Metal Cutting and Machine Tools
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Lecture – 13
The lathe

Welcome viewers to the 13th lecture of the course Metal Cutting and Machine Tools. So, today we will be starting a discussion on the different aspects of the first machine tool that we have selected the lathe. So, today let us start right away on a discussion on the lathe.

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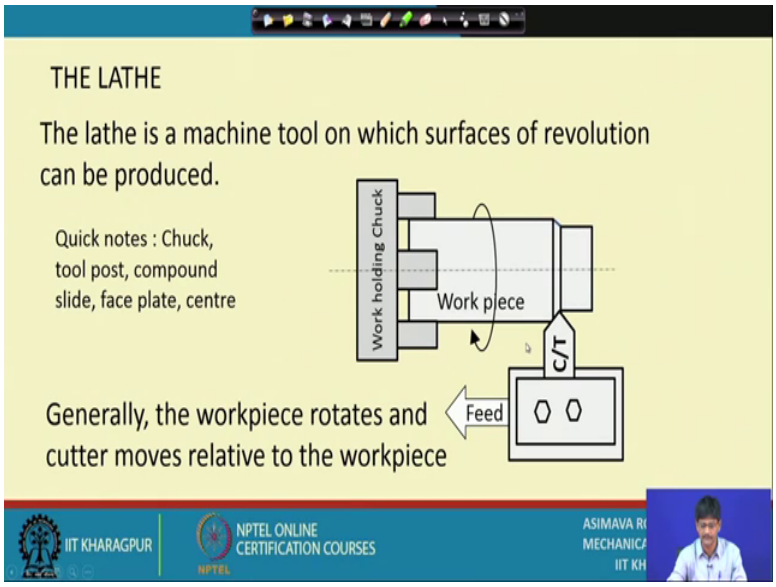

So, first of all the lathe is a machine tool on which surfaces of revolution can be produced, that is I can make a cylinder, I can make a cone, I can make a flat surface you know by which is also a surface of revolution, I can make grooves, I can make threads, I can make frustums of cones. So, all these which are surfaces of revolution I can make you know curved surfaces also, all these which are surfaces of revolution they can be produced on the lathe.

On the lathe basically we have to first of all have provision for holding the work piece rigidly and securely so that it does not slip because heavy forces are going to occur during cutting of metals. For example, in hundreds of Newtons, here on the figure we see the you know work piece shown this is the work piece or the job or the part or the item

on which we are going to carry out the cutting action. So, that we get a desired shape and size. This is the cutting tool about which we have already studied you know the tool geometry and other things they all you know pertain to this particular body the cutting tool in short I have written C slash T.

There are some bolts shown here with the help of which I am attaching the cutting tools securely to the tool post this is the tool post. So, just like a work piece the cutting tool also has to be held very securely so that it does not move or you know slip from its position. As you can see the cutter is given a rotatory motion, the cutter is given a rotatory motion and the cutting tool is given a longitudinal motion parallel to the axis of rotation of the work piece. It might be given different types of motion this is one the typical motion which is called straight turning in which if the cutter is you know moving parallel to the axis of the work piece in that case it produces another smaller cylinder.

The work piece is being held on a work holding device called a chuck and if you refer to this quick notes there can be different types of work piece holding devices like we can have face plate, we can have the work piece held between centers and lathe dog we can have a face plate sorry face plate we have already mentioned. So, we can have 3 jaw chucks, self centering chucks and 4 jaw independent chuck; that means, all the 4 jaws these are the jaws. So, these may move separately independently of each other or they may move concentrically on the circumference of a circle.

So, different work holding devices are their tool is held on the tool post and relative motion is you know obtained from the you know from the machine tool. The machine tool should be able to provide some relative motions by which cutting will be possible. So, hold the two securely and provide relative motion this is the main function of the machine tool. Let us see.

