Farm Machinery
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Lecture – 46
Harvesting Equipment

Welcome students to my lecture number 46, which is on Harvesting Equipment. Well, so far we have discussed about the crop all details right from tillage to planting of the crop, then plant protection, weeding etcetera. And now, we have come to a situation, where the crop is ready. And this crop needs to be harvested, and then transported to the yard for threshing and then after that to bagging and then storage.

Now, what is the equipment, which is used for this particular task, which is known as harvesting. We will I have gathered here the basic principles which are involved in harvesting. In fact, if you find that there are several machines now available from small to very big for this particular task in agriculture. What is important from as engineers point of view, what you should be knowing is that what is the principle on which the different elements of the particular harvesting equipment work, what are the different lacuna which they have, what are the features important features, which they must have correct at the time of harvesting? Those are the principles, which you must know.

And what are the varieties of the harvesting equipment available, because crop could be a cereal crop, crop could be a you could say a fruit crop, crop could be a root crop. So, depending upon the type of the crop, then you have these harvesting equipment vary. So, we will discuss in the 1st lecture, we will discuss about the basic principles and talk about what are the ones which are available, and what are their basic principles? So, let us follow the slides, which are here with here.

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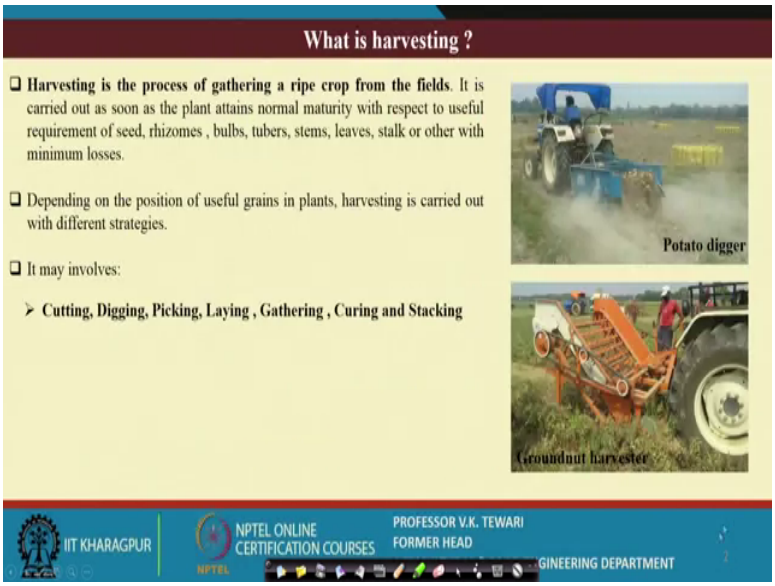

Well, as I told you, what harvesting is? Well harvesting is the process of gathering ripe crop from the fields, yes we would like to gather this crop, which is standing a crop, stand you must have seen and that crop is stand has to be now cut, and then taken. When it is in the right condition, whether it is as I said it could be a cereal, it could be a bulbs or the leaves, stalk or whatever that has to be (Refer Time: 02:31).

Then depending upon the position of useful grains in the plant, depending upon that the harvesting is carried out. And what are the things which it involves, in fact it involves cutting, the digging, in case of root crop, then picking, laying, gathering, curing and then stacking. This these are the different various unit operations, which are involved in harvesting.

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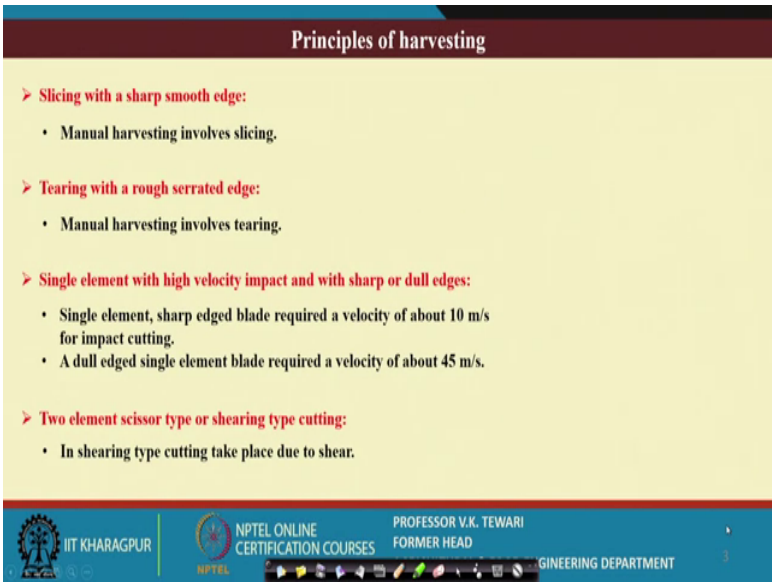

Basic principles, actually, when you want to cut a particular plant or a particular you can say tree, what do you do, you must have seen that you take a action and then start hitting on through that, so that is not possible in case of a plant, which is very thin and which is very soft. So, how do you do, and what are the various aspects, you must have seen that their lawns are there, (Refer Time: 03:22) would like to maintain the lawns, wherein we would like to keep a cover of grass, but then the bigger ones we would like to trim them off. So, there are various methods we employee, depending upon where it is and what is the crop?

