Introduction to Mechanical Micro Machining
Prof. Ajay M Sidpara
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 52
Fabrication of micro tool by EDM process

Hi, I am Ganesh Milyar, I am I am a research scholar in IIT, Kharagpur under Prof. Ajay M. Sidpara. And I am working in fabrication of micro tools using micro EDM.

(Refer Slide Time: 00:28)

Welcome to the lecture on Introduction to Mechanical Micro Machining. In the last classes, you have studied different kinds of manufacturing processes machining strategies and all. In this lecture, you will be studying how to fabricate an end mill cutting tool that is in micro dimensions. So, the what is a popular tool fabrication process in the macro region actually it is called grinding tool grinding.

The tool grinding process not much reliable in the case of micro machining of cutting tools why is that the tool grinding process is a contact type process. So, there will be always cutting that contact between the tool and the workpiece. So, while dealing with very small cutting tools in the micro dimensions if there is high cutting force or contact force on the cutting tool, there will be on the on the work piece, there will be chance of breakage. So, the that is not easy to make cutting tools using grinding.

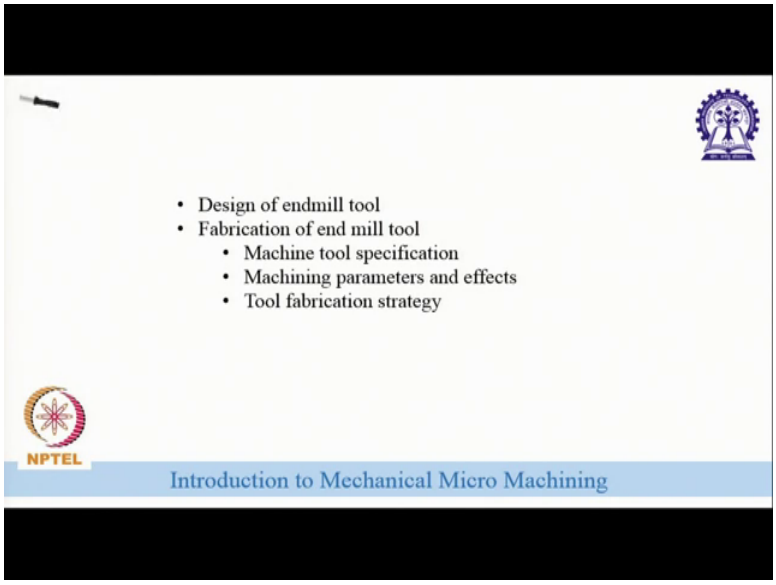
So, we need a process which is not contact like in non-contact type which is capable of machining the cutting. Tools there are different processes like that one once one example is laser; other example is FIB that focused ion beam machining. And the popular example for non-contact type machining process is a electro discharge machining or EDM. So, in this lecture we will be demonstrating how to machine a micro end mill tool using EDM that is micro EDM ok. And why we are using micro EDM or what is the speciality of an EDM process. So, so for that I will explain shortly like how a EDM process works.

So, there will be a tool electrode, there will be a workpiece. In this case this is our end mill tool blank ok. So, what happens this two will be the two electrodes will be must be electrically conductive, and this will be connected to a dc power supply. One will be connected to the positive terminal and one will be connected to the negative terminal. And there will be dielectric fluid in this case it is called EDM three oil.

And there will be dielectric supply in between the tool and the workpiece. And the dc power supply as the voltage increases, there will be a critical voltage above which there will be dielectric breakdown, and the electron starts to flow through from the cathode to anode continuously that flow of electrons we will see as it discharge. And this discharge is actually capable of melting and vaporizing material from the workpiece ok.

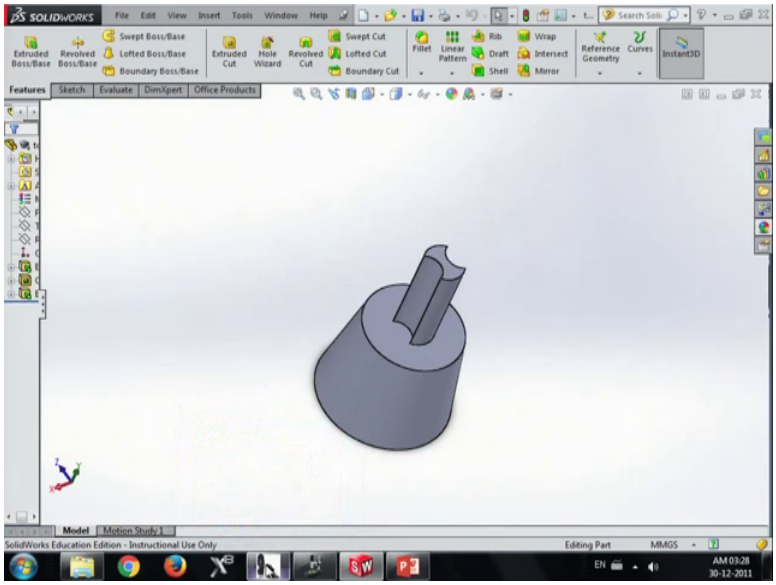
So, this discharges so the what is the advantage we can machine any type of material any hard material which is which are electrically conductive ok. So, this discharges we are trying to make use of these discharges to make micro end mill tools ok. So, this is our in this class, we will be demonstrating how to use the make use of the discharges to make micro end mill tools.

(Refer Slide Time: 04:02)



So, what is our strategy here today like we will be first designing a micro end mill tool and fabricating the micro end mill to using area. To fabricate the micro end mill tool we must know that what is the capability of the machine we have machine tool we have; So, first is the design of end mill tool.

