**Advanced machining processes**
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**Lecture 30**
**Electro discharge micro-machining of process**

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Welcome to the course on advanced machining processes. Today I am going to discuss about electro discharge micro-machining process.

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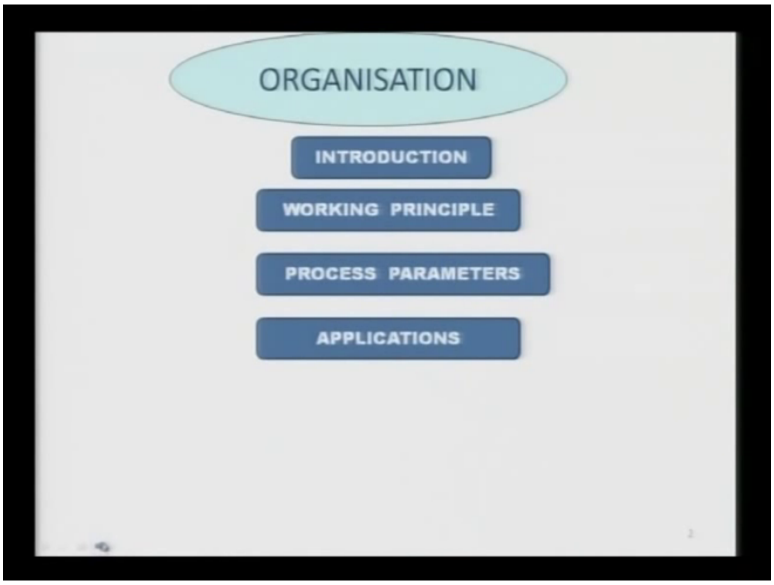


Organization of the (())(0:36) introduction then working principle of electric discharge micro-machining. After that I will tell you the process parameters of the process then applications of the process.

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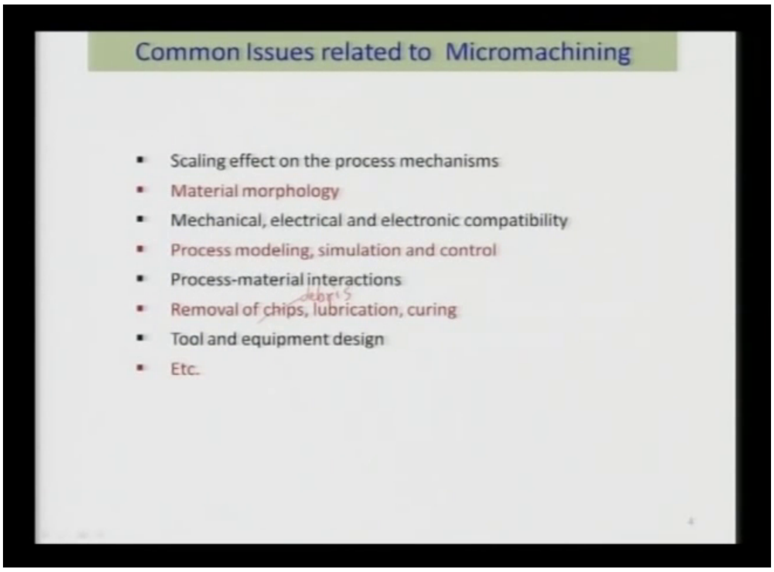


Introduction, we have already seen in the lecture on electric discharge machining and this is the lower scale version of the discharge machining. So let us see what are the common issues related to micro-machining, first one is the scaling effect on the process mechanism, material morphology, what kind of material you are going to get and after electric discharge machining?

Then mechanical, electrical electron  compatibility, after that I'm going to discuss about the process material interaction removal of material in the form of debris rather than writing it here, my chips it is the one we normally call is debris not the chips, lubrication, curing etc. Tool and little bit of equipment design. After that we will show you an actual real life demonstration of the electric discharge micro-machining machine that we have at IIT Kanpur.