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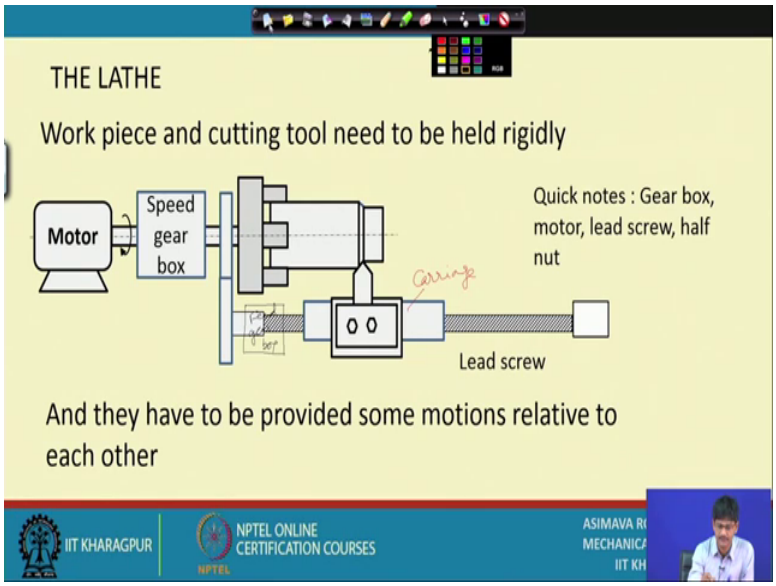

This is you know we are going on adding. So, with this add on process ultimately we will be getting the full picture of the lathe. Then here comes the prime mover the motor from the motor in order to rotate the work piece we see that we have put something in between. What is this? This is called a speed gearbox. What is its utility? You know we might not always want to rotate the work piece at a particular rpm. We might be changing this rotational rate and in order to be able to change this rotational rate we give provision to you know there is provision in the machine to change this particular rpm or rotations per minute. How do we do it? We are going to see that in a few moments.

But first of all what are the other things that have been shown here, here there is a threaded element called a leads screw lead screw shown which is you know deriving power from the motor only. And it is interesting to notice that it is after the speed gearbox that the bifurcation for power of the lead screw is taking place. How is the lead screw being utilized in order to make the tool move? So, the tool is being moved with the help of the lead screw. There is a device called a half nut inside the tool post we will see detailed view of the tool sorry you know carriage later on, but this is part of the carriage seen from the top. The carriage has different parts like you know apron and saddle etcetera. It is basically a device which can move you know move by the side of the spindle containing the job so that the tool is given a relative motion with respect to the work piece.

So, this is part of the carriage. So, let me quickly put in all these nodes that we are coming across. So, this I am calling the carriage scene from the top and this is the lead screw, already written down this is the speed gearbox and in fact, just a moment. In fact, we also have, we also have another gearbox which I have not shown at this moment which is called the feed gear box why have two gearboxes like this one after the other this is because just like I would like to change the rate of rotation of the work piece I would I might also like to change the rotations per minute and ultimately the tool movement rate per revolution the work piece past the work piece. That means, I might want to make this tool move at different rates generally this particular rate of movement is not expressed, but with respect to time, but it is a rather it is expressed with respect to the rotation rate of the work piece we will come to that in a few moments. So, we have yet another device which I have not written it is called feed gear box. So, this is roughly the you know kinematic structure how power flows from the motor through different gear boxes.

Now, let us have a quick look at the basic structure of the lathe that we have defined up till now. So, for that let me. So, let us first of all select fresh page in which we start with you know here we had the motor from the motor there was the shaft and we had the gearbox speed gearbox. From the speed gearbox we had a bifurcation power was going this way and it was serving the tool. So, this is called feed gear box and this is the spindle, here I have the part.

