# Basics of Mechanical Engineering-2

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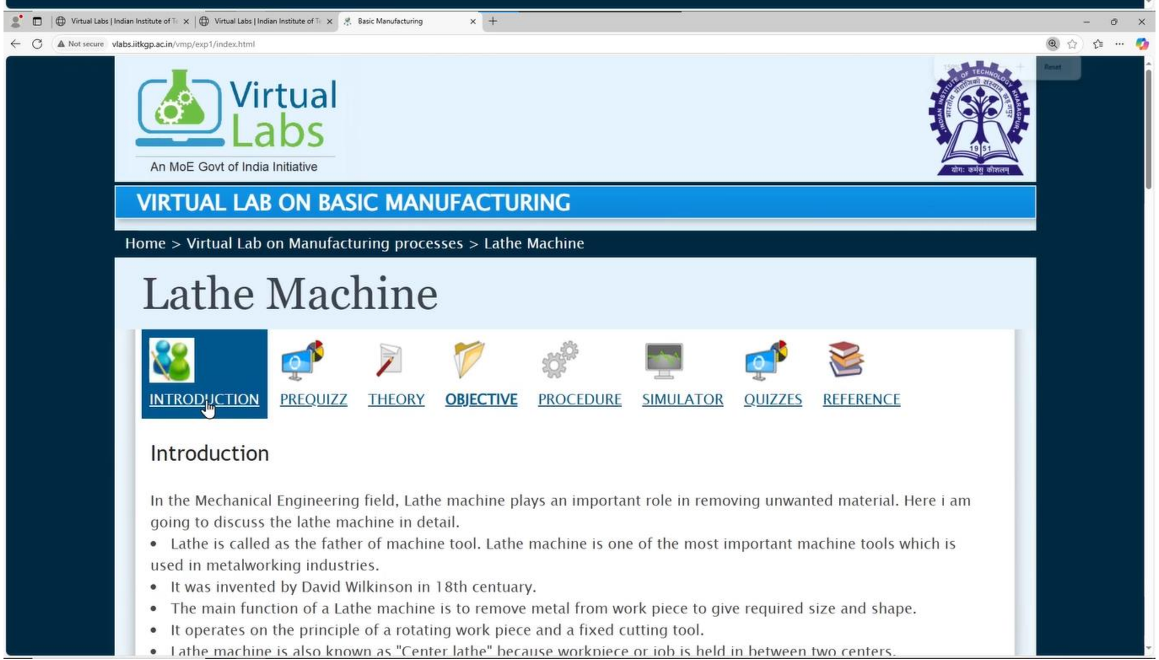
**Week 10**

**Lecture 42**

## Virtual Lab. Demonstration (Machining)

Welcome to the last lecture of week 10. We have discussed the manufacturing processes throughout this course. And this week, we have discussed machining. In machining, specifically the single-point cutting tool nomenclature, the kind of tool materials, and the kind of tool designs were discussed in the first part. Then we started talking about the machine tools, the lathe machine, milling machine, and grinding operations; those were discussed.

Then certain problem statements on calculating some parameters, for instance: the speed and the single-point cutting tool angles. Then we also talked about calculating the tool life based on the kind of tool material and the kind of cutting speed that we have. This was a very simple tool life equation that we discussed. In this lecture, I will give a demonstration—the virtual laboratory demonstration on the machining processes.


Here, I am on a dashboard with the virtual laboratory on manufacturing processes; this is the homepage that you can see. So, there is a list of experiments here: technology use, people feedback. Let me click on the list of experiments. Two experiments are there: one is the lathe machine, and the second is CNC turning. I'm zooming it out.

Let me go through the lathe machine first. In the lathe machine experiment, we have an introduction, a pre-quiz—that is, the pre-test questions that we have seen in the previous lectures as well. Then we have post-test questions, which are here in the form of quizzes. We have the theory of the topic that is under discussion. Here, the lathe machine is the topic, and the procedure to run the simulator.

We have the simulator here, and the references are also here. In the introduction, the general overview of what the lathe machine is, when it started—it began in the 18th century, invented by David Wilkinson—and the components of the lathe, such as the headstock, bed, main spindle, tailstock, and lead screw, along with their functions. In the feed mechanism, different kinds of feed mechanisms were discussed, including the belt mechanism and gear mechanism.

