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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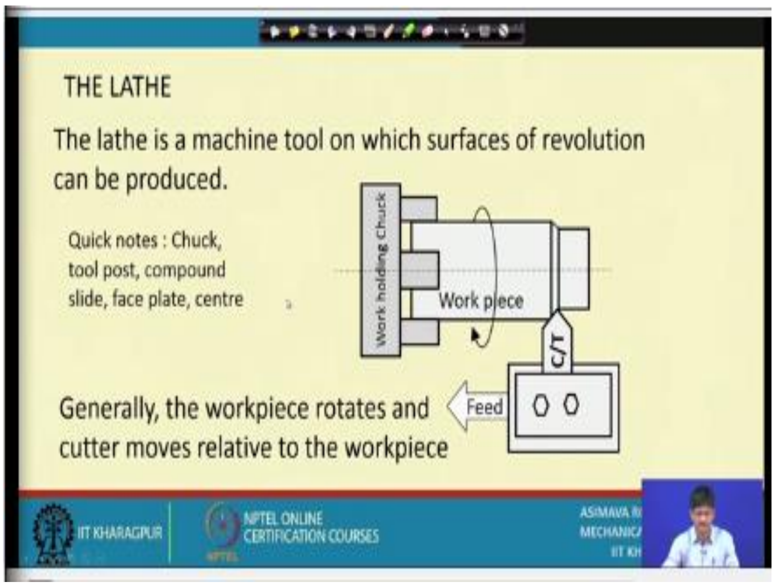

So, first of all the lathe is a machine tool on which surfaces of revolution can be produced. That is, I can make a cylinder, I can make a cone, I can make a flat surface by which is also a surface of revolution, I can make grooves, I can make threads, I can make frustums of cones. I can make curved surfaces also, so 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 workpiece rigidly and securely, so that it does not slip because heavy forces are going to occur during cutting of metals, for example in 100s of Newtons. So, here on the figure we see workpiece shown, this is the workpiece 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 the tool geometry and other things they all pertain to this particular body. The cutting tools, in short I have written C/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 workpiece the cutting tool also has to be held very securely so that it does not move or slip from its position.

As you can see the cutter is given a rotatory motion and the cutting tool is given a longitudinal motion parallel to the axis of rotation of the workpiece. 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 moving parallel to the axis of the workpiece.

In that case it produces another smaller cylinder. The workpiece 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 workpiece holding devices, like we can have face plate, we can have the workpiece held between centres and lathe dog we can have a face plate, 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 there, tool is held on the tool post and relative motion is obtained from the machine tool.

The machine tool should be able to provide some relative motions by which cutting will be possible. So, hold the tool securely and provide relative motion, this is the main function of the machine tool, let us see.

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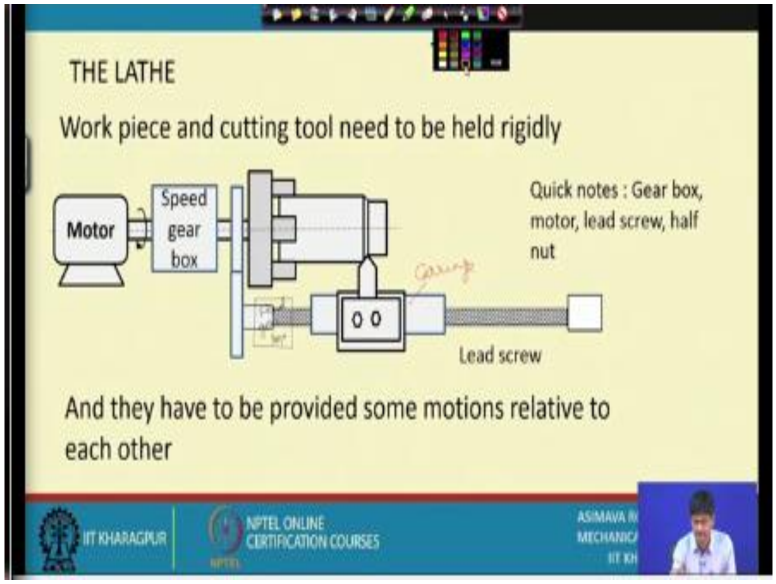

This is you know we are going on adding, so with this add on process ultimately we will be getting the full picture of the lathe. Here comes the prime mover, the motor, from the motor in order to rotate the workpiece; we see that we have put something in between, what is this? This is called a speed gearbox, what is its utility? You know we might not always want to rotate the workpiece 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 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 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 a detailed view of the carriage later on. But this is part of the carriage seen from the top; the carriage has different parts like apron and saddle etcetera.