(Refer Slide Time: 04:30)

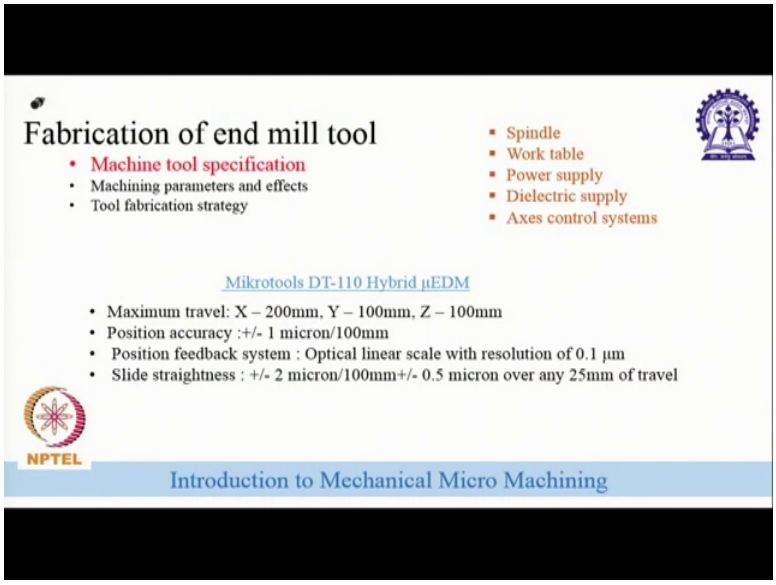


So, for that we will be using make use of a modeling software in this case solid works. So, this is actually a 200 micron micro end mill tool, which in which this is two fluttered micro end mill tool. So, you can see these two floats are available. So, comparing to the micro end mill tools or end mill tools with a complex shape; in this case, the shape is

much simpler, so but it is effective because like making a very complex flutes on a micro dimension is very difficult.

So, in this case, what we are doing is we are making a micro end mill tool which is simple in shape, but it is effective ok. So, this is a two flute micro end mill tool with top 200 micron diameter. So, we had designed it previously and find out what must be the dimension this is has a 200 micron diameter and 0.5 mm that is 500 micron length ok. So, we have done the designing part and we found out what is the position of the flank what is the what must be the dimensions of the flank and all.

(Refer Slide Time: 06:01)



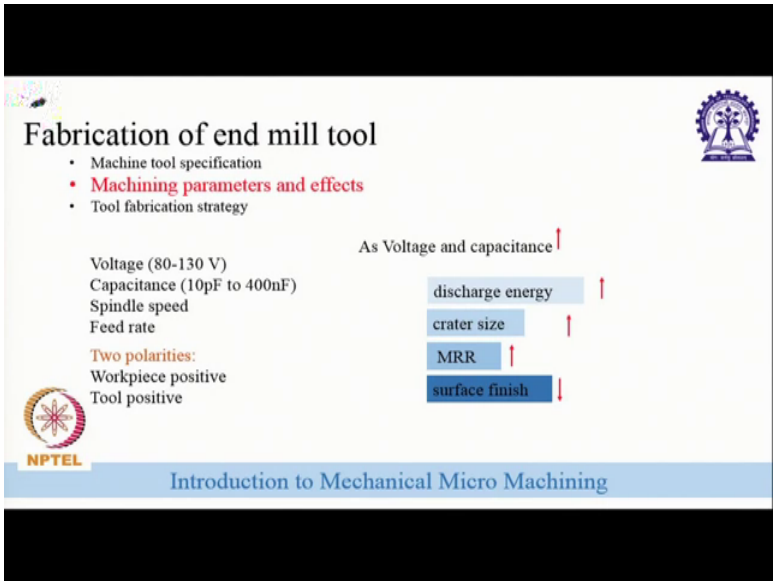
So, after designing we must know how we can make the design on the workpiece blank. So, for that we must know what is the capability of the machine tool; We have we have here a machine tool it is called it is the it is applied by micro tools and this is micro tools DT-110 hybrid micro EDM machine ok. So, what is the capability of this machine, this is maximum it has maximum travel of 200 micro mm I mean X, Y, Z, X. Y it is 100 mm, and Z is 100 mm. So, very small dimensions, but it is it is enough for a micro EDM machining.

Position accuracy is plus or minus 1 micron per 100 mm position feedback system, why we must need a position feedback system for a as explained in the previous classes, we must need a position feedback system while we are dealing with very micron dimensions because we do not know like in 1 micron is it or 10 micron is a very big dimension in in

case of a micro machining system. The slide straightness plus or minus 2 micron per 100 mm or whether like plus or minus 0.5 micron over any 25 mm of travel ok.

And what are the machining what are the parts of the machine, we have spindle. This which we are will be connecting the tool electrode or and work table in which we will be setting our work. Power supply a dc power supply like that is a pulsed power supply and dielectric supply that dielectric fluid I told you before that is EDM three oil we are using and access control systems ok. These are the main parts of the machine tool ok.

(Refer Slide Time: 07:51)



And as I told you before the EDM the process of EDM is actually a non-contact process, the discharge is responsible for the material removal ok. So, what is the machining parameters here, the machining parameters are one is voltage and that the in our machine tool the range is from 80 to 130 volt. Next is capacitance this is an RC pulse supply, so that the main thing we will be varying here is voltage and capacitance.

So, the voltage is 80 to 130 volt capacitance we can change from 10 micro farad to 400 nano farad and we can change spindle speed and we can define the feed rate. And two polarities we can set as I told you like we are the tool and work piece will be connected to the dc power supply either it can be the tool can be positively when workpiece can be positive or the tool can be positive that is a positive polarity or negative power.