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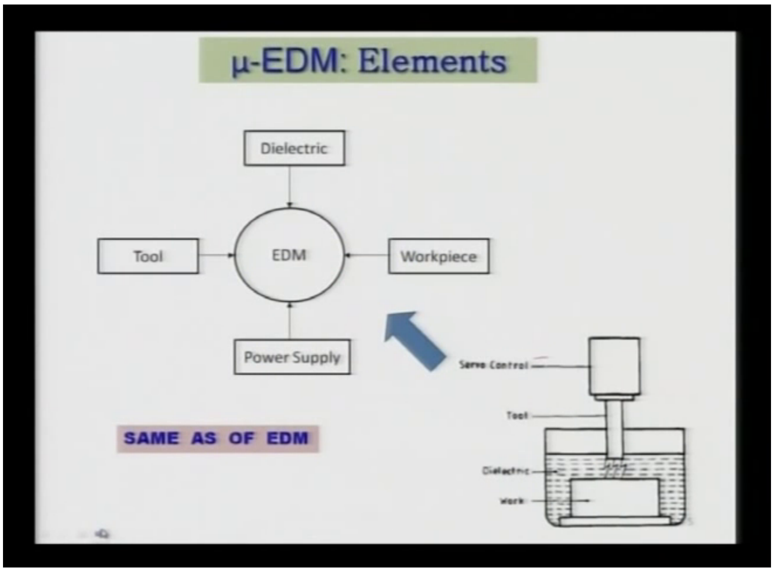


Now what is electric discharge micro-machining setup elements. It is the same as you can see what we had in electric discharge machining that is the tool which is also known as cathode and made of electrically conducting material then you have the work piece again made of electrically conducting material the work piece material should have a certain minimum conductivity then only you can use this electric discharge micro-machining process and then for filling up the gap between the tool and the work piece we use the dielectric and there are various kinds of dielectric which I will tell you and to make them electrically conducting the whole circuit we have power supply and the working principle is very simple you can see clearly here there is server control of the tool, then there is a tool dielectric is there, work piece is there and the gap is filled with helpful of the dielectric.

When the potential gradient between the cathode and the anode that is the tool and the work piece is sufficient enough to breakdown the dielectric then you get what is known as spark. In this process we are not interesting in the arc, so we are always interested in the spark. So people call it as electro spark machining, in the beginning it was mentioned like electro spark machining when EDM was developed by Lazarenkos brothers and the working principle is the same as that of electric discharge machining, so I am not going to discuss much about the details of this process, many of the elements of micro-EDM process are the same as that of EDM.

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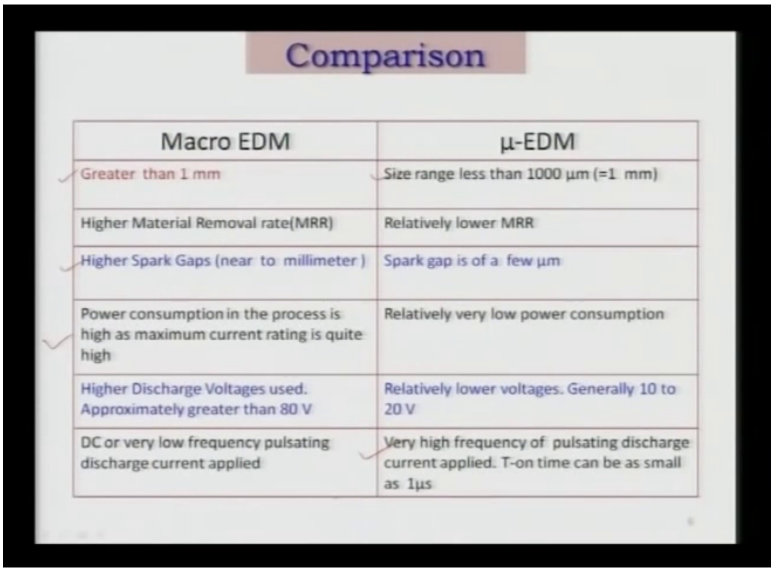


However we have a comparison table over here as you can see the macro EDM where the size of the parts are the features that you are creating is bigger than 1 millimetre while in case of electric discharge micro-machining or micro-EDM size range between or below than or less than 1000 micro-meter. In case of macro-EDM material removal is higher compared to material removal rate in case of micro-EDM.

