Computer Integrated Manufacturing
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Lecture 27
Laboratory Demonstration, CNC machining

Hello, welcome back to the next lecture on Computer Aided Manufacturing, we had discussed one of the softwares that is Delcam PowerMill in the last lecture. Now, I will takes you to the three axis milling machine where we will use the information that we have fed in the software.

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So, this is our laboratory demonstration machine here this machine is known as a vertical three axis milling machine. The milling machine can be broadly classified into two categories horizontal milling machine and vertical milling machine, it all depends upon the orientation of the tool. In this the tool is vertical, tool is vertical means that movement of tool is vertical in the z direction that is quite is known as the vertical meaning machine. In the horizontal milling machine the tool direction is towards x direction.

So, in this what happens, z axis can go up and down and tool goes up and down it is vertical to the bed, specifically it is vertical to the bed that is why it is known as vertical milling machine. So, in z axis we have spindle, spindle provides rotation to the tool and the tool is held in the spindle with the help of a tool holder we have different kind of tool holders, like Chucks are there, collets are there, so many systems are there this is held with a pneumatic system, this tool holders use a pneumatic force, the pneumatic system will also show you an at the end of the demonstration.

So, z axis provides RPM to the tool and it also provides feed in its z direction. So, the tool movement is all taken care by the z axis here, this is all again done by the pneumatic system. Going downward is minus z count going up is plus z. So, depth of cut pin can be definitely controlled by this. So, this is from left to right and right to left we have x axis and toward the other wall towards the end wall of the machine that is y direction. So, it can be minus x plus x. So, this is x direction, this is y direction, so the whole system is set in this way and cutting takes place.

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So, this is actually the hardware section as mentioned before this is integrated with the control panel, this control panel that is why it is known as CNC, Computer Numerical Control, this panel has knobs, buttons, keys on it, that can be used for MDI, MDI is Manual Data Input and also the initially we have to set the reference for that that is used.

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So, in this we have this turret as well, this is also known as tool magazine. It can hold number of tools, it can hold 24 tools, and these tools can be changed while working. As you know, M 6 is the miscellaneous command M 6 is tool changing command, will can put tool number like T 4, M 6.

The tool at the fourth number in the magazine would be taken up and this can be done in the program itself the tool, the machine can keep changing the tools while it is working, like it can do roughing operation at the beginning, then it can pick a profiling tool, then it can pick a ball mill another finishing tool and do the whole operation in one go. So, this is the beauty of the CNC machine.

So, most important point here is referencing, that we will see here. So, in the software we had the reference that is x 0, y 0, z 0 that has us to match with the reference of the machine. So, how do we put that? Now, this table is too big, because the tool does not know where the work piece is mounted, the hardware and software has to be interconnected, has to come in one plane in one point this back is too big, this x direction you can say the is necessary you can see this actually x direction is 650 mm is the size of the job that can be held here and in y direction it is 500 mm that is 0.5 meters, in z direction it is around we can hold 400 mm thick block.

So, it is the dimensions become 650 by 500 by 400 millimetres cube. So, we have to feed in our computer system or mentioned in our computer system that way the job is to be held. So, we have mounted a work piece here, the tool does not know this, reference with a tool and a job has to happen, so how do we do this? This we will learn.

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So, in the right hand side, this black control is our handheld control panel, we can hold it on the hand also we can mount it on the machine. So, how does this work, let us see.

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So, it has x, y, z on it. So, first we click z and z negative, z positive, then we click x, x negative, then x negative and positive both are being set both are being shown you, then y negative and positive, we can rotate it. So, this is for the manual control. So, this is used for bringing the tool closer to the work piece, now the tool is too close to the work piece. Now, we need to set (0,0). So, which we just try to put any of the points to pick any of the points and try to say that okay, this is the present 0, this corner, this corner or this any point at the edge is 0.