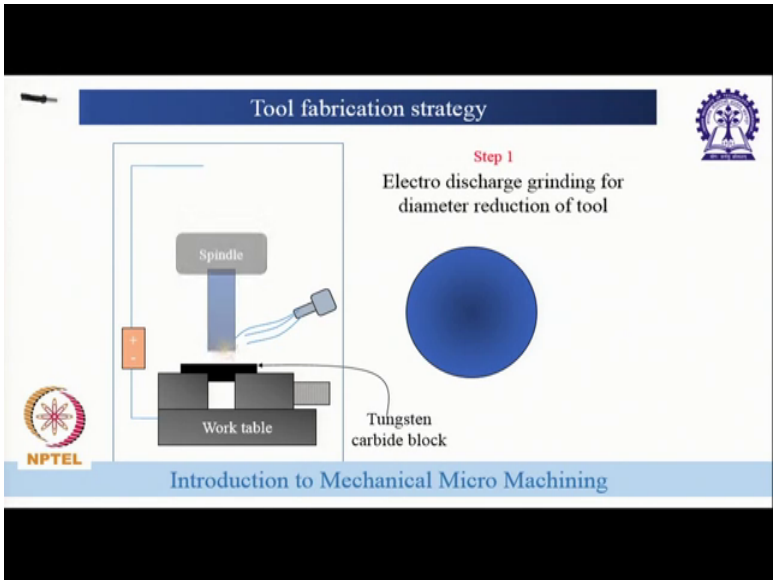
So, what happens as we increases the voltage and capacitor that is what happens if we change the parameters machining parameters. So, if we are increasing the voltage and capacitance, what happens is we will demonstrate it later and I am telling you what happens happening is the discharge energy the total discharge energy will be increasing.

So, as the discharge energy increases, the more material will be carved out from the workpiece, so that the crater size will be increasing as the crater size increases or the more material he is removing that MRR will be increasing, but that will be affecting the surface quality. So, the surface quality will be diminishing or surface roughness will be increasing. So, that is how the machining parameters will affect the whole machining outputs ok.

(Refer Slide Time: 09:52)

So, finally, we know what is the what the what is a machine tool we are using. We know what are the machining parameters, we have; And finally, we are defining what will be our strategy for fabrication, the fabrication of the micro tool ok.

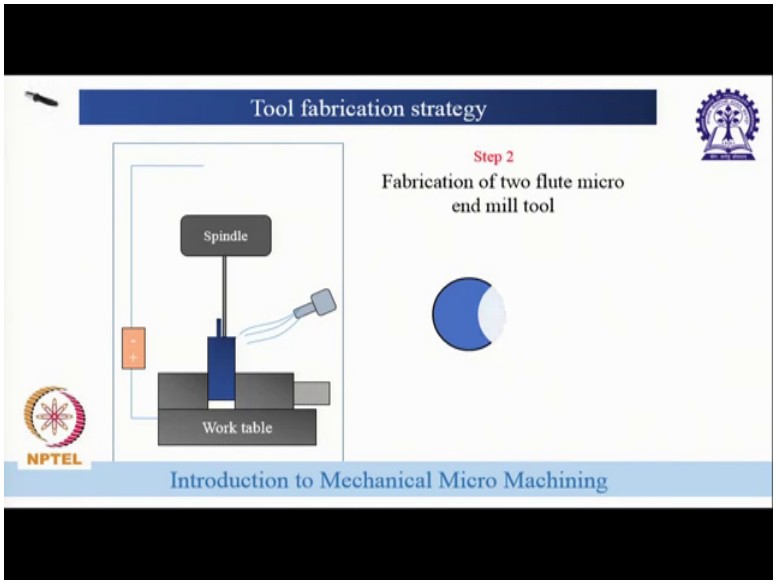
(Refer Slide Time: 10:13)



So, the tool fabrication strategy started starting with a blank, we are reducing the diameter of the blank from 0.5 mm to 0.2 mm using a process called electro discharge grinding. Electro discharge grinding is very much similar to EDM. So, only the thing is like we have a block, we have a tungsten carbide block, and we are using we are that tool material is also tungsten carbide. And we will be doing a operation in which like the standard piece we will be moving with touching the I mean like mean with along with the tungsten carbide block.

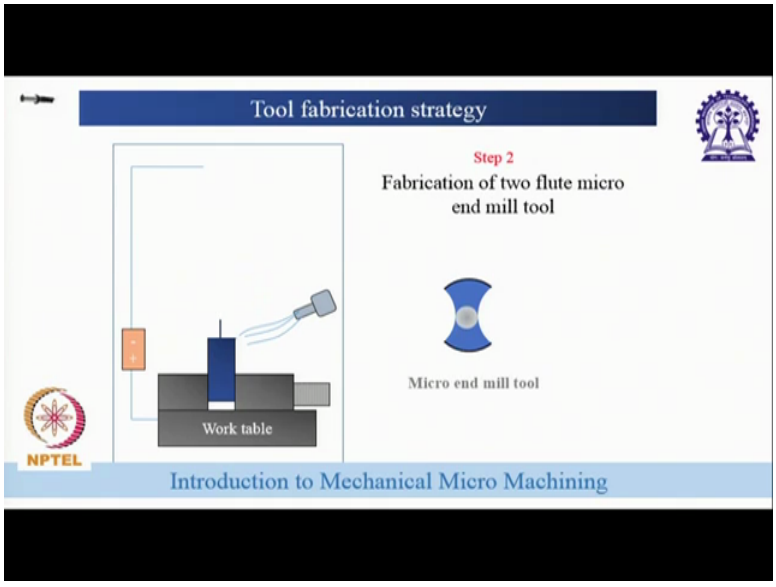
In the in that time the diameter of the 0.5 mm tungsten carbide rod will be reducing into 0.2 mm that is electro discharge grinding process. Here you can see this is tungsten carbide block. The black one is the tungsten carbide block and this is the tool which we are using or the micro and the blank of the micro end mill tool, and we have reduced the diameter 0.2 mm from 0.5 mm ok. The next process is we want to make the flanks of flanks on the on this tool.