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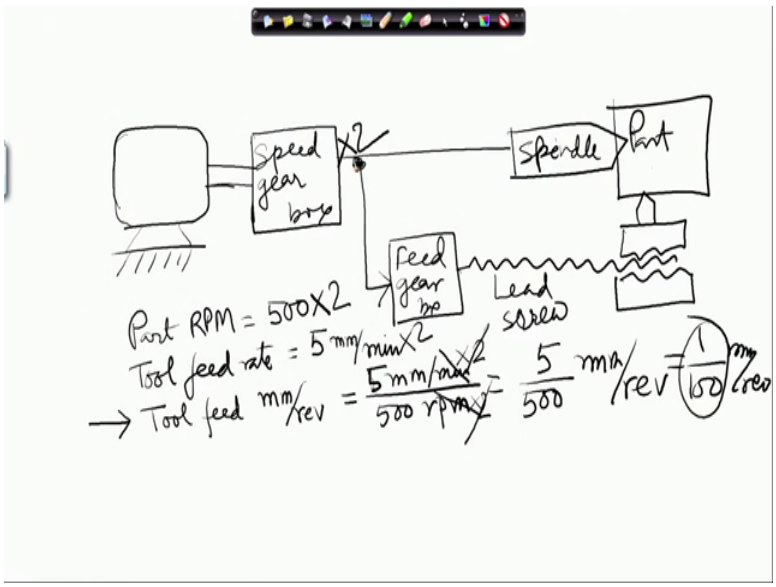

Now, what is the basic; why do we choose this basic structure of the machine, I mean on the lathe on this one I have a nut which I am calling the half nut and one that is sorry it is mounted the tool. So, this is called lead screw. The basic idea is this, that the speed gearbox should change the you know rpm of the apart and nothing else. So, straight it is connected speed gearbox should not affect the you know feed of the tool, but obviously, if it is placed upstream of the tool it is definitely going to affect if it is changed. Suppose we change the settings inside the gearbox speed gearbox so that the output gets multiplied by 2 in that case we will definitely find that the you know whatever is the movement that will get multiplied by 2.

However the feed which is defined in millimetres per revolution it will remain the same even if I change the speed gearbox. Why so? That is because suppose I have you know let us take an actual example say the there are speed which is coming. And the part rotation is part rpm equal to say it is how much 500 and say the tool feed rate is 5 millimeters per minute, in that case tool feed in millimeters per revolution of a work piece comes out to be you know 5 millimeters per minute by 500 revolutions per minute, per minute per minute cancels per minute per minute cancels. So, that we have this is equal to 5 by 500 millimeters per revolution that is of course, 1 by 100.01 millimeters per revolution. But where are we heading to? I am claiming that this tool feed remains constant even if you change speed gearbox setting; that means, tool feed in millimeters per revolution will remain same whether you change speed gearbox setting or not speed gearbox will change the you know rpm of the part no problem with that, but it will not affect feed.

In the same way feed gear box setting will not affect part rpm, but it will definitely change the tool feed in millimeters per revolution this is how the lead architecture has been you know contemplated. So, let us see whether tool feed changes or not.

I multiply the output of the speed gearbox by two; that means, I do something inside the speed gearbox you know just like you know changing the gear of an automobile I can get different speed outputs in the same way I multiply the output by 2. Therefore, in this expression this gets multiplied by 2, naturally the tool also becomes faster because its downstream this gets multiplied by 2 and therefore, in the denominator and numerator here they get multiplied by 2 and therefore, it remains you know this cancels out and this remains 1 by 100 millimeters per revolution. So, speed gearbox is so, placed that it does

not affect the feed of the tool and that is why you will find that that bifurcation for power is taken after the speed gearbox. So, millimeters per revolution being a unit of feed you know makes it independent of speed gearbox settings. So, that having have after had we have gone through that let us come back to the original discussion.

In the original discussion, it is understood now what is this lead screw doing here does it pertain to feed lead screw is generally used for thread cutting, and we have yet another you know such a shaft parallel to the lead screw which is used for longitudinal field. So, we are making a difference between lead screw and feed rod for obtaining different types of motion of the cutting tool. So, are there machines in which feed rod is absent? Yes, there are some machines in order you know save money and mechanisms etcetera the lead screw has just a keyway all through and that serves the purpose of lead screw as well as that of the feed rod.