So, it could be see you must have seen that people using devices, which are just they use and try to fit and cut the plants. So, one is slicing with sharp smooth edge that if you have just like sword if you have seen, the you can just use and try to cut it, it could be a smooth edge, it could be very sharp edge. Now, depending upon the sharpness and depending upon the bluntness of the edge, you will have to apply the force.

The tearing with rough serrated edge, you might have seen the scissors we use, you might have seen these sickles which are used from ancient time by the people, generally for harvesting or cutting. By that, we have serrated edges and those serrated edges are rubbed against or pulled against while holding the particular plant or a group of plants or group of those leafs etcetera to get.

A single element with high velocity with sharp or dull edges, now, these are the basic things what we do in this, either you have cutting by a high impact or you have shear cutting, these

are the two basic things. Now, there could be variations in that which as I told you. So, with these basic principles of harvesting, what are the equipment which are available and how do we go about the basics of mechanics which is there in this?

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Now, you see the harvesting equipment, I wanted that you should have a look at these equipment as such for the purpose of information that which are the equipment, where they are use and how. They are already available in the country and broad and very places for different types of crops. Maybe we will show you the working of this at so later stage in this particular lecture but then, I just wanted to show you, what are the crops which are available?

See combine harvester, this is one, where number one this is the combine harvester. Here you would like that when we say combine, actually generally when we are talking of harvesting, we are talking of only cutting the crop, whether you whatever be the methodology for cutting, you require this. But, in case of combine, what we do is we would like to cut the crop, then we would like to thresh the crop, then we would like to clean the crop and then we would like to bag the crop. Several other several you can say the operations are done in this, and that is why this is known as combine either you can say combined or some people say combine harvester as such.

Then the groundnut harvester, now, this is a groundnut, you have seen that this is groundnut is inside the soil. So, what is done through this, there is a cutting blade here and that the cutting blade, in fact will cut and then this groundnut bushes etcetera will be going through it

and then it will fall so, the soil will be removed. Similarly, the potato digger, I will show you the operation of all these. Potato digger, potato is also a root crop so, it is there in the root in the soil and that is to be dug, and then to be removed.

Then you have one, which is very widely used in this country and even in all Asian countries. And the one which is known as vertical conveyor reaper, which we call as VCR, you must have heard and many of you might have seen their working etcetera, this is where smaller unit, which is very handy only for cutting. But, what is done if you have seen the harvesting by the manual method, you see the cut and then small bundles are made and they are put on the sides, which is known as weed drawing now, this job is not done by this.

So, for cutting and weed drawing, we have another machine which is available, which is known as reaper binder that means, it will reap, as well as it will create the bundles. When I show you the operation of this, you will appreciated that time. Then some fruit harvesting, see you must have seen that fruits are either on the smaller trees particularly for apples and all that and some are on bigger trees like you should have say mangoes and other trees, which are slightly tall.

Now, if you harvest them, then what will happen is that once they fall on to the ground, they will get hard. And then after sometime, they will get spoiled and hence, their self-life will be deteriorating and it will be reduced a lot. So, the ultimately the farmer will not get enough revenue, so we do not want that to happen. So, what they will do that small devices you can see that these small devices are there which the person either he can start from the ground itself and then click it up.

And just taking these ones, or in these ones or maybe that he can go onto a platform that platform is reached, you can have a hydraulic platform, tractor operated hydraulic platform, which platform rises and then you can have this unit and we can pluck the mangoes. Particularly for the mangoes, good quality mangoes that they will be available and this will help you to get good quality and good price of that, so that is why so, I have shown you just these harvesting equipment, which are available in the country for on cereals and then root crops and then food crops etcetera so, just for information, this is worth knowing.

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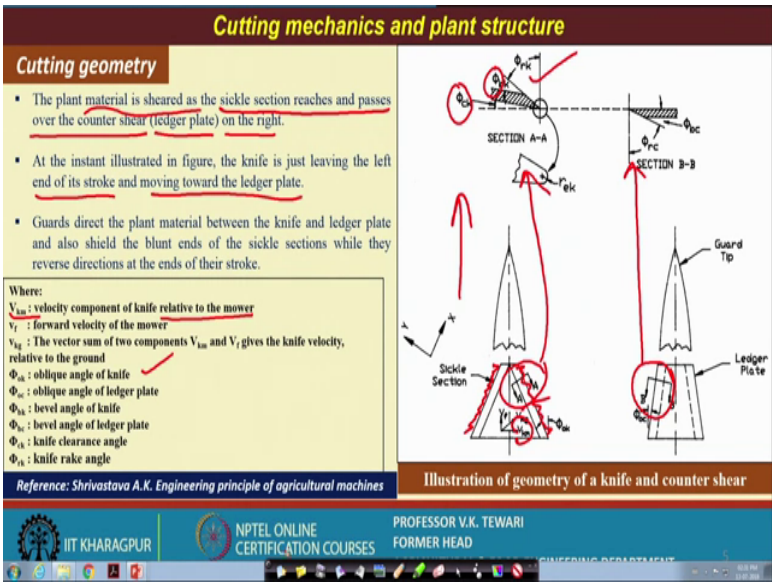

Now, mechanics, what is the mechanics of cutting and the plant structure? This is very important. As an engineer's point of view, you must know what is this mechanics, what does it happen, where does it happen? You have the plant here, you would like that cutting should take place properly. Now, it should cut in such a way, there should be enough strength for cutting. If it is such that it simply bends, then it will not cut. So, you will have to have that the when the plant is straight, there should be the cutting should take place and the proper moisture content.