(Refer Slide Time: 11:39)



So, how to make that we are just plunging the tool down I mean we are taking the tool from the spindle and we are keeping on the workpiece.

(Refer Slide Time: 11:45)



And on the on the anvil tool flank, we are making two flanks by plunging another tool from the two sides. So, that in the finally, we will get a micro end mill tool over on a base and there are will be two flanks on the two sides of it. So, this these two things these two sides can be worked I said it can be work as a tool edge or the cutting edge.

And while rotating this cutting edge can remove material and it can perform as a micro end mill tool. So, this is the whole strategy of fabrication. So, the fabric strategy start

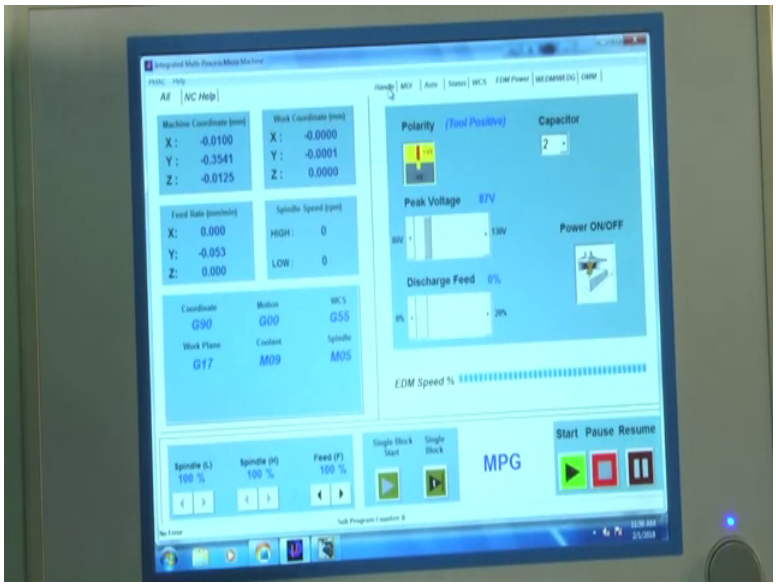
from micro like EDG to reduce the diameter to from 0.5 to 0.2 mm and making two flanks and the two sides of it, so that we will get a two flute end mill very simple as a symbol size symbol shape, but two flute micro end mill tool.

(Refer Slide Time: 13:04)

As a next step I will be demonstrating the whole process of fabrication of micro end mill tool as we explained here. So, for that, the first we will I will introduce the user interface to the machine. This is actually the micro tools DT 110 hybrid micro EDM. So, here you can see there is a panel in which there this is just like a CNC machine the panel you will be familiar if you know and if you are familiar with any kind of a CNC machine.

Panel is almost saying. There is a MPG mode, in which we will be controlling manually JOB mode; and MBI mode in which we will be putting a manual data inputs, and auto mode will be writing program and we will be performing the program ok. So, the EDM parameters we will control by this panel actually. So, what you can see there is a polarity, polarity with icon in which we can change the polarity to post your native that means, here it is show us what positive now if I am putting so.

(Refer Slide Time: 14:08)



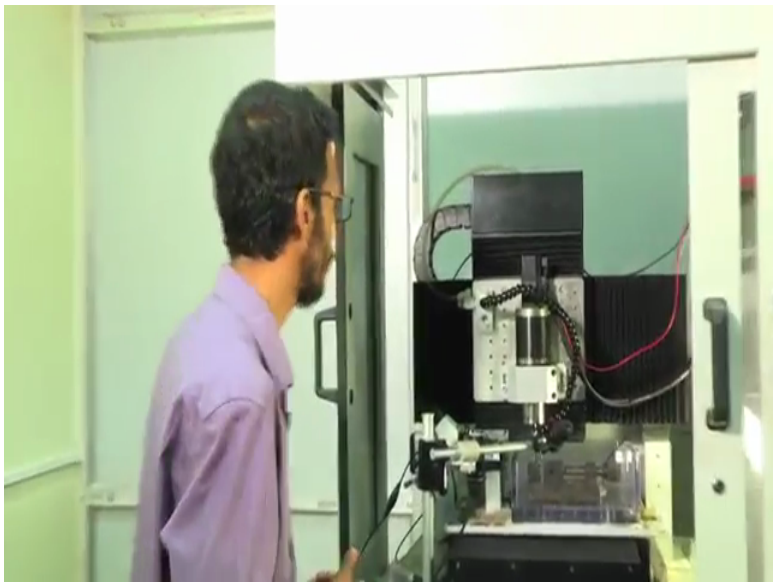
First for that we have to start the power supply power now the power is on and we can change the polarity tool positive or work positive, so that usually the tool will be connected to the spindle, and the workpiece kept in the work table. So, we can see in work positive or tool positive accordingly using this icon. We can change the capacitance from, so it is a coded value from 0 to 6, so that the 10 pico farad to 400 nano farad we can change; So, from 0 to 6 actually the coded value for that. And we can change the voltage from 80 volt to 130 volts just like sliding this one.

And this is all about the setting parameters machining parameters. So, first step will be we will be finding out what is the optimum parameters for machining and we will set the parameters. So, the first step will be finding out the optimum parameters for machining, and we are setting the machining parameters here in this window. After that we have to for the first as you know if you remember the first step is to reduce the dimension of the blank EDM tool blank from 0.5 mm to 0.2 mm that is 5 micron to 200 micron.