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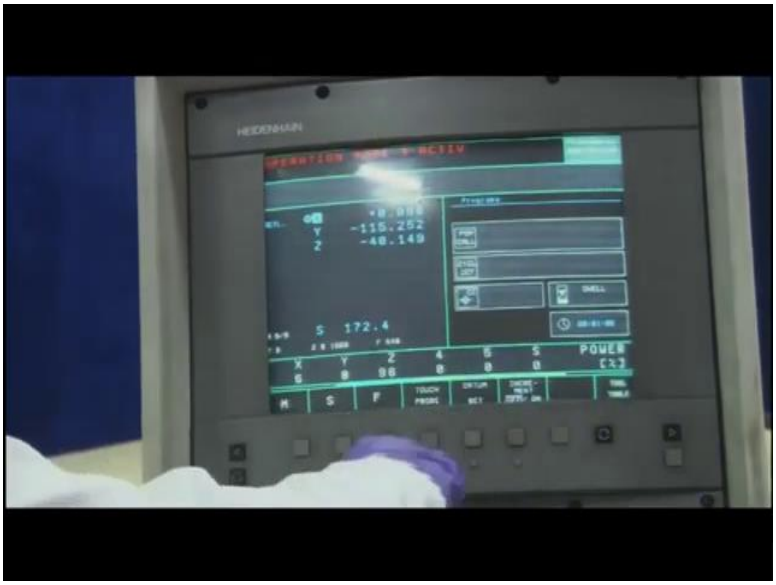

So, let us see how do we make 0, there is the control system this is the present location of the tool based upon the present data or the position that is recorded by computer itself. So, we will see here we put x 0, we will put y 0, enter and x, y are put 0, now as per this position, now the hardware understand or the software here for the machine understand and the software for the machine or the hardware understand that this is x 0 and y 0.

So, but in the software in the powermill software what we did? We put we had put the work piece center as a reference point, so we will bring it close to the center. So, I will say for z also x and y we have bring it closer. So, how do we do that?

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So, what we do? One of the ways is we put a piece of paper between the tool and the work piece. So, slowly we will start bringing our tool down, see, this paper is being rubbed below this it is stuck, let us repeat this. The paper is being moved, once it is stuck it is move, now the tool has just touched the work piece.

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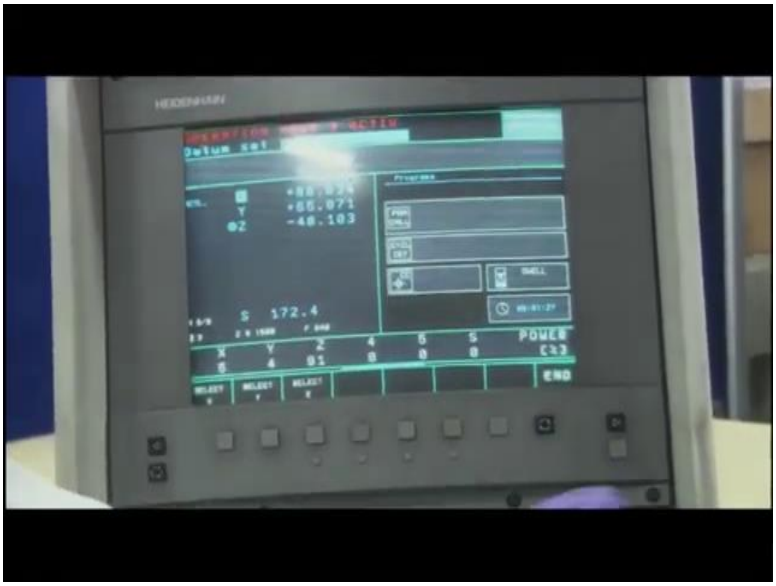

Now, this can be made as z 0 and also this is a new reference point if I say this is at the center, I can put it at x 0, y 0 and z also 0. Now, x, y, z all are 0 here. So, this is our center, so this is our actual reference point, also this is what would be taken by the software will be understood with software as well as the reference point.

So, this should be also understood by the software as the reference point, now the job reference and the tool reference or on the same page. Now, the job center is 0, the same thing is done here.

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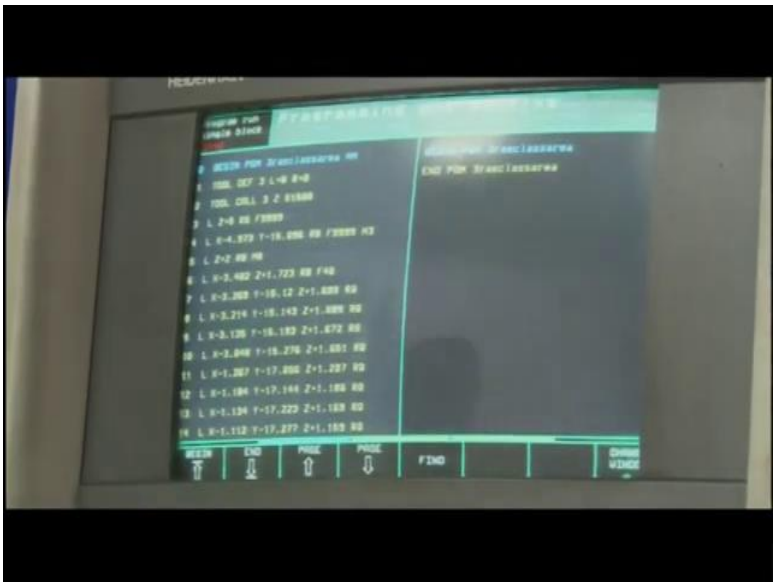