The belt mechanism is also used for quick working, but there is always slippage. Why does this slippage happen? You can understand this while going through the course, Basic Mechanical Engineering, where we have discussed the differences between belt drives and gear drives. Gears provide positive transformation with no slippage at all, whereas belts can slip. So, the belt feed mechanism is here, and the gear feed mechanism is here.

So, this is a simple gearbox or gear feed mechanism that is shown here. The carriage is very important; the saddle, apron, and tool post are components of the carriage. Then, in the theory, we have the block diagram that shows how the lathe machine works. There is feed from the right to the left direction. There is a tool that moves in the upward direction here, which determines the depth of cut, and there are two major components. One is the carriage, and another is the tool post.

The carriage provides the feed. The tool post determines the depth of cut. These two will be presented here in the simulator as well. Let me just go through the key relationships that we have discussed. Cutting speed, feed, depth of cut, machining time, etc.

Peer quiz questions, that is, to have a readiness to understand the simulation. There are only a few pre-quiz questions here, only five questions. The first question is: Which machine is known as the mother of the machine tool? Lathe is the correct answer. The second question is: Lathe cannot produce internal features like holes.

It can do. Internal boring is also possible. So, this statement is not correct. I will mark false. Which type of feed is needed in a turning operation?

For a turning operation, longitudinal feed is required. Longitudinal feed, as I said, is given by the carriage in the direction or in the direction parallel to the axis of the workpiece. The cross feed is in the perpendicular direction of the axis of the workpiece. So, here for a turning operation, longitudinal feed is given. For a taper operation, both cross feed and longitudinal feed could be given.

So, here the answer is longitudinal feed. Which type of surface is produced by turning operation in lathe machine? We get cylindrical surface. Majorly, the lathe is known to produce cylindrical surfaces. Flat surfaces are produced by milling, by shaper machines or by planer etc.

Lathe bed is usually made of it is usually made of cast iron because it is a very bulky portion and cast iron has property of self lubrication or so that helps us to develop the lathe beds. These are the general materials usually I will submit it and all of them are correct. Now, let us come to the objective that is given here for the experiment.

The main objective of the lathe machine is to remove excess material from rotating workpiece by hard cutting tool, identify important components of lathe machine such as headstock, tool post, bed tail, gear chain, lead screw carriage, cross slide legs etc., set the position of the tool, set the spindle speed of chuck and feed rate, simulate lathe machine to obtain desired shape and size.

Procedure is given here. Procedure has certain steps. This would be the kind of the interface that we will have in the simulator. it says it has three panels; left, right and middle. Left panel shows the instructions of simulator. Right panel shows the control keys to operate the lathe machine. Middle panel shows the lathe machine simulator X and Z rollers are used to place the position of the tool manually while machining.

Darker roller indicates Z positioning wheel and lighter roller indicates X positioning wheel. We will see when we come to the simulation here. So, for changing X coordinate, there are steps given here. These steps you can read. Set the desired spindle speed by using control keys.

Control keys are here on the right hand side. And turn on the spindle by clicking the forward button. This is a forward button here. And this is off, this is the spindle rotation. Switching off the spindle rotation, rotating the spindle in the forward direction, rotating the spindle in the reverse direction.

These buttons are here. So, continue the same feed and depth of cut to obtain desired shape and size. Let me come to the simulator now. There is a link to the simulator. I click on this and it opens in a new window.

This is left panel, middle panel and right panel. Right panel is my control button. Middle panel is the display. Left panel is the instructions also. I will just go through the display and the middle panel.

Middle panel, they say this dark circle shows my Z direction. If I try to click here and try to rotate it, you can see this is moving. So, I will just reset it. It is Z is at position 0.3. and x is at position 1.5.

If I try to rotate x by one complete circle from 1.3, it turns to 0.9. That means one complete rotation is around 1.3 - 0.9, 0.4 millimeters. And for z, if I make a one complete rotation from 3, It gets to 7. This is again 0.4 from 3 to 0.7. That is one complete rotation is giving 0.4 movement to my tool.