So, for that we have to find out like we have to do we have to select a blank micro for micro end mill tool, so starting with what we are doing here is we our ours we are selecting a flank as a commercially available 0.5 or 500 micron end mill tool. On the surface of that, what we are doing is we are flattening the surface out on the top to remove all the available features, and we are flattening the top and over that we are making our own end mill cutting tool that is like micro end mill tool ah

And this micro end mill tool. So, why we are using a plank of like commercially available tool that will be easily like easily can be put into the spindle put into the collars, and the collars are available that is the only reason we are using that. Our actual tool will be on the top of that just like a pencil carving ok. As the next step I will demonstrate the whole setup whole experimental setup to you, and we will demonstrate the machining process ok.

(Refer Slide Time: 16:56)



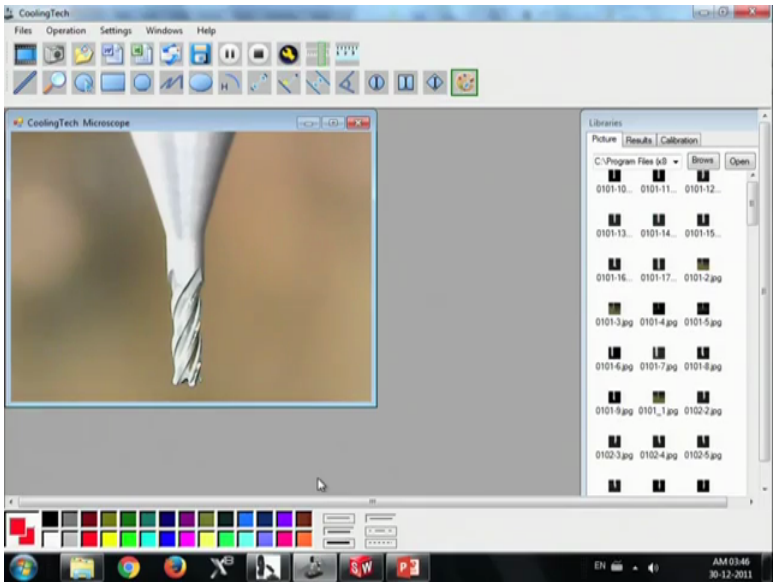
Let us see what is the setup for fabrication of micro end mill tools ok; So, from here, I think you will be seeing there is a spindle, and there is a workpiece which is which is set up on the bench on the vice ok. The both material for the tool blank and the like the standard piece is tungsten carbide. So, what we are going doing here there will be there is a block and there is a tool the tool blank, and we will be just touching the tool blank first to find out the point the touching point that is will be done using a contact probe method.

After that to reduce from 0.5 mm to 0.2 mm, 0.5 mm to 0.2 mm, we will be more moving 150 micro inverse, and we will be moving along this direction, so that the sparking will be occurring between the tool and this standard piece or the tungsten carbide block and the dimension will be reducing from 500 micron to 200 micron because why it is going inside by 150 micron and is rotating so that 300 micron will be taken from the outer vice, left and what one will be left 200 micron diameter ok. This is just like a turning process,

but the whole there is no tool available, no cutting tool available or the whole machining is done by the sparks ok. Ah

Then I if to get a more fine view, we will be changing the view to the microscopes; Then we will get how the machining happens, and how the sparks will be responsible for the machining ok. So, for a better view, we will be changing the view to the microscopes because we are dealing with very small dimensions and mic in micro dimensions. So, by naked eye, it will the process will not be much visible. So, the whole process we will see as in the microscopes.

(Refer Slide Time: 19:08)



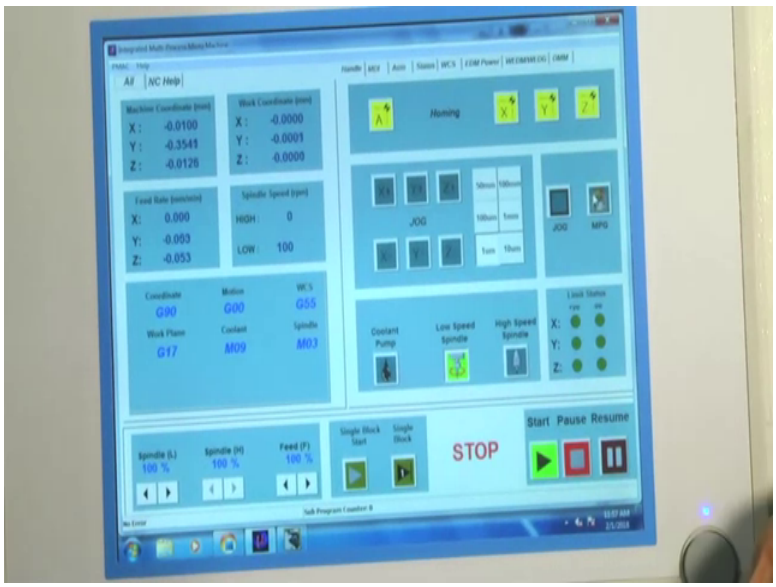
So, here you can see in the micro cohesively available for flute micro end mill tool which we are going to use as a blank, blank for our original the micro end mill tool which we are going to make. And here you can see the flanks and all what we are going to do is we are flattening out that the bottom of it we are reducing the diameter into 200 micron.

And after that we will be do the doing the plunging and all ok. So, there are two cameras actually we are using. So, one camera is this one or one microscope microscope camera is this one and another is so there are two cameras we are using; one is this one, and one is attached to the machine. So, this is a digital microscope camera, and that one is a charge coupled device CCD microscope ok.