So, we can transfer the same code here on this machine through pen drive through internet or CD or DVD there are certain ways. So, whatever our machine control accepts, there are certain ways. So, once the code is transferred, we the code opens here. This is directory the same file if you remember, the file name was 3rasclassarea, this is the file that is being opened here.

So, this is the program that we had made there. So, this is open here, this is the big program that is opened here, the same program that would be run here. So, also we can make small changes if we need according to the machine setup, we can we can make certain changes here.

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For that we have control panel, we have keys here or the whole keypad is here and some important keys like these knobs are there, feed override and feed under ride also can be charges generally known as feed override. So, there are certain controls MDI Manual Data Input button is there.

So, to find the references etc. we can also feed some small codes to see whether the machine is running properly, so small codes can be written directly on the machine, it is maybe 2, 3, 10, 20 maximum 50 blocks is okay to write with the keypad, but to write the big codes obviously, it is better to use a CAD model and to get the CNC code extracted from that, when I say code, it is NC code extracted from that.

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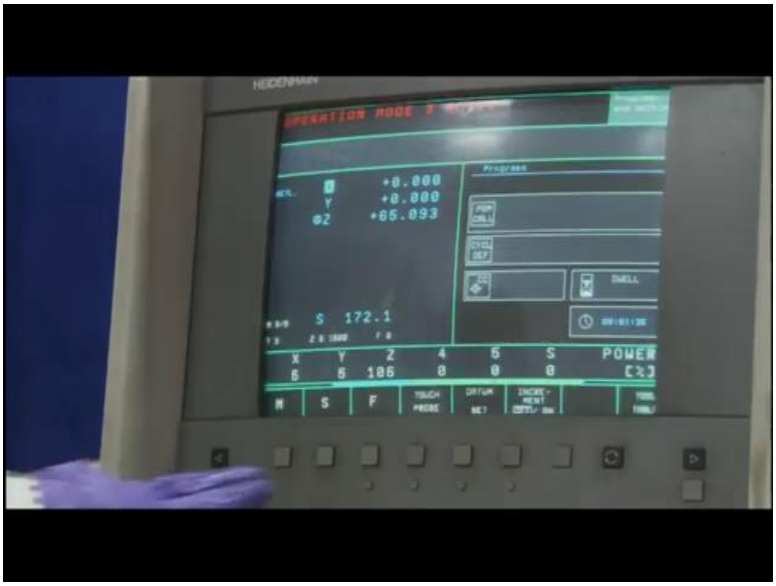

So, this is the manual operation, S is for spindle speed. So, if I say spindle speed, I can put some value, let say 1500 rpm. M 03.

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So, if I try to run that, so the tool has been given clockwise rotation, tool is been given RPM and given rotation. So, this these things we can check definitely manually when we feed it here on the control panel. This is clockwise and anticlockwise both the directions are being shown, then x movement, y movement then z movement all the movements can be done manually.

Now, let us try to run the machine and the software that is software means the power mill program that we generated there, so let us try to run that program here. So, to run the machine it is important also to note that the door locked. The door the machine would only run the

program when it is locked, this is also good for the safety for the safety precaution there is a sensor over there, the machine would not run the program unless the door is closed.

So, the door top we have the lock here, so now we can see the tool is engaged, it has started making the pattern that we have fed in the PowerMill that was just a CAD model and the tool is moving. A same thing plunging happened. Now, the tool is cutting.

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Now, step by step the codes are moving, see the codes are moving the move. See the movement is now going in x and y direction. So, the tool is not moving, the z axis is almost fixed, once the plunging has happened and cutting get started. Now, x and y direction are all taken care by the table, machine table, you can see here, see how rapidly tool moves from one point to the other in the rapid movement.

It jumps up moves rapidly to the next stage and then comes down. Again in a milling machine the depth of cut and RPM is provided by the tool and feed is provided by the table and turning depth of cut and feed is provided by the tool and speed is provided by the job. So, this is a difference between billing and the turning.