I will reset it. If I come to this interface here, while using my roller on the mouse, I can zoom in and zoom out. While clicking the left button, I can pan and try to see it from the different direction. For example, if I try to see from this direction, whether the tool has engaged or not, this could also be seen. So, I am just zooming it out so that we try to see it clearly.

So, let me reset it, and here, while clicking the X or Z alphabets, I can input the value. For example, if I click on X and I just click 2.0. And here, there are options: increment setting or absolute setting. I say absolute, X turns to 2.0. And if I click on Z and I say 3.0, again, absolute setting, it is set to 3.0. So, from here also, values could be put in. I will restore it or reset it to the original position. Now, let us see how we try to do some machining here. Again, Z is giving me the movement of the carriage. The carriage is being moved left or right in the Z direction.

This is the Z direction, and the X direction is the movement that is in the cross direction. So, let me reset it once again and try to see it closely so that I can see the tool being fed here, right. I will now move X forward so that some depth of cut is given. Let me try to first see where the tool touches; 1.37.

If I try to move it further, it is not going further because now the tool tip has touched the workpiece, so at 1.37, it has touched. So, I will now bring it back, move it to the right, just simulating the lathe machine. And 1.37 was the contact to the workpiece. From 1.37, I will reduce it by maybe 0.05; 1.37 minus 0.05 is 1.32. So, this is manual setting. I am rotating the mouse manually.

Just this mouse is being rotated while clicking. So, there could be some error. So, there could be some precision errors. So, because this is all manual. Also, when you rotate the carriage, it is also a manual rotation that you do.

So, 1.32 means a 0.05 depth of cut is chosen here. Then, I will now start the spindle and try to rotate my carriage toward the left. You can see this turning is happening. Slowly, it will go through. It is not showing the surface finish here, but it depends on the kind of surface finish you require. Accordingly, you need to set the speed of the rotation of the chuck and the longitudinal feed, which is also to be set accordingly. Now, the diameter is such that 1.32 is my position of the x-coordinate.

I will bring it back and take it to the right once again. This is how you actually do it. We rotate the carriage wheel clockwise so that my carriage moves away from the workpiece. To bring it close to the workpiece, it has to be rotated counterclockwise. This is the exact simulation that it is showing now.

Next step, I can make another 0.05 reduction. 1.32 - 0.05 = 1.27. Now, I will do one more step. I am now doing step turning: one diameter, then a smaller diameter, then a smaller diameter, and so on. Now, I am moving my carriage again.

So, this is the next step that is going on right and bringing it back taking it further So, it has come to 1.35 here, X position from 1.35. So, this is I am trying to do step turning here. You can even watch this closely from any of the direction the way it is going just for the view. So, I will now bring the tool back.

And I can stop this while pushing this off button; spindle off. This is a step that I have produced. So, this was not very precision specific dimension that we wish to do. Just to demonstrate that how the lathe machine operates and this simulation is developed accordingly. But this was a virtual laboratory simulation on lathe machine.

Let us try to see further questions or anything that it has one quiz here, that is a post test quiz. This quiz somebody has already taken. Let me try to mark the right answers. Process of removing unwanted material from a block metal in the form of chips is called it is metal cutting. So metal addition is there in the additive manufacturing where the material is added.

It comes in the form of the filaments. It comes in the form of the sheets. It comes in the form of the powder. It is being added and there is no wastage. In metal cutting, scrap is there.

Those are the chips that are produced. Those are also going to waste. The second question: machining parameters on a lathe are speed, feed, and depth of cut. All of these are the parameters. The lathe bed is usually made of—again, the same question—it is made of cast iron. Which of the following lathe operations requires that the cutting edge of the tool bit be placed exactly on the workpiece center line?

Exactly at the center line—which of the following parameters? Boring, facing, drilling, and turning. In facing, we need to place it exactly along the center line because facing is when the workpiece is rotating. This workpiece is rotating. On this face, we try to do that. Exactly along the center line, it is done so that it is performed correctly. Question 5: In a lathe machine, the carriage and tailstock are guided on the carriage and tailstock. The carriage is for longitudinal movement.

The tailstock is for cross movement. These would obviously be guided on different guideways. The same guideway is not the correct answer. Different guideways—B is the correct answer. The power is transmitted by the lead screw to the carriage through.