See when you must harvest at a particular given moisture content of the crop. If the moisture content is very high, then also there is a problem, because the moment you touch the plant itself, it will simply start shedding and then lot of grains will fall. So, it is very important that particular moisture content and that the agronomists have told us that what is the moisture content for harvesting, wheat, paddy and things like that?

So, accordingly we should be doing that, but what is the mechanics behind it? So, we want to I have just jotted down some of the things, which you may also get in different books and literature as well. Just jotted down for the purpose, so that you can understand particularly the undergraduate students and postgraduate students and those in the industries, who are have not undergone a course on agricultural engineering, and working for industry, developing harvesters, developing other equipment and all that, this will this is worth knowing.

So, what is important here is the plant material I will show you. The plant material sheared as the sickle sections reaches and passes over the counter shear, the which is known as ledger plate on the right. Now, at the instant figure with the figures, which we have shown you here the left end of the stroke and moving toward the ledger plate.

Now, you see here the if we what we are showing here, in the sections which are shown here. So, this is a section, which is cut this section is shown over here ok. Similarly, this section is shown over here and this is for the cutting edge or the we can say that the cutting section and this is for the ledger plate. So, this so sickle section or ledger, these are all actually the serrations are on to this here.

So, this stocks of the ledger plate. So, what happens you have, you can see here that end of see start from end this is the ledger plate is here and then the cutting blade starts like this and then it will cut, and then it maintain a certain position. So, this is what the different angles, which are shown here. Now, what are these angles, have a look at this. See velocity component of knife relative to the mower V km now, this is here. Similarly, the V f forward velocity of the mower, the forward velocity of the mower here is yes, this is here ok. Similarly, the oblique angle of ledger plate, the oblique angle of knife, all these angles are given here. The rake angle rk knife rake angle see this is the knife rake angle here.

Similarity, the knife clearance angle, in the knife clearance angle ck, this is the knife clearance angle. Then knife bevel angle, this is knife bevel angle. Now, all these are very important angles, so one must look into this. Then similarly, knife clearance angle here rc between rc and phi b will come later ok. So, this talks of the cutting mechanics that means, cutting geometry what happens, when the cutting serrating blade comes to the ledger plate and cuts. And this is the forward motion actually this is motion taking place in this direction so, let us go ahead and see what else is there.

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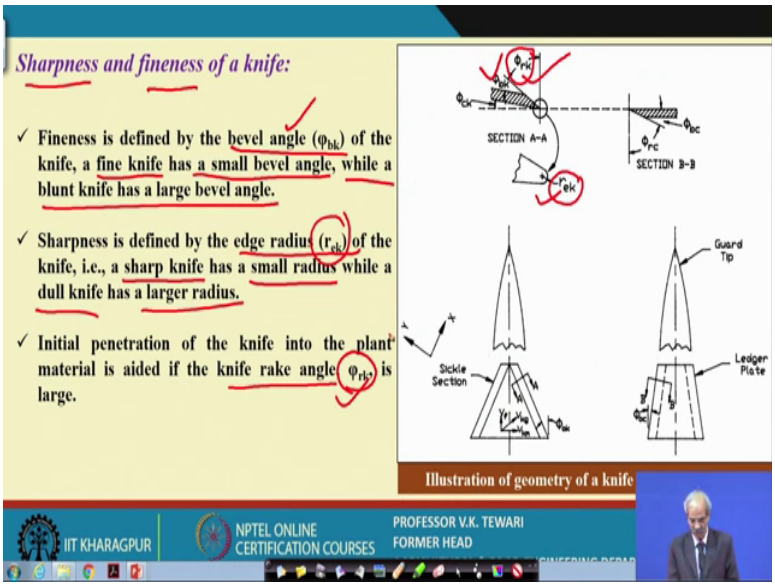

Well, sharpness and fineness of a knife, what are these important parameters actually, these are very important parameters. The sharpness of the blade is important, how fine is that blade sharpness. Now, here fineness is defined as the bevel angle so, this bevel angle b phi bk, this talks of the fineness of that a fine knife has a small bevel angle, while a blunt knife as a large bevel angle.

So, this is important to be noted that if you if the fine knife has a small bevel angle. When this bevel angle is smaller, then the knife is fine. And the other is when the blunt knife, when the knife is blunt that means, bevel angle is very high value. So, you must mark this points and see the proper angles to be maintained, when the cutting blade is designed.

Similarly, sharpness is defined as the radius of curvature is r ek. Now, this is where it is you can see here, this is r ek, this is this portion is shown here. So, the sharp knife has a small radius, while a dull knife has a large radius. Now, these are various important things, which I am trying to tell you. In nutshell, we have put all these parameters, which are very important to understand.

So, we talk of the mechanics, we are talking of the angles, we are talking of the velocities, and we are talking of the important behaviour of these very angles. So, when it is said that whether the knife is a sharp knife or whether this knife is a blunt knife, so what are the parameters, which differentiate them from their.