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So, the code is running. So, how the job is moving the z direction is moving, we can see the movement on the right side window here, and on the left side the code is running. Also one thing is missing here, this is all the run, I won't say dry run I is a dry machining, dry run is something when we when we try to cut air, when we try to move the tool without a work piece, the work piece is there but there is no coolant that is why it can called the dry machine when no coolant is used.

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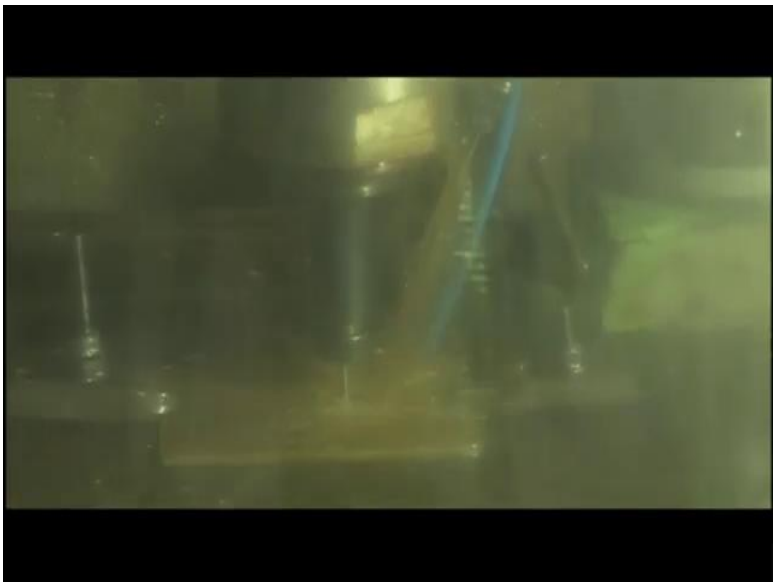

Now, let us switch on the coolant as well. So, manually we have switched on the coolant, so now this is the coolant, this lot of advantages of using coolant. This is also known as flood machining, there are certain ways of machining, flood machining, MQL is Minimum Quantity Lubrication, then dry machining then near dry machining, this is the generally used method,

flood method, in which this rate is maybe 6 liters per minute or maybe 4 to 20 liters per minute is the flow rate for the coolant.

Now, this coolant is also beneficial it flows through all these slides and different kinds of like ball screw is there, so many joints and links are there, it tries to lubricate and it actually lubricates all the joints those are there across the bed. So, it also takes care of majorly the coolant is as the name suggests is for the cooling of the job, it takes care of the heat that it dissipated during machining.

So, there certain other methods MQL is one of the methods in which minimum quantity or fluid is just sprayed over the tool that is also one of the researches that is being taken care by many researchers. So, coolant prevents the tools components here from getting corroded and also it enhances the tool life because it controls the temperature and the tool deterioration or the tool wear is minimum. So, M 08 is used for switching on the coolant system, M 09 is for switching off the coolant system, these things we have already discussed before.

So, this is how the machining is happening. So, what we did? We just produced or generated the code there in the powermill system, we first made a CAD model, we brought that or imported that CAD model in the powermill software, we could have used any of this software any of the CAM software those are compatible with this Heidenhain three axis vertical milling machine.

So, then we imported or we then we transferred that code to the machine that code was made on a computer separately that computer is a linked to here through the internet itself. So, then that code is run here, before running the code we just made sure that the references for the machine and for the software are same, 000 is same, so that this has made the machine. Now, while the machining happens let us see different kinds of cutting tools here.

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So, these are different kinds of milling tools here, this is the end mill cutter, where we have cutting edges at the hand, it is a four flute or we can say four edges are there, four edges or four flute end mill cutting tool. The dia is 10 mm, this is a completely solid carbide tool.

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In the same way we have this tool, this is an inserted tool, this is that was a completely solid carbide tool, it means in this tool we have solid inserts. So, this is a tool in which the inserts can be put in and those can be shown, this they can be locked in using a screw, though their sharp tip there. Only the inserts get deteriorated and that can be definitely changed.

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So, another kind of tool here is this, these are ball milling tools. So, again this is one of them is inserted and one of them is solid carbide tools, inserted when I say inserted, the inserts are solid carbide, when I say solid is a completely solid carbon tool, solid carbon tools are obviously very expensive in comparison to the inserted tools. The ball mill is always used for finishing operations and the tool cutters and these cutters end mill cutters are used for roughing, so, finishing and roughing, this we have already discussed in the previous lecture.