It is basically a device which can move and move by the side of the spindle containing the job, so that the tool is given a relative motion with respect to the workpiece, so this is part of the carriage. So, let me quickly put in all these notes 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 so in fact we also have another gearbox which I have not shown at this moment which is called the feed gear box. Why have 2 gearboxes like this one after the other? This is because just like I would like to change the rate of rotation of the workpiece, I might also like to change the rotations per minute and ultimately the tool movement rate per revolution of the workpiece past the workpiece.

That means I might want to make this tool move at different rates, generally this particular rate of movement is not expressed with respect to time. But rather it is expressed with respect to the rotation rate of the workpiece; 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 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.

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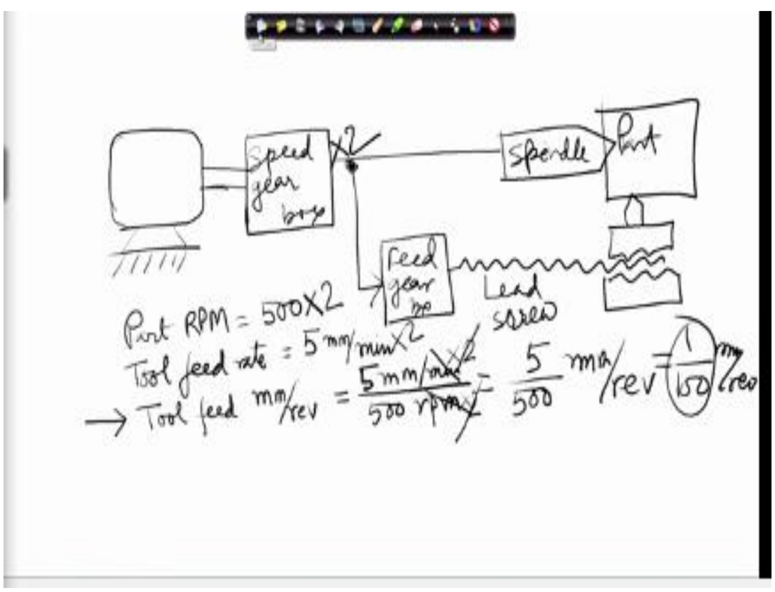

So, let us first of all select fresh page in which we start with, here we had the motor, from the motor there was the shaft and we had the gearbox, speed gearbox. From the speed gearbox we had a bifurcation, power was going this way and it was serving the tool, so this is called feed gear box and this is the spindle, here I have the part. Now what is the basic? Why do we choose this basic structure of the machine on the lathe?

On this one I have a nut which I am calling the half nut and on that it is mounted the tool, so this is called lead screw. The basic idea is this that the speed gearbox should change the rpm of the part and nothing else, so straight it is connected. Speed gearbox should not affect the 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 whatever is the movement that will get multiplied by 2. However, the feed which is defined in millimeters per revolution it will remain the same, even if I change the speed gearbox, why so? That is because suppose I have let us take an actual example.

Say the speed which is coming; 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 workpiece comes out to be 5 millimeters per minute by 500 revolutions per minute, 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, 0.1 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 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 lathe architecture has been contemplated.

So, let us see whether tool feed changes or not? I multiply the output of the speed gearbox by 2 that mean I do something inside the speed gearbox just like 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 it is downstream, this gets multiplied by 2.

And therefore in the denominator and numerator here they get multiplied by 2, and therefore it remains 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 bifurcation for power is taken after the speed gearbox. So, millimeters per revolution being the; unit of feed makes it independent of speed gearbox settings.

So, that after we; have gone through that, let us come back to the original discussion. In the original discussion, so 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 such a shaft parallel to the lead screw which is used for longitudinal feed. 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 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 rough calculation, manual calculations that we did. So, it is time that we can have a look at the next slide.