(Refer Slide Time: 20:18)

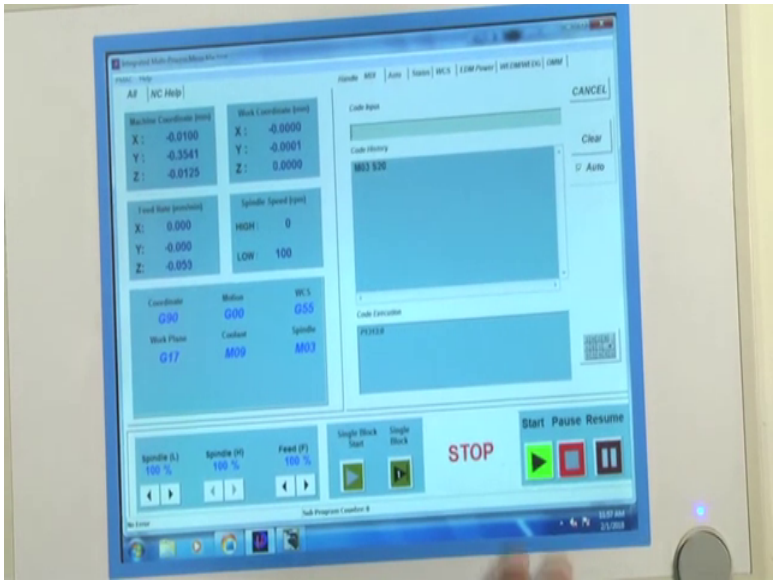
To explain that you can see here, so this is a CCD microscope which is this is actually the shadow of the hall tool available. So, you have seen the original end mill tool which is connected there, and which has shown there. And this is actually the shadow image of it. In this actually we can measure the that so I am just trying to rotate this one.

(Refer Slide Time: 20:49)



So, now, you can see it is so I will rotate in very slow manner.

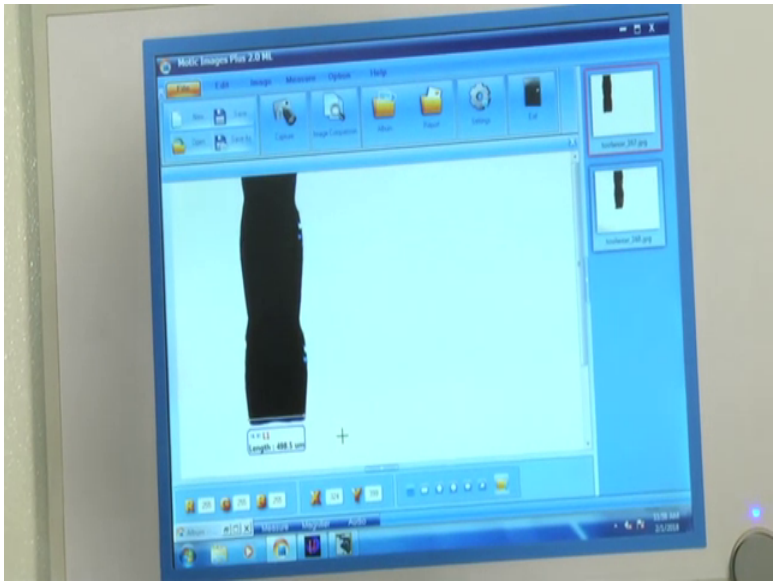
(Refer Slide Time: 20:56)



Ok, this is actually the micro end mill tool which we have we have shown there. So, you can see the flute and all. So, what is why we are using this one. So, after making the tool or while doing the manufacturing process, we are not sure the dimensions are correct or not.

So, it frequently we have to check the dimensions in the in the microscopes. How to do that we can actually capture the this shadow image capture the shadow image and just like here you can capture it and that will be shown in the figure.

(Refer Slide Time: 21:45)

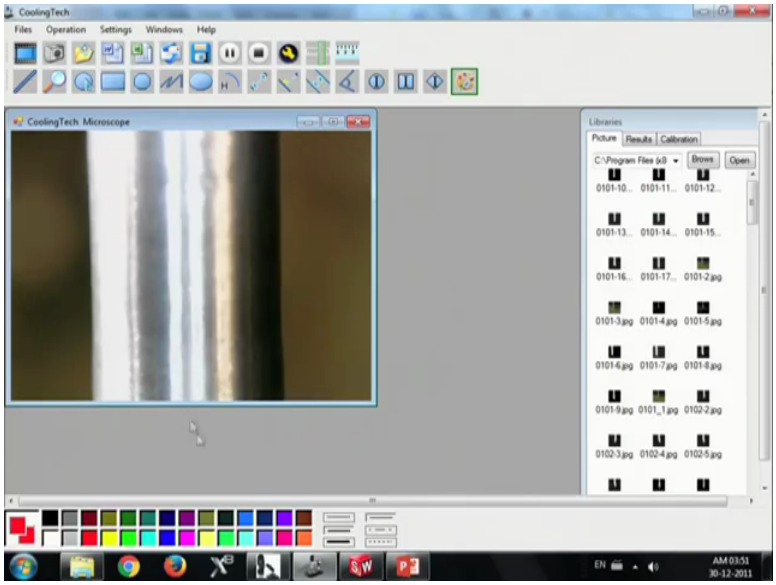


So, and we can measure the dimensions that is a measuring system and we can measure the dimensions. And here you can see the length is showing 480 around 500 micron this we are originally using it ok. And so this is so this purpose we are using a another CCD camera and the software which is connected to it ok. So, this so what we have to do like we have using two cameras for measurements and to view what is happening what is it correct or not the process is correct or not any problem with the process ok.

If so everything is ready, two cameras are ready for the measurement and the for observation and the machine tool is available for it. So, before starting the machining we have to find out the points the boundaries of machining like where we have to start the machining. For that we have to use a contact probe method. The contact probe is method is nothing but it will find out the point the touching point by when the shorting occurs.