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So, also while machining one can observe that whether the machining is going right or not, if any alteration or any changes required that can be put in here by the operator here, he can stop the machine in between and then see whether the machining is going right or not or what is the state of machining.

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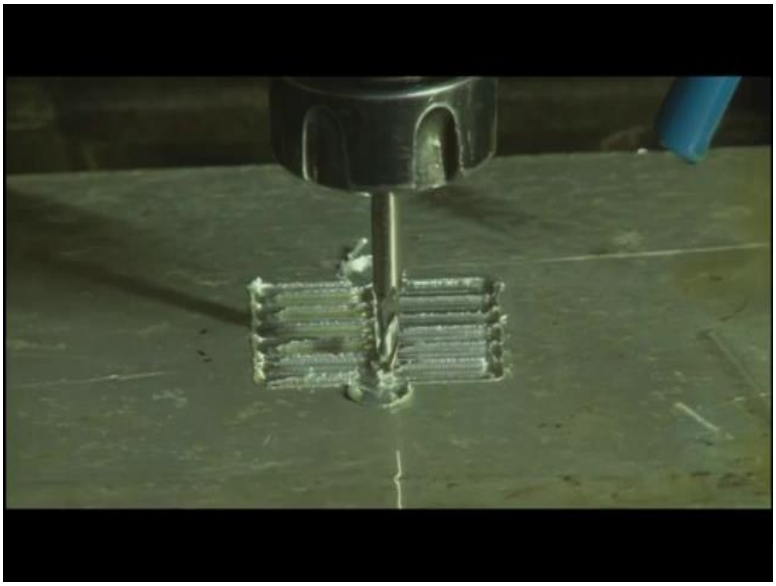

Now, we can switch off the machine and also see that what is the state of machine. So, this is the profile that is generated using end mill cutter, so this is whatever code we generated there using G and M codes that is used here to develop our workpiece profile here. So, once we have coded properly, once we have put the code in the machine and put the references proper, selected proper tool, selected the proper cooling system we will get what we needed. So, this is how we do CNC machining, this is one of the very small or very simple machining that has happened, this machine is capable of making profiles as well.

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Let us see about the pneumatic system here. All these blue pipes that you see here these gets the air passed through them. So, there are certain gauges here these are special gauges, actually these are pressure gauges, this controls or this indicates what is the pressure of the air that is passing through them.

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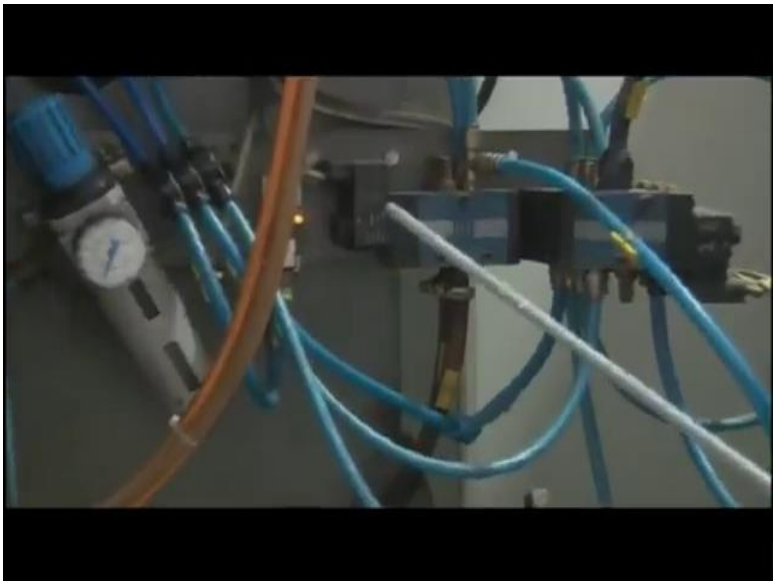

You can see the three pipes 1, 2, 3 going this is actually back of the machine, these tubes are going towards the front of the machine, these actually give the movement to the slides x and y and the switches are activated and deactivated. This number of solenoid valves are here, solenoid valves are use to switch on and off the supply of air.

So, also this is one of the supplies that goes to the spindle. So, with help of pneumatic systems is well with the help of air only the tool is held as I just told before. So, this is all the pneumatic system that is there, there so many LVDT's are there, solenoid walls there, pipes are there, pressure gauges are there, this is all integrated in a system machining system itself.