It is transmitted through half nut. Tool life is most affected by machine. Tool life is most effective by multiple parameters, but what we have studied is cutting speed is one of the major parameters that determines the tool life.  Let me submit. All of them are correct answers. So, this was the virtual lab simulation on lathe machine.

I am coming to the home page once again of the virtual lab on manufacturing processes. Let me come to the list of experiments. Lathe machine we have seen. Let us now try to see CNC turning. CNC turning, Computer Numerical Control, though this course limits itself to the conventional machining processes, there are Computer Numerical Control machining processes.

The machining is completely controlled by computer. There are different components other than the regular components which are there in conventional machines. We have the control panel where we feed or enter the feed, depth of cut, the speed and everything. Also, the programming, MDI (Manual Data Input) programming could be added there. The G codes are there which helps us to give us the complete code to get the specific component or the part to be manufactured through the CNC machines.

So CNC machines is a self-contained numerical control system for a single machine tool including a dedicated mini computer controlled by stored instructions to perform some more all the basic NC functions. So, there are certain kinds of CNC machines it has come through general terms that is direct numerical control or industrial robots There are certain do's and do nots. So there are instructions if I say make sure that the power button is off when we try to take care while working on the machine. Fixing the part in the chuck is the step.

Loading the tool. Calibration that is known as homing of the machine that is important. Let me come to the theory part. CNC system is described here. We have machine tool control.

Then we have in process compensation that is adjusting the errors sensed by gauges and probes, recomputation of exit position, offset adjustments for tool radius and length, adaptive control adjustments to speed and feed, computation of predicted tool life and selection of alternative tooling when indicated. Improved programming and operation features are there. Diagnostics are there and see which is a complex and expressing system. So, complexity increases the risk of component failures which lead to system downtime. So, diagnostics are very important here.

The types of CNC turning could be CNC checking centers, CNC universal turning machines, and depend upon the degrees of rotation. It could be 2.5 axes, 3 axes, 4 axes, or 5 axes. A 2.5-axis machine is only the regular lathe machine that you see; the longitudinal cross movement is there, kind of a two-axis machine. 2.5 could be another manual feed that could be given. In a three-axis machine, the third axis is also there; the Z action could also be controlled. In the fourth axis, the angle could also be given to the tool post.

In the fifth axis, the spindle that you have could also have a swirl movement. So, there are certain axes—a kind of degrees of freedom—that enhance when we have a 5-axis machine. The advantages of CNC machines are flexibility in operation, machine adjustments, programs can be prepared rapidly, and faster prototype applications are certain. Nowadays, when we say subtractive manufacturing, in the case of mass production, CNC centers—or those sometimes known as VMC (vertical machining centers)—are used for producing components rapidly.

The only point is the coding has to be there; the G-code has to be there. Additive manufacturing is an alternative that gives us versatility—the kind of complexity in the design of the component—which is more readily produced in additive manufacturing. But for mass production—producing maybe a hundred or thousands of components on a single machine in a single day—CNC machines are still relied upon. Let me try to come to the PQ's questions. The depth that the tool is plunged into the surface is called the depth of cut; we have studied this.

Speed and position in CNC can be controlled using the speed and position controlled by the slide table and spindle. For CNC machining, skilled part programmers are needed. Yes, skilled part programmers are needed because part programming is what we do manually. If we do it manually, an accident may occur, such as giving a deep depth of cut and breaking a tool tip. A similar accident could happen in CNC machining when the code is not correct. So, skilled part programmers are needed. In machining a workpiece, the material is removed by drilling, which is an operation.

Melting happens in casting holes. It is by shearing action. You saw the shear plane in the problem statements when we observed it is by shearing action in metal cutting when the material is removed. How many ways can CNC machine tool systems be classified? It could be classified in multiple ways, but what we have seen here is three ways.

Let me submit the correct answers. So, the objective of setting or developing this virtual laboratory is to study CNC turning machines, to perform experiments on CNC turning machines like step turning and facing, and to understand the cutting mechanism of the CNC machine. The procedure is given here. Click on the link of the simulator tab. Keep the values between 0 and 2.