See initial penetration of the knife into the plant material is aided by the rake angle. Yes, this is very important phi rk so, this is the one. So, this important is that was initial penetration of the knife to the plant material. So, this angle is very important for entering or cutting so, this you check this angle. So, the values of all these angles of rake angle, sharpness angle, or the radius, bevel angle etcetera, are very important and they must be maintained, when you are designing.

So, here as an engineer, you should be very careful about choosing these angles. Well, it is not that you have to redesign the field as such, but these are very important, when you are going to take up the blades, you must check whether the blades do have this important angles as per the requirement or not. Otherwise, the working will not be that satisfactory and then acceptable see the same figure we have put here, just to understand the other factors as well.

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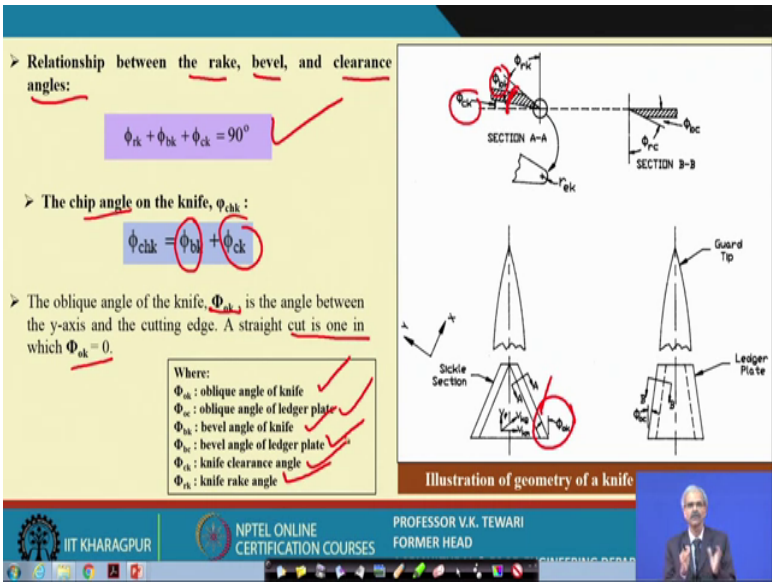

Now, this what is the important of these? See very important in fact, you see here that the relationship which is been rake angle, bevel angle and clearance angles, now these are important angles. So, what is the relationship? The total of that must be equal to 90 degrees check this. So, you have to now decide how the rake angles should be there, what should be the bevel angle, what should be angle clearance angle? So, that it is not more than 90 degrees, it must be equal to 90 degrees. Accordingly, you have to choose, depending upon the plant material, which is there, the thickness of the plant material and the strength of the planet material etcetera.

Chip angle, now, this chip angle is the angle, which is about the phi bk plus phi ck. So, you can see here that phi bk is this, and phi ck is this that means, this angle, this angle is your chip angle, this is the which is important. Now, oblique angle of the knife ok, the, here this is oc, well it is not it is here, the this is here now, this is the angle. So, the angle between the y-axis and the cutting edge, a straight cut one you are having phi equal to 0. So, we will see here this is the angle, so this angle depending on the angle that you have, the oblique angle knife a is very important. So, a straight cut is one in which pi k is 0, when it is straight away ok.

So, this is so these are the angles, which are important and how they are related is shown over here. And it is worth understanding from your point of view, we have you have put the angles together again here, the oblique angle of the knife, the oblique angle of ledger plate, then bevel angle of the knife, similarly bevel angle of the ledger plate, clearance angle of the knife, then rake angle of the knife. These are very important angles and how they are relate worth understanding and then following it for your design.

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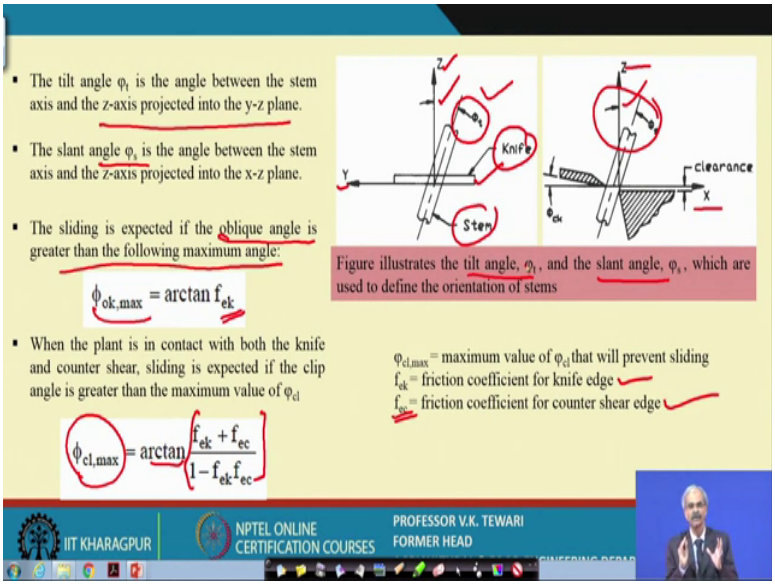

Well, how the whole thing takes place, when the plant is cut. Now, you have a look at this then so, the tilt angle is the angle between the stem and the z-axis is y-z now. Here see this is y-z plane; this is z, this is y so, in the y-z plane, this is tilt angle, this tilt angle here. So, it is important about when this is the knife, which is cutting, and this is the stem, this is a knife here and this is the stem, which is written here, you can have a look at it.