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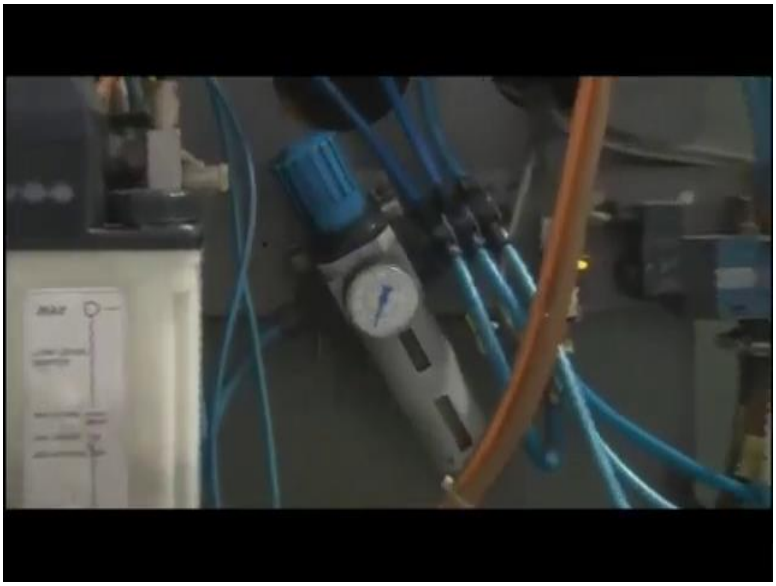

So, normally machine needs 6 bar pressure, you can see it is a little lesser than the 6, so it is close to 6 bars. So, this is the pressure that is needed by the machine to work this specific machine.

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Now, let us try to see, how do we take off and put on the tool, the tool holder? It is very simple, we just click the button and take the tool off, there is a sharp sound of air when we take it off, also when we put it back in, then also there is sound. So, there is a slot here the slot has to match with the pin there to put it in, this slot and the pin.

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So when we again put it in, this pin goes in here, then there is a sharp sound of, kind of sound of the air passing and it holds the tool pneumatically. So, this is our job that we have got. So, let us try to take this job off, un-screwing the clamps here in the spanner manually, so this is a T slots there on the machine table.

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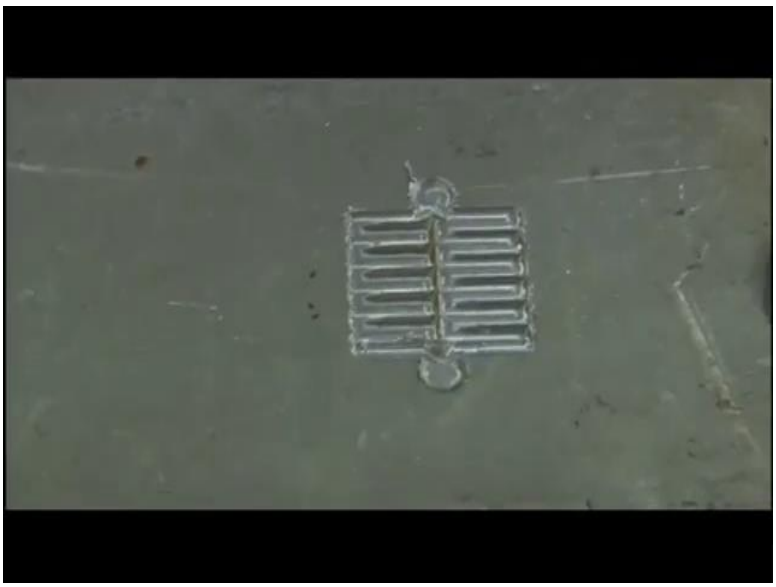

This is the work piece that is generated, it is exactly the profile that we did there. So, let us try to clean it a little bit. So, this is a profile that we have put it there and we have got it here. So, this is serpentine movement, these are straight movement, so we did not do finishing, this is just a rough machining cut that we have made using end milling cutter only, we did not use ball milling machine, ball milling tool to finish it. So, just to show you that how does that happen.

So, this is the laboratory demonstration on CNC three axis vertical milling. And CNC machines are as we all know are capable of producing so many complex surfaces, so that is also possible. This was a very simple profile that we picked to show you the demonstration on how does CNC machining actually happens. So, this is all about the demonstration on the CNC machines we will meet in the lecture. Thank you