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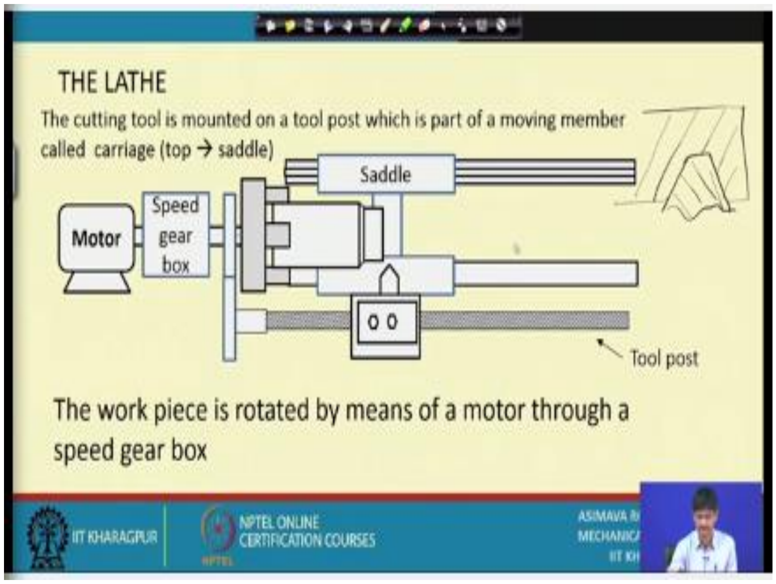

In the next slide what we see is, now the upper part of the carriage called the saddle just like we put a saddle or seat on the back of a horse on top of the lathe bed seen from the top. The basic body of the lathe we have put a saddle like element. So, this one is containing the tool then why not what is the lead screw doing? Lead screw is simply passing through the carriage and we may or may not connect to the lead screw to derive power.

But the carriage as the body is simply like a car on wheels on a track, this is the track on which the carriage can travel. So, let it travel, this is it, the carriage can travel from one side to the other just like a train on rails, it has one straight rail on one side 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 direction we have a V shaped guide.

Let us quickly have a look at that this in actual 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 topple. But if this is the carriage and if this is this particular track, 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 remove material this way. So, now let us move on to the next part of the discussion.

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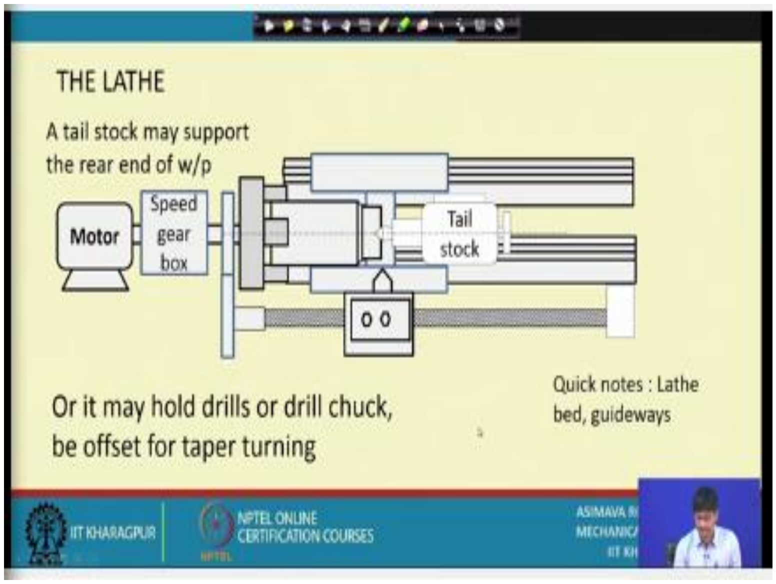

We also have another very important mechanism which is machine element which is called a tailstock. You can see the tail stock is drawn in white colour here to make it conspicuous, so that we can notice it. And how does it come into the picture? You find that we have made a skin section here, to show that the rear end of the workpiece is having a hole. It is called that hole is done by something called a combination centre drill and inside that hole, the hole is a little more intricate in shape, inside that hole goes in something called a centre.

It is basically a cone at the front and at the back also it is 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 moved just like the saddle, the tailstock can be moved. Why does the tailstock have to be move? For jobs of different lengths, it has to be located at different positions. In addition to that this particular what you call it?