Now, let us go back to our discussion. So, we have roughly got this idea bifurcation of power taking place after the speed gearbox and here the lead screw rotating and making the tool move. And here there was the existence of the feed gearbox which we have seen during our you know rough calculation manual calculations that we did. So, it is time that we can have the have a look at the next slide.

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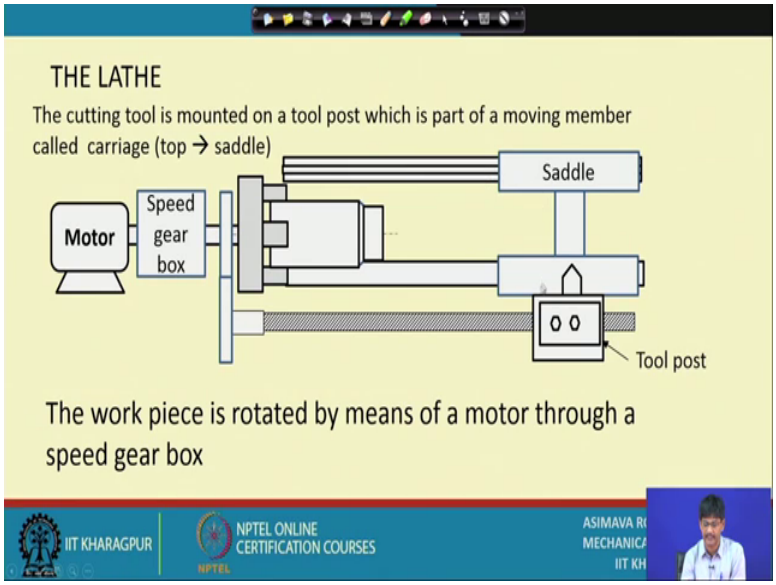

In the next slide what we see is that now the upper part of the carriage called the saddle just like we put a saddle or seat on the on the back of a horse, on top of the lathe bed seen from the top the basic body of the lathe we have put a saddle like element.

So, this one is containing the tool, then why not the what is the lead screw do it lead screw is simply passing through the carriage and we can we may or may not connect to the lead screw to derive power. But the carriage as a body is simply like a car on wheels on a track, this is the track, this is the track on which the carriage can travel. So, let it travel. This is it.

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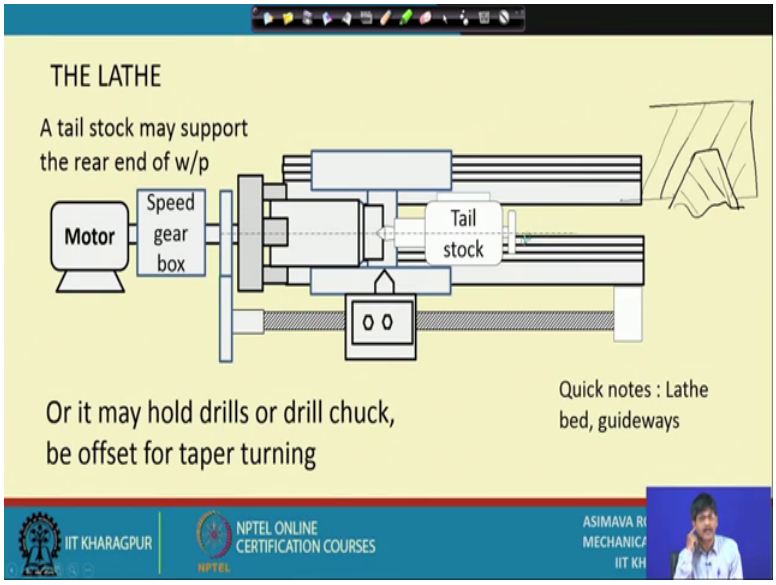

The carriage can travel from one side to the other just like a train on rails it has one straight rail on one side you know to provide enough bearing surface a flat surface is the best bearing surface and on this side in order to keep it located on a particular you know direction we have a v shaped guide. Let us let us quickly have a look at that.