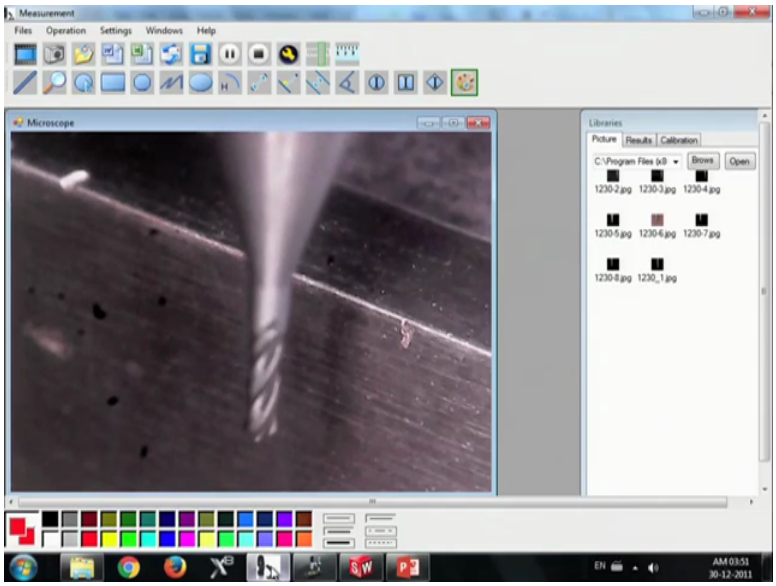
We will be moving very near to the near to the standard piece or the tungsten carbide block and as it touches the block then what that there will be some shorting and that point will be taken as the contact point, so that what we will be moved doing just remember we will be touching and we will be moving 150 micron inverse and we will be moving in y direction. So, like in one other direction so that it will the diameter will be reducing ok. So, next I will explain how to use the contact probe method.

(Refer Slide Time: 23:54)



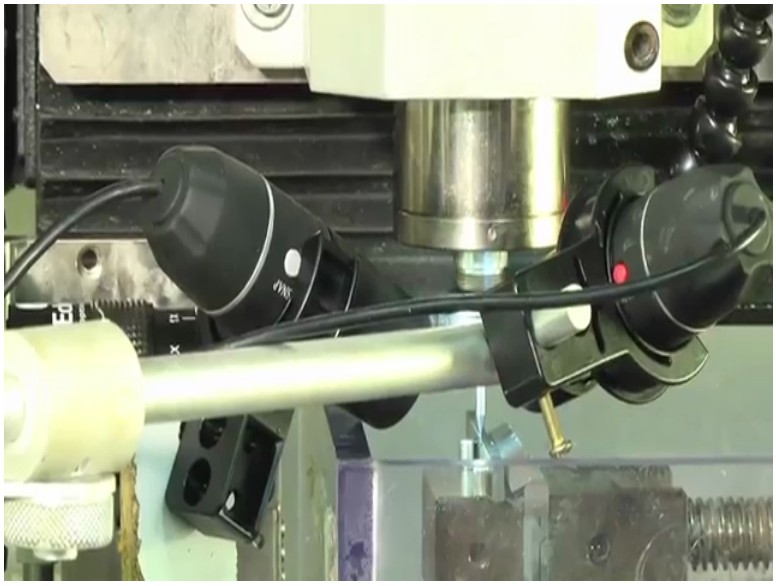
So, I am changing into MDI mode. So, the manual mode and.

(Refer Slide Time: 24:03)



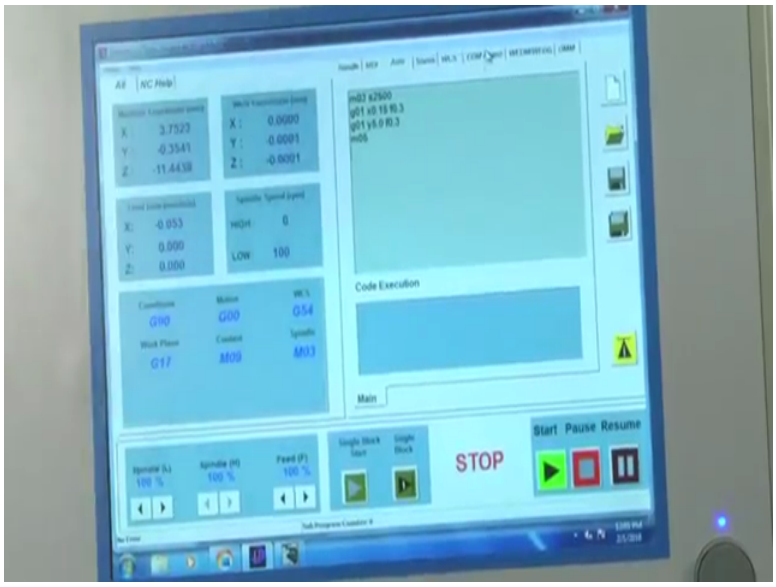
So, in this you can see from the microscope that the tool is approaching the tungsten carbide block. And once the it touches the tungsten carbide block, the program here it stops like I have written a skip function program, so that as it touches the touches the tungsten carbide rod, this stops. And that point we will taken as the starting point and we will move inside 150 micron and move along side, so that it will be machining into the required dimensions.

(Refer Slide Time: 26:39)



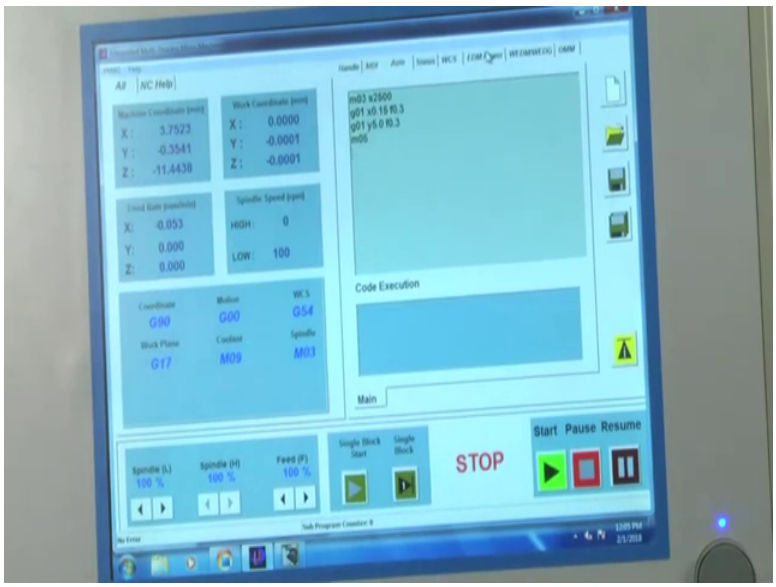
So, this is the point has been set into the contact point has been find out using the contact probe method and that said to 0, then we have to move 150 micron inwards, and we will be doing the machining ok.