Now, this slant angle phi, yes now this is slant angle. You can see here for this angle, which is shown over here, this is in another plane; this is in x-z plane. So, you have to be careful about this, phi s slant angle is in the x-z plane, whereas the tilt angle is in the y-z plane. Now, the sliding is expected, if the oblique angle is greater than the following maximum angle. Now, what it is oblique angle max should be equal to tan inverse or tan inverse of f ek, where what is this f ek? F ek is the fiction coefficient of the knife edge. Similarly, friction coefficient of the counter shear edge is ec ok.

Now, these are related, how they are related? When the plant comes in contact with the knife, what happens, you see phi cl maximum is given as tan inverse of this relationship. This is the imperial relationship, which have been developed by the researchers, who have done work in this particular area and gone into details of how they are taking how do they are cutting takes place.

This work has been done at IIT, Kharagpur and we wanted to have a you to know that this is the details of the mechanics, which is working on the plants, depending on whether it is a hard one or a grass or a crop, whatever it is. So, these are the important angles now, the figure shows here, the slant angle and the tilt angle, which as I explain to you here. So, the various angles are now understood by now you see what happens next.

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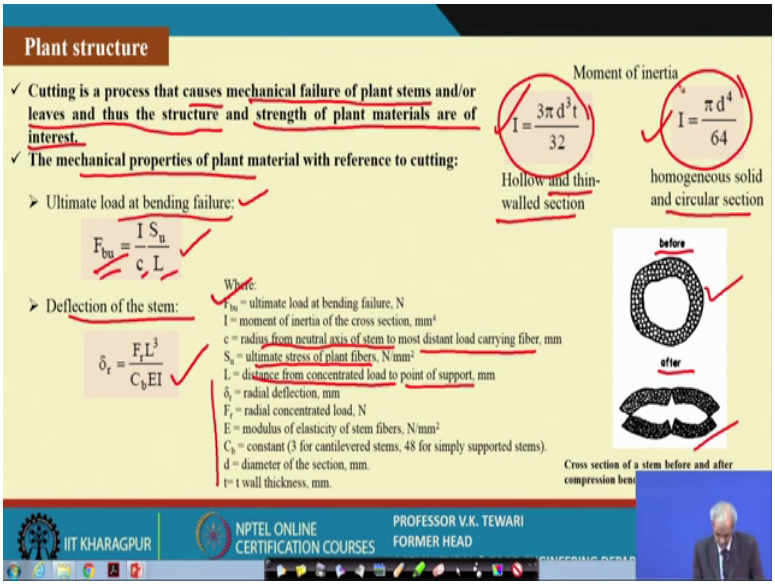

Plant structure, now, what is the plant structure? You must have seen that every plant see this is the plant here. Now, you can see if you take a cross section, if you take cross section of

this, so here you can see that this is a cross section here, before the plant is cut. Now, the cutting process that causes mechanical failure of the plant stem now, this is the plant stem, this is the cross section of the plant stem here and this is before, this is before and this is after, it has been cut now, this will be the situation.

Now, how this value takes place, when the blade acts. So, have a look at this, the cutting process is the is a process that causes mechanical failure of the plant stem and or leaves and thus structure and strength of plant materials are of interest, when we are talking with respect to the plant structure.

The mechanical properties of the plant material; what are the mechanical properties of the plant material, which are also important to us. So, we need to know what is the ultimate load or bending failure, we must know about this. We must know what is the deflection of the steam, yes the stem will deflect depending upon where you have started cutting and how and what is the strength of that and at what velocity the blade is coming this deflection of this stem will take place. And we have to be careful that it takes it does not bend properly and the simply goes over it, we have to be we have to design.

Now, where these parameters are already indicated, here you can see that the ultimate load at bending failure is represented by F bu, which is here. I is the moment of inertia is given here, s u is the ultimate stress of the plant fibres, these are available from the literature. Then c is talking of the radius for this neutral axis to the most outer fibre ok, then L, this L is the distance from the concentrated load point to the support, this is the eldest.

So, using this and knowing the details of that similarly from deflection of this stem, we have all these parameters which are indicated here, where E is the modulus of elasticity of the stem fibre. So, these details are with us and the researcher knows about it. So, we can we can find out for a hollow and thin walled sections, this with moment of inertia for a solid and circular cross section, this will be the moment of say, where d is the diameter, t is the thickness here of this and d is a diameter here.

So, using what you are talking and what you are trying to cut, accordingly this I will be used. So, this is about the plant structure, this will vary from plant to plant. If you have taken a tree, you must have seen the cross section, what will be the if you are talking of other stems may be that if you cut there, you will find something like this. So, you have to be careful and

understand what is the structure of the plant and how the blade should move on, what should be the velocity etcetera?