This in the other in actual you know side view will look like this a v shaped guide on top this carriage can rest. Actually the carriage might be having some encompassing slide and guide connection in order that it does not toppled, but this will if this is the, if this is the carriage and if this is this particular track it cannot move this way, it cannot move this way, but it has to be located along this direction. So, the saddle is able to move and it takes the tool with it and the tool can you know remove material this way. So, now let us move on to the next part of the discussion.

We also have another very important mechanism just a minute we also have another very important mechanism which is machine element which is called the tail stock. You can see the tail stock is drawn in white color here to make it con conspicuous. So, that we can notice it. And how does it you know; how does it come into the picture? You find that we have made a skin section here to show that the rear end of the work piece is having a you know hole, it is called it that hole is done by something called a combination center drill and inside that hole, the hole is a little more intricate in shape inside that hole goes in something called a center its basically a cone at the front and at the back also its a frustum of a cone which is fitting inside a fitting tapered hole of the tailstock spindle this one can move out and move in by rotating this particular handle.

So, the tailstock can be you know moved just like the saddle the tailstock can be moved. Why does the tailstock have to move? Because for jobs of different lengths it has to be located at different positions in addition to that, this just a moment this particular what we call it the spindle that can also be moved out and in. So, the basic idea is put the tail stock at the desired location and clamp it to the lathe bed and then make the spindle move out or in as you desire. So, at this moment the tail stock is be used to hold the rear end of the work piece because work piece might be sufficiently long and if it is not held on this side it may be sagging and that will cause a lot of inaccuracies.

The tail stock; however, might also be used for holding tools for example, we might be holding you know a drill or we might be holding a drill chuck we might be holding so many other types of tools. So, at this moment it is holding the rear end of the work piece and it also has its own rails just like the saddle and we have shown to such rails here a flat on this side and once again a v on that side on our side. So, as we have built up the machine tool now, we see that these are the basic parts of the machine tool and they have their respective functions.

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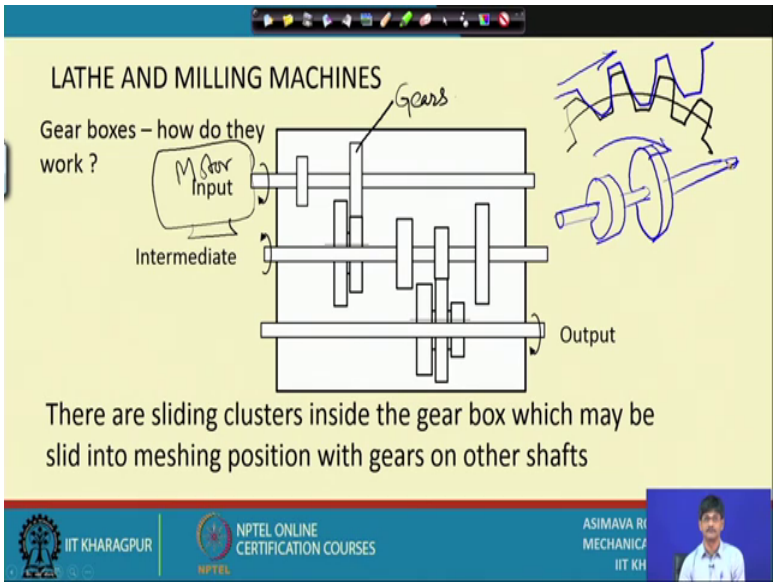

Yeah, this is the you know a more detailed figure of the gearbox that we were naming just now. What is the gearbox? You know just like we have speed gearbox and feed gear box they have some machine elements inside so that if they are you know shifted from one position to the other we would be attaining different output rotations you know output rotations of the gearbox.