The spindle that can also be moved out and in, so the basic idea is put the tailstock 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 tailstock is being used to hold the rear end of the workpiece, because workpiece might be sufficiently long. And if it is not held on this side it might 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 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 workpiece and it also has its own rails just like the saddle. And we have shown 2 such rails here, a flat on this side and once again a V 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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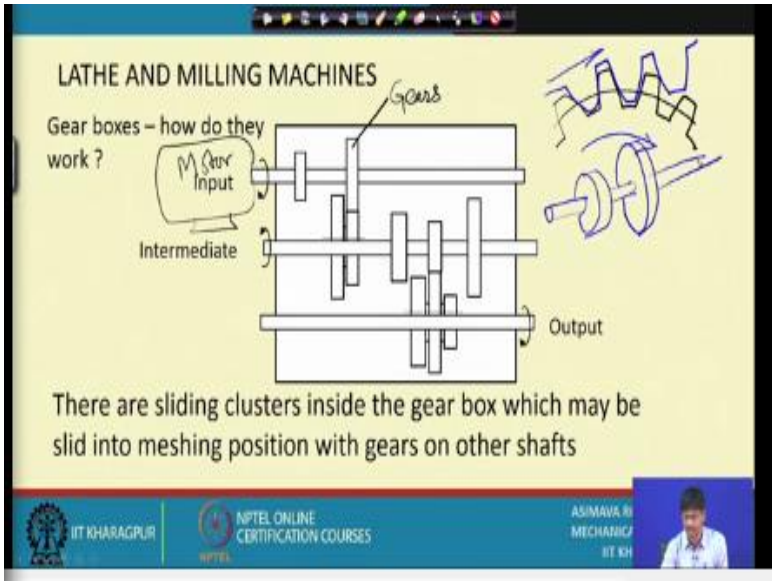

This is a more detailed figure of the gearbox that we were naming just now. What is the gearbox? You know just like we have speed gearbox and feed gear box; they have some machine elements inside. So, that if they are shifted from one position to the other; we would be attaining different output rotations 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 write down, gears. What do gears look like? Gears will be looking like this, and they will be connecting up with other gears, like this.

So, that if this one rotates, this one will be rotating with it, 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 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.

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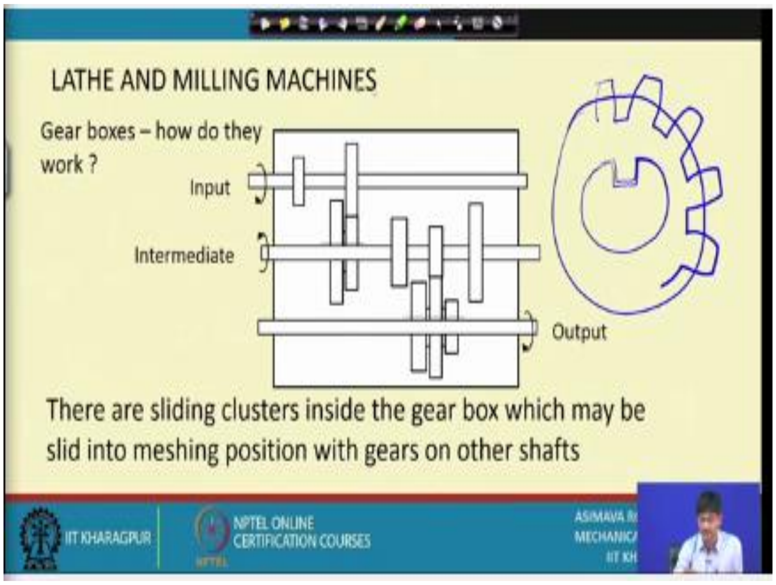

So, this is the input shaft, it is rotating due to its connection with the motor, and these are 2 gears on it. This one is another gear I mean a set of gear 2, a pair of gears which is sometimes referred to as sliding clusters, so this is a sliding cluster. What does it do? It can slide along the shaft 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 continuity of connection? By you can just have a keyway on the shaft? 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 tooth 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.

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?

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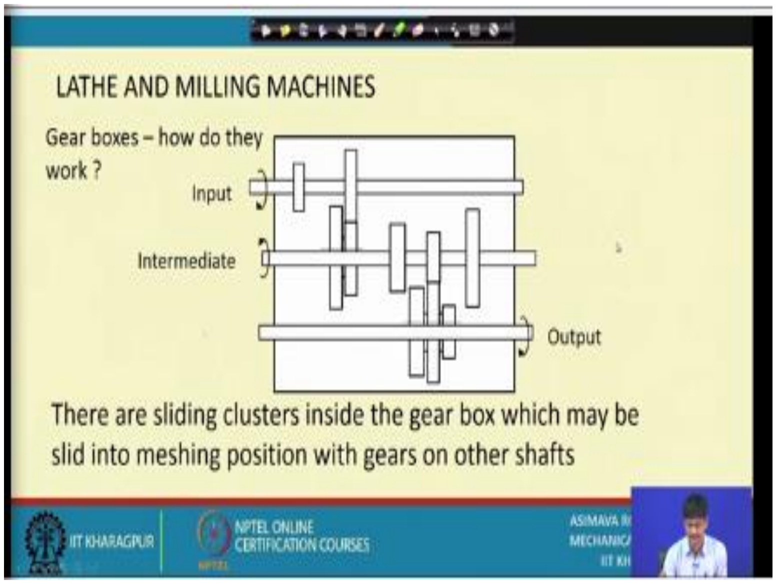

So, this is the way in which it can be slid or it can come back also, you can have this position as well as that position. Now why have we shown 3 shafts? Because by shifting it from here to here I can get different speed ratios, these 2 gears will have different teeth ratio, and these 2 gears will have different teeth ratio and they will give rise to different speeds on the intermediate shaft.

