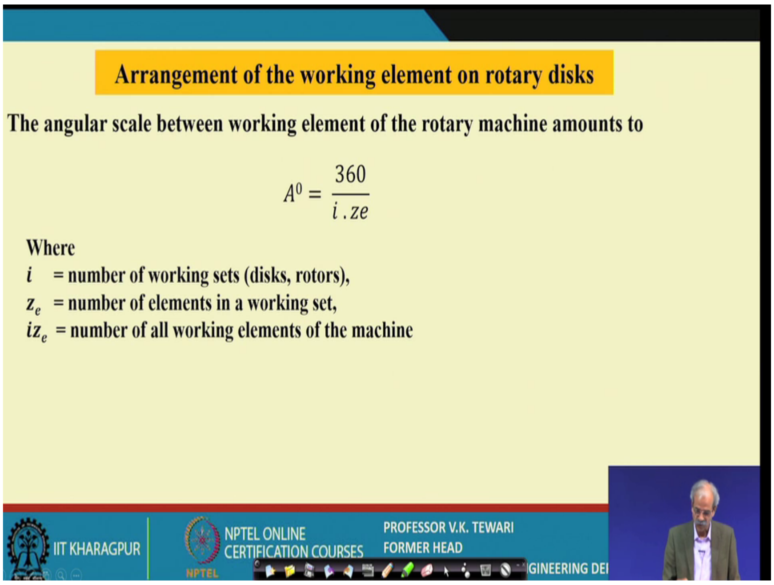

Now, these are arranged with respect to see the space you give here regular space is A 360 by i into z into e here. There is number of element working elements and number of working sets. So, once we know that because 360 is the rotation of that. So, we should be in a position to find out the value A which is the working element angular scale between the working elements; that means, angular positioning of the between these two.

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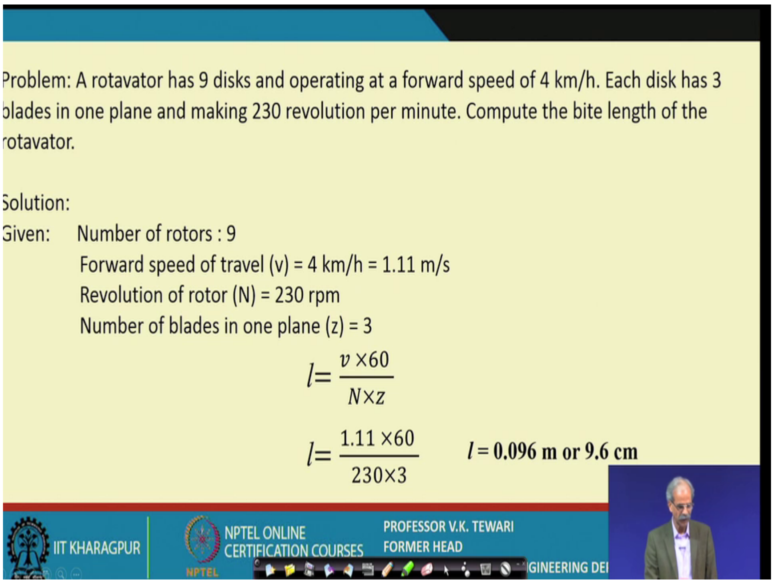

Well a problem has been taken if you all those details and you will find that this problem is nothing, but simply putting those values and you will get the length of the bite length or length of the slice which has been cut.

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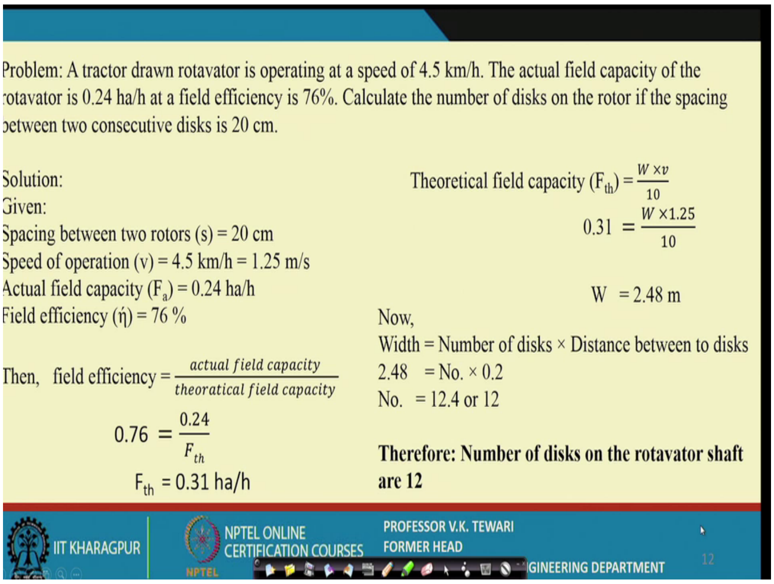

A similar another problem on the similar count with certain changed values and certain other considerations has been given, where you we have tried to find out what is the total number of a number of discs on the shaft, and just putting those values and taking care of the details which we have discussed earlier, you will be in a position to find out the number of disc on this.

Thank you.