So, which is the input and which is the output? We have shown here 3 shafts basically. So, let us see this is one shaft number 1, here I am putting in the input. What do I mean by that? Maybe I am putting in a motor. So, let me draw here. A motor, my drawing is not very good I have put a motor here. So, if I connect up a motor what are these things? So, these are basically gears let me see write down gears. What would gears look like? You know gears will be looking like this and they will be you know connecting up with other gears like this, so that if this one rotates, this one will be rotating with it ok we will be having a little more detailed discussion about gears. So, please imagine that these are gears seen from the side; that means, this shaft would be you know looking this way this is one gear drawn in a simple form like this, this is the larger gear and I have drawn it as if it is from the side so that we will just see rectangles.

So, this is the input shaft its rotating due to its connection with the motor and these are two gears on it. This one is another gear, I mean a set of; a pair of gears which is sometimes referred to as sliding clusters. So, this is a sliding cluster. What does it do? It

can slide along the shaft, but still maintain rotational connection; that means, if the shaft rotates the sliding cluster has to rotate. The other way if the sliding cluster is rotating it will make the shaft rotate.

So, this way this can be moved sideways. How does it have that you know continuity of connection? By you know you can just have a keyway on the shaft. There can be a shaft of this type, just a minute sorry, there can be a shaft of this type with a gap here and on that gap will fit our gear the gear will also have a fitting gap here, I mean fitting teeth here. So, that when they rotate together they have to rotate and when the gear wants it can longitudinally move along the axis of the shaft the shaft will not be affected.

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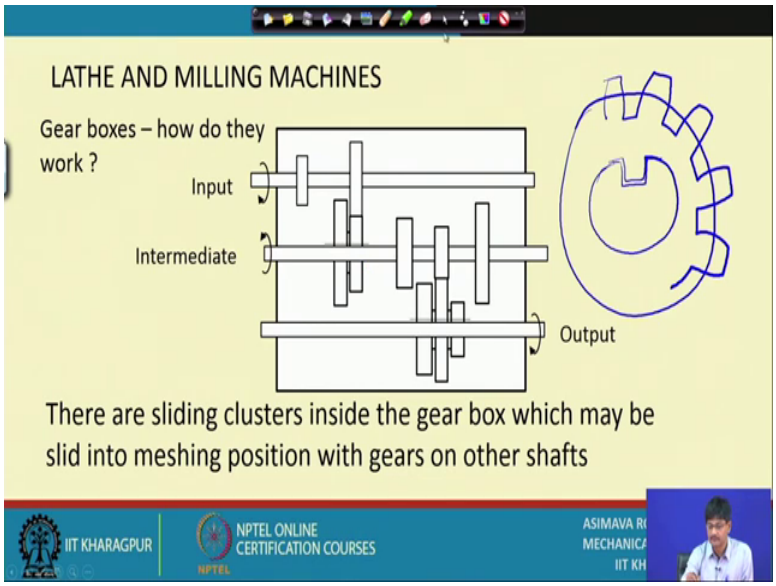

So, this is what is there on these and this sign is the sign that they are having this sort of a connection, sliding connection, key and keyway. So, let us see how the thing proceeds. So, this is the way in which it can be slid or it can come back also. You can have this position as well as that position.

Now, why have we shown 3 shafts? Because by shifting it from here to here I can get different speed ratios. These two gears will have different teeth ratio, and these two gears will have different teeth ratio and they will give rise to different speeds. On the intermediate shaft on the intermediate shaft we are having 3 more gears and the same thing is being done by this particular sliding cluster. So, that you can have 2 speeds here

multiply it by 3 speeds here, so that I can have 6 output speeds here. This is the shift, it can be placed here or middle or it can also be put in this contact.

So, once it is put at some position we can leave it there and it will have it will maintained connection at that particular point. So, this is the way in which gearboxes operate. There are mainly 2 gear boxes on the lathe, one is for speed gearbox; that means, speed changing and another is for feed gearbox or feed changing and basically they use some device like this or some other related devices like Norton tumbler arrangement, meander drive etcetera when we get time we will definitely go through these.