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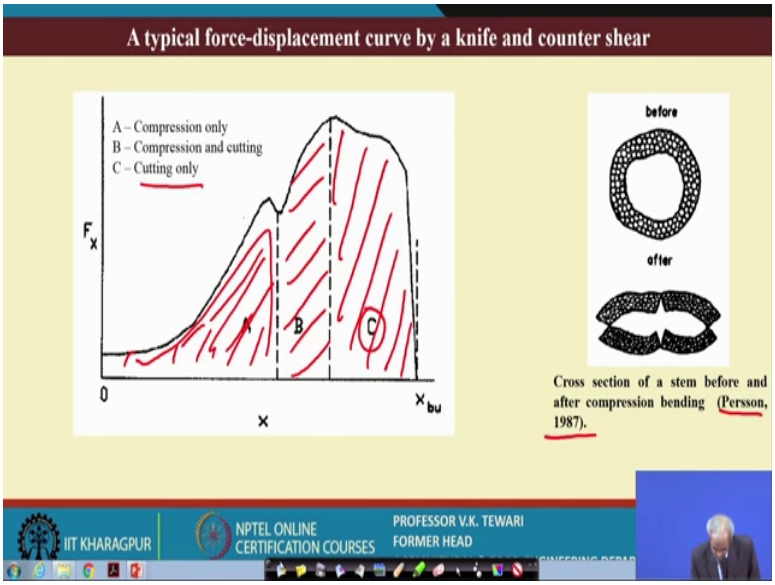

Well, when the this cutting takes place it is worth showing you here the so, the energy during this process area under this, we will talk of the compression only that means, energy for compressing that particular plant or collection of plants material, which are being cut. Then compression and cutting, which is taking place the energy for compression taking place is this direction this area. This is the area, which is talking of B.

Then cutting only, only pure cutting will take place during this part of the energy so, this part of the energy which is represented by C will be the complete cutting. This will talk of compression, and then cutting starts, and this is talking of compression only. Complete compression and after that the compression and cutting starts and then there will be only cutting. So, this is what happens, when the actual the actual cutting of the plants take place as we have said that in the ledger the selected knife and the ledger plate, when they come together this exactly is happening.

This is the energy, which is force and deflection curve for knife and counter shear. Counter shear is that which we are calling as the ledger plate. This is the reference from where we have seen, you can have a more detailed information if you want, you can check from here, because, this is worth showing you. You will appreciate this part of it, because the mechanics

as an engineer, you must understand the mechanics of what is happening, while cutting is taking place.

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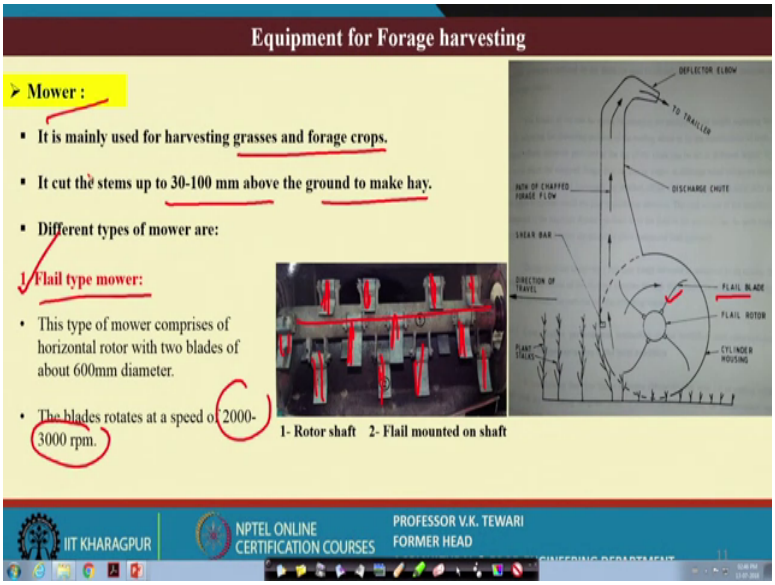

Well, what are the equipment for first equipment we are talking with respect to forage harvesting, we just talked of the plants certain of forage, now forage. You have seen that this forage is required for our animal. And it is very essential and it is grown separately, and then their heights etcetera, the stem height stem height, as well as the stem thickness, all these vary and of various types. Now, we would like sometimes grasses now, these grasses, which are quite about 2 feet 3 feet grasses, they also need to be cut. So, these such equipment are known as forage harvesters.

Now, what is the basis of such cutting? You can see here that the cutting takes place through the various types of mechanisms that we have, one is known as mower here. So, mainly harvesting grasses and forage crops, which are there smaller then the it is some say for about 30 to 100 mille metre above the ground maybe about you can say 30 to 100 mm above the ground very small distance above the ground it cuts, and maintenance also generally used for lawns etcetera.

Then sometimes when you have very big grass about 3 4 feet grasses, and then you want these grasses to be completely cleaned and all that. You may not use a harvesting equipment just like that we have, because those grasses you want also them to be cut and may be used for say cover. So, moisture maintaining the moisture of that so, this is better.

Then you have a flail mower, now, you can see these are the flails. This is the shaft here and on the shaft, these are flails, which are there. These are the flails you can see here, these are the flails, these are the flails, these are the flails, these are the flails, here, here. Now, this many a times, these flails could be chain, you must have seen a short about 30 35 centimetre chain. So, these chains could be also there, where it rotates at about high speed of 2000 to 300 rpm, then these will bit onto those and then like that they cut so, accordingly this cutting takes place.