(Refer Slide Time: 27:48)



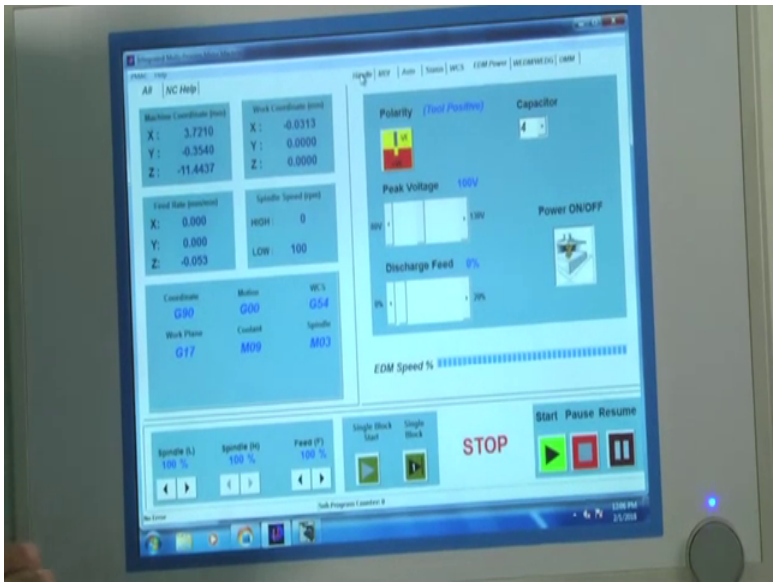
So, we have to write a program for that and we will be writing in an auto mode. So, this is very much similar to all the CNC programming methods on CNC programming machines, we see all the CNC machine. We will be rotating this clockwise in 25000 rpm and.

(Refer Slide Time: 28:08)



We are moving X into 150 micron inwards. And after that we will be moving in Y-direction 5 mm. So, here field is 0.3 and we are moving 5 mm in Y; and 0.15 mm in X. And we are stopping the spindle that is all about it.

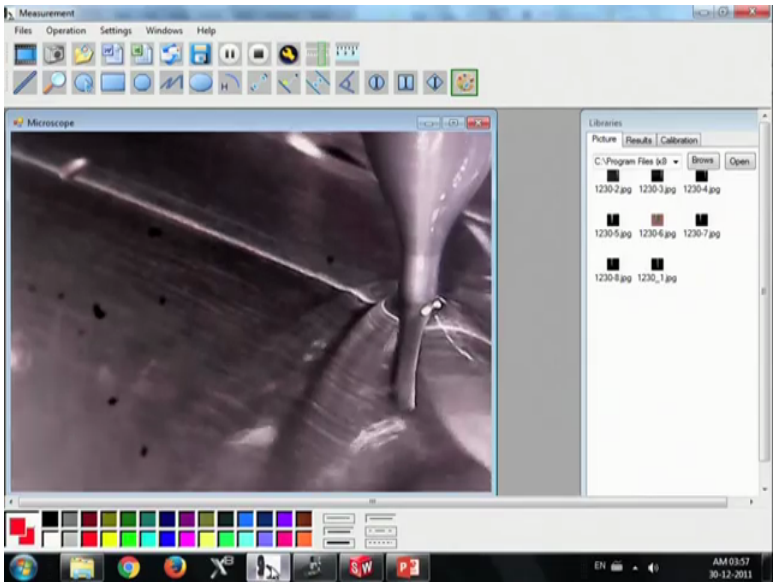
(Refer Slide Time: 29:05)



So, before starting we have to setup the electrical parameters was you will be starting the power we are changing into number four and increasing the voltage to 100 ok. So, here and we have set the program, we have set the electrical parameters.

Now, we have to start the dielectric fluid. The dielectric fluid is very much necessary to perform the operation.

(Refer Slide Time: 29:57)



So, the fluid is flowing in between and yeah. So, everything is there is the discharge the dielectric fluid is flowing, and the electrical connections are ready, and we are just going to start the machining process ok. Now, you can see from here from the microscope that that is sparking or querying between the blank and the block. So, as it goes 150 micron and moving into the y-direction then the dimensions the diameter will be changing from 0.5 mm to 0.2 mm. And we will be reversing the tool down and we will be plunging the source on the blank tool blank.

So, for to explain what happens if I am increasing the or changing the machining parameters I can explain you if you are changing the electrical power here, so you can see that the discharge the discharge energy increasing or the spark intensity is increasing.

So, I as I am increasing the voltage and capacitance, we can see a very heavy sparks on it; and as I am decreasing the capacitance the sparks decreases the that what I am told like if you have we are increasing the capacitance and voltage, the crate in the discharge energy increases the crater dimensions increases and the surface roughness will be increasing and the MRR will be increasing, but the surface roughness will be also increasing like the surface quality will be diminishing.

So, this will be the process and, but this is a micro EDM or EDM process in all ways it is not it is very time taking process compared to the conventional machining processes. So, this will take much time for machining. And as a next step we will be showing the

machine tool. So, the final machine tool which we are going to use as a micro end mill tool.

Thank you.