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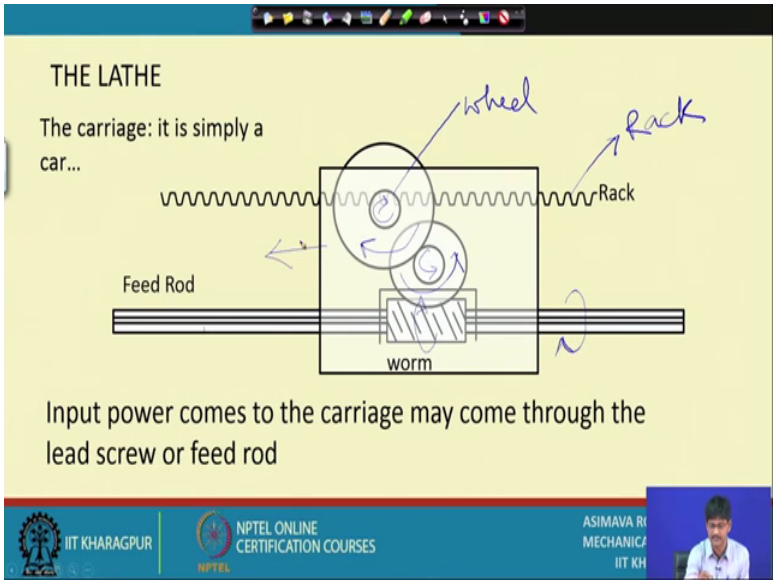

This is the way in which the apron mechanism of the carriage operates. So, what is the carriage? It is a car, it is simply a car nothing else. Then where is the wheel of the car? This is the wheel of the car, this one wheel. Where is the road? This is the road, this rack is the track of the wheel. So, how does it move? You know this is the feed rod by the same mechanism as we have discussed, it has a keyway inside it and on that fits a worm I will explain what a worm is, there fits a worm and a worm is in connection with a worm gear so that if this rotates, if this rotates, this one rotates it makes this rotate and you know this one also rotates, this one makes this rotate, this one makes this rotate and ultimately it starts moving this way. Let us see how, that is it, it simply moves this way.

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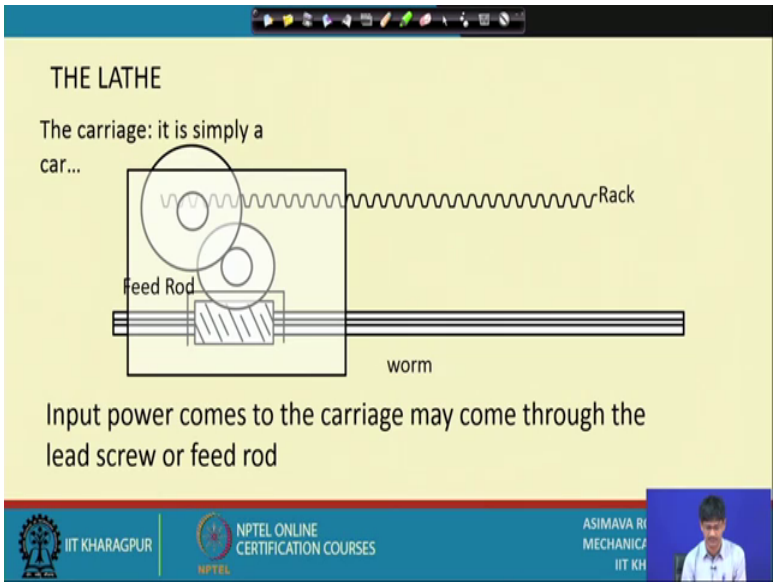

So, this is how the carriage is working. So, this mind you is the feed rod, feed rod not the lead screw. A lead screw is just by the side of it in order to maintain simplicity I have removed it. I have also removed the mechanisms for you know automatic feed, mechanism for foolproof arrangement, mechanism for you know cross feed all these things I have removed for maintenance of simplicity because at this moment we are not doing anything about these mechanisms. For example, what is this? There is a straight sided called a rack and to that fits and a small gear which is generally referred to as the pinion these are all gears, this one is a worm gear.

So, with this we come to the end of the 13th lecture.

Thank you very much.