There are certain sets of values. Let us come to the simulator and try to see what it is trying to represent. So, this is a CNC simulator. We can zoom in or zoom out. We can pan. So, this is the workpiece. This is the spindle. This is the chuck. When we rotate the spindle, this chuck would rotate, and this is the turret. The CNC machine has turrets that hold between 8 to 24 different kinds of tools.

It could be a drilling tool, a slotting tool, a facing tool, or maybe a truing dresser for the grinding wheel, etc. So, multiple tools could be held. So, this is the turret that we have. Now, for spindle motion, we have to set some value for the spindle RPM. Let me say, suppose I put a value of only 50 RPM and start.

So, it has started rotating. I can stop it from here. CNC machine also is just like that. You have a start button, you have a stop button for rotation of the spindle, for feed, etc. So, if I suppose here give only the value as 5 rotations per minute start.

You can see how slow is this rotating. It is 5 rotations per minute. If I suppose turn this to 500 rotations per minute. It is rotating very fast now. Let me just keep it in number such as 200 rotations. It is rotating now. I can stop it. Then position of the tool. Position of the tool could be set at any point. This is the speed at which this position would come.

0, 1, 2, 3—they have suggested keeping it between 0 and 2. Let me keep this value as 2. If I start it, you can see the tool moving toward the workpiece. This is moving toward the workpiece. I stop it.

If I set this value as -2, it will go in the opposite direction. So, it is going away from the workpiece. This is the X direction here in this CNC setup. Now, here in the Y position setup, let me set this value as 1. I start it.

The tool is coming toward the axis. So, it will come down. This is the Y direction. If I increase the speed, Let me stop it, increase the speed to 3, then start.

It is coming at a faster speed. Again stop it. Increase the speed. Let me say to 8 and start. See it is going very fast.

Now I will stop it. I will put here minus 2 and try to bring it up. Stop. Now Z position. Let me put value 2 and start.

It is coming towards this direction. Now the major concern here in the CNC systems is the connection between three. There is workpiece, there is machine and there is the software. When I say machine, machine is holding tool. The tool and workpiece, when they contact, the software should understand that this is a zero position.

When the workpiece has tool contact with it, this could be set as the zero position. This zero position is set here, indicating that this is the zero position. From here, incremental coordinates can be given. For example, 0.1 inside, then it is supposed to be 100 mm towards the left, then 100 mm is going left, etc., etc. So, these are things we generally do.

So, this is a general machine setup. Let me just try to touch it; I will touch it from this direction. This will also bring it here. More to the left side, stop, then I will bring the x position closer a little faster at a speed of 3, stop. Now, slowly moving in the y direction. Towards the negative side, I have to put minus 1 here. So, this is where my tool touches.

This was just a CNC setup. Let me come to the post-simulation quiz here. So, what does CNC stand for? CNC stands for Computer Numerical Control. What type of motor is used to drive the CNC machining center axis?

What type of motor is used? We use servo motors because small buttons have to give us a big change servo motors are used. Machine tools have heavy components. The depth that the tool is plunged into surface is called that this is depth of cut. Feed is measured in the units that is very well known to you now. It is measured in length per revolution. CNC machining centers do not include operations like milling, boring, welding, tapping. It does not include welding. Milling, boring, tapping could be there in the one machine itself.

In the turret, we could have different tools corresponding to doing milling, corresponding to doing boring. That is the internal hole enlarging and then tap could also be held on the turret. Next, which of the following is not the advantage of CNC machines? Higher flexibility, improved quality, reduced scrap rate, improved strength of the components. Strength is not even related to the kinds of CNC machines or so.

Yes, higher flexibility, improved quality, reduced scrap rate is definitely there. For CNC machining, skilled part programmers are needed. Yes. When referring to CNC operations, an excessive surface cutting speed will result in excessive cutting speed could result in many unwanted things. For example, workpiece could have an indentation that is not required.

The tool tip could break. The tool could break. There could be chatter in the machine. Here, out of the options—extended tool life, a longer time to machine the workpiece, rapid tool wear, decreased use of coolant—rapid tool wear is the correct answer. Let me submit.

All of them are correct. So, this was a virtual demonstration on conventional machining—that is, the lathe and CNC turning was taken. Next week, we will talk about non-conventional machining.

Thank you.