Similarly, when and what does it do see after the cutting, you see the flail the blades are these are the flail blades, which are shown, a rotor is shown over here. And after this cutting, then they are thrown to the trailers, we can have a trailer behind it so, these some of the forage harvesters or the mowers which are mainly for maintenance of the lawns, gardens, playgrounds, etcetera. And flail mowers generally for say area which is very bushy area and not attended for a long time. So, if you want to clear that, you can use the flail mowers.

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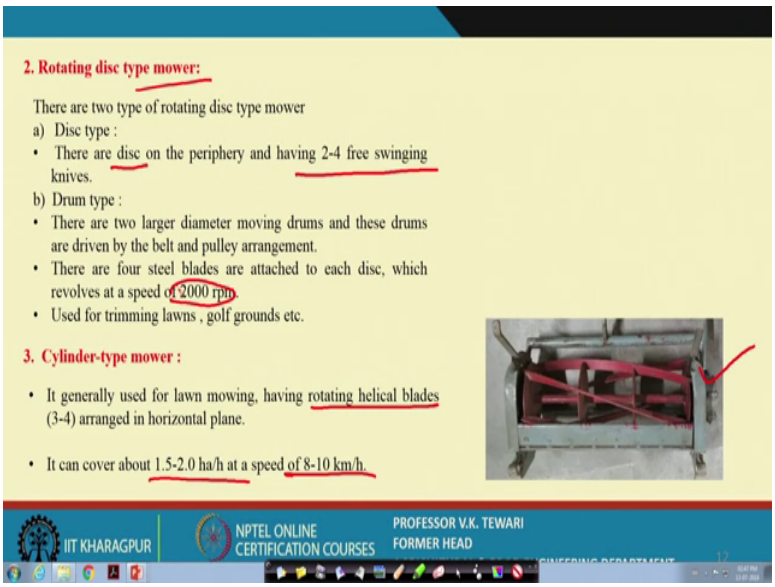

Rotating disc type mowers, where these are also small mower cylinder type mowers rotating (Refer Time: 28:45) cylinder type mowers, these are some of the smaller mowers, which are manually driven. You can say if this is one, which is a manually driven, this is cylinder type how this the these are the blades. So, when it goes on to that, in fact it will maintain a very smooth carpet sort of a cleaning of the grasses and maintain a carpet of the grasses. Those are actually the helical blades and you can see here that they can cover about 1.5 to 2 hectare per

hour at a speed of 8 to 10 kilometre per hour in fact. Then you can have a small engine connected to it and then you connect these two this, so that they can rotate. And then also these are operated manually operated, as well as engine operated ones are also available.

And some of the rotating disc type yes, there are various discs on which the blades are kept and then free 2 swinging, you can having 2 to free discs which are free to swing. And then while the swinging, they just by their action of swinging in the cut and because of the speed is very high. So, at high speed when they swing, they will cut the grasses etcetera so, these are other types of mowers, which are used, which you might have seen also, but these are the ones, which are available. And you must know these that they are available. And you should not be I mean ignorant of this that no, you have not seen, at least you must know the actions and the principles on which they work and where they are used.

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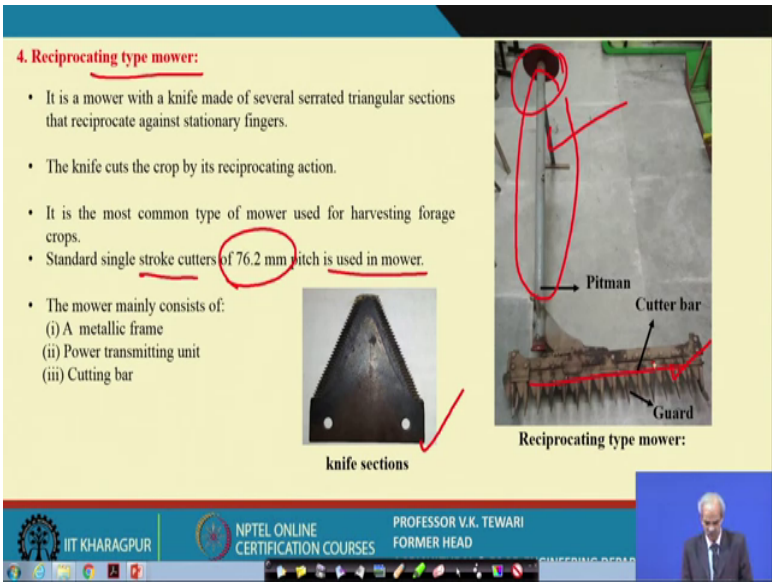

Well, we wanted to show you the some details of the mower. Here see this is the knife edge section here and reciprocating type mowers. These are the ones, which are very large ones; even you can have about 3 metres, 4 metres depending on the type of the tractor you have connected too. These are and there is a pitman here, you can see this is the pitman, this is called pitman here. And then cutting into the cutter bar, these are guards and then these are the cutter this is the complete cutter bar this is the complete cutter bar here and there reciprocating type mowers, they reciprocate. There are certain things, which are important for

this, because on the other side, they are not supported. So, there has to be a proper balancing of this and proper alignment of this, which are very important.