On the intermediate shaft we are having three more gears and the same thing is being done by this particular sliding cluster. So, that you can have 2 speeds here, multiplied 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 maintain 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 we mean 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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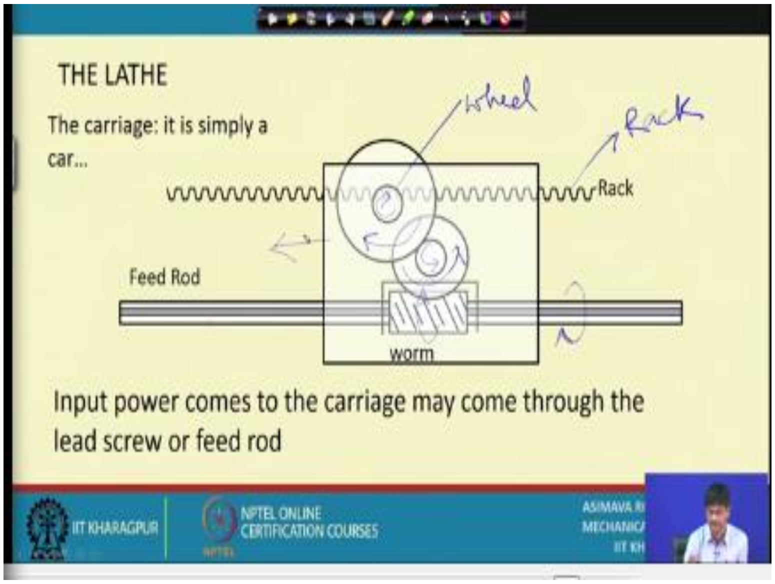

This is the way in which the apron mechanism of the carriage operates. So, what is the carriage? It is a car; it is simply a car nothing else, then where is the wheel of the car? This is the wheel of the car, this one; wheel. Where is the road? This is the road; this rack is the track of the wheel. So, 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 this one rotates, it makes this rotate and 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?

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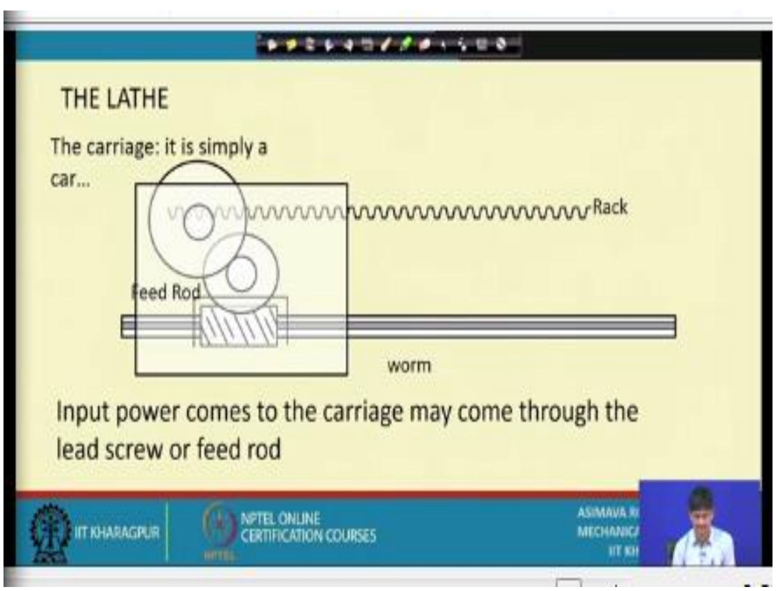

That is it, it simply moves this way, so this is how the carriage is working. So, this mind you is the feed rod not the lead screw, the lead screw is just by the side of it in order to maintain simplicity I have removed it. I have also removed the mechanisms for automatic feed mechanism for foolproof arrangement, mechanism for 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? This is a straight sided gear called a rack and to that fits 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.