And these are standard strokes are about 76.2 millimetre pitch uses in this mowers. And they the power is see the power is given to this pitman and the what happens is the rotary power is given here and the reciprocation takes place with this. So, it moves with the power from the tractor and then by reciprocating action it cuts. Now, what are the other principles, which are followed for a particular balancing of this and alignment, let us have a look at it.

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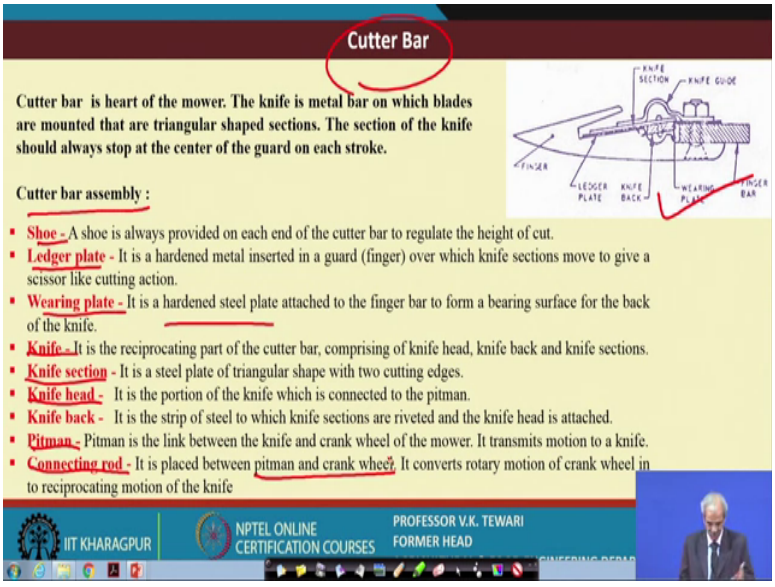

This is the cutter bar so, in the cutter bar, there is important things which are here in this cutter bar, which has been shown here the in one of the sections of that from the side. And what are the details of this, you can see the cutter bar assembly as the shoe the ledger plate, which you have talked of. The wearing plates, which are there, hardened steel material, then knife is there, and knife section will be there.

Then knife head, of course these details are shown over here, then the pitman, which I was showing you the pitman, then the connecting rod. Now, this connecting rod and there is a pitman and crank wheel. So, depending upon the power is given to the crank wheel, so the pitman is off set and that is why the rotatory rotary motion is converted into reciprocating motion and then it cuts.

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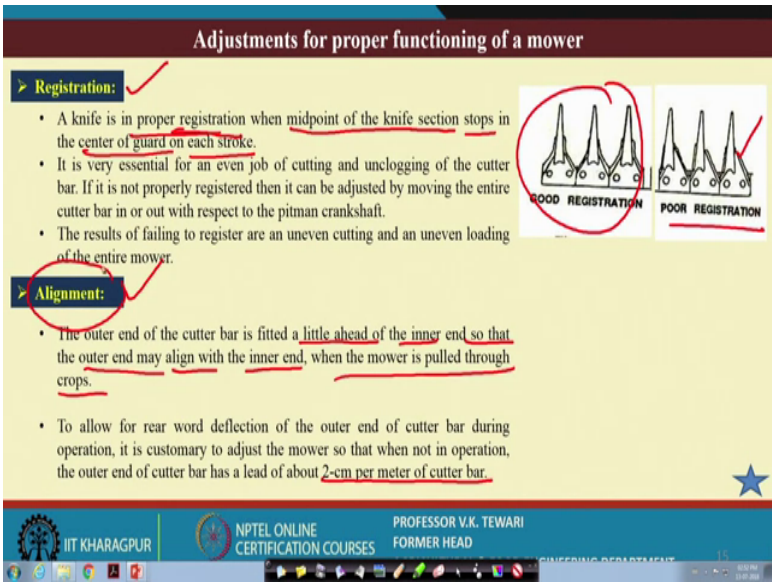

Adjustments, what are the important adjustment? See adjustments are very important here; otherwise it will not cut. And the two important ones are the registration and alignment, which are known as. Now, here a knife is proper registered when the midpoint of the knife is section is stops in the centre of the guard on end of the each stroke. This is exactly why a good registration, you can see here that you can see the cutter as well as the ledger plates, they are just that means, at the end of the cut, we will find that the center line of the ledger plate and the cutter are in one line. Same way if it is not so, then this is wrong registration or poor registration, which is shown over here.

Then what happens is that when the this long one, so the outer end of the cutter bar is fitted with the little head of the inner end so that the outer end may align with the inner end, when the mower is pulled enough through the crops yes, this is very important. And what is that head, how far is that head, actually it is put 2 centimetre per metre of the cutter bar length and virtually it maintain certain angle.

So, this is important to maintain this alignment is important, the cutter bar should be maintained. If you do not maintain this, then the cutting will not take proper placing place, and then you will lose power unnecessary. So, this is very important that the registration and alignment are maintained for these mowers which are there.

So, as such in this, we have given you an overview about what are the harvesting equipment, what are the root crop equipment and what are the knife edges and what are the details of

that, what mechanics happens and what are the structure be plant etcetera? So, we will follow this into more details about this equipment in the later lecture. So, I think will close here.

Thank you very much.