Then higher spark gap, the gap between the tool and work piece is normally larger, potential applied is also larger, so the spark gap is also larger in Macro EDM as compared to micro-EDM. Power consumption in the process is high definitely in case of macro EDM compared to micro-EDM, higher discharge voltage used approximately greater than 80 volts in case of macro EDM while it is just 20 volts or less than 20 volts in case of micro-EDM.

So one thing should be very clear that the size of the spark in case of micro-EDM is going to be much smaller than size of the spark in case of macro EDM or in other words we can say that the greater size that you are going to obtain in case of micro-EDM is again going to be smaller than much smaller than macro-EDM because energy per spark is much smaller in case of micro-EDM as compared to macro EDM.

And that is simply mean that you can get much better accuracy in case of micro-EDM as compared to macro EDM and DC or very low frequency pulsating discharge current is applied in case of Macro EDM while very high frequency of pulsating discharge current is applied and T on time can be as small as 1 microsecond. So we can clearly see there is a basically a scaling down or scaling difference between macro EDM and micro-EDM.

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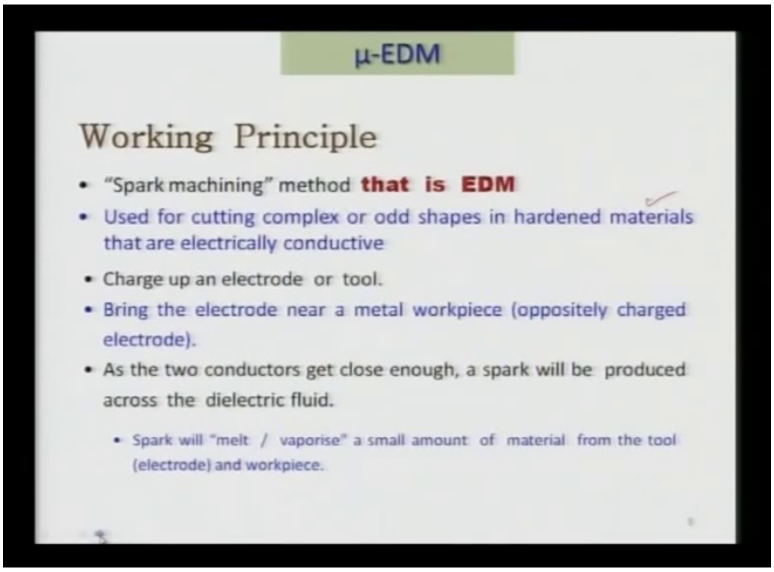


Let us again reiterate in brief the working principle of electric discharge micro-machining. I am saying reiterating deliberately because this principle is the same as the principle of EDM and I have already discussed EDM principle working principle. Now spark machining this was as I mentioned few minutes back. It was initially named as electro-spark machining by Lazarenkos brothers.

So again we can see spark machining, method is the same as the electric discharge machining method. It is used for cutting complex or odd shapes in hardened materials that are electrically conductive and one more thing that it can machining very very hard materials, if it is electrically conducting or you can say difficult to machine materials can be easily machined by this particular process.

Here you can the electrode that is the tool and work piece to the negative and positive terminal of power supply as we have seen in the schematic diagram in the earlier slide and this electrodes that is the tool and the work piece are brought closer to each other and the gap between the 2 is few microns as I mentioned in the earlier slide that the working gap is few microns while in case of EDM it is much larger.

And tool is negatively charged that is the cathode and work piece is positively charged and it is called as anode. However in certain cases you may have to use the reverse polarity but not much research has gone into that. So I am not commenting much about that particular feature of the electric discharge micro-machining. As the 2 conductors get close enough, a spark will be produced across the dielectric that means when potential gradient in the path of the dielectric that is there between the anode and cathode becomes so large that it breaks down the dielectric then you have what is known as spark.

Spark will, spark has a localised high intense energy, heat energy and this energy is good enough to melt and or vaporise the work piece material, once melting has taken place then dielectric will eject out the molten material from the cavity or if vaporization takes place then due to the sudden you know explosion due to the sparking taking place or plasma formation that shockwave is generated and that shockwave will remove the molten material from the cavity.

And as a result a small amount of material from the tool and work piece both is removed that means here one has to note again that in case of EDM here also wear of the tool as well as wear of the work piece material both is taking place but definitely wear on the cathode that is the tool is less compared to the wear on the work piece that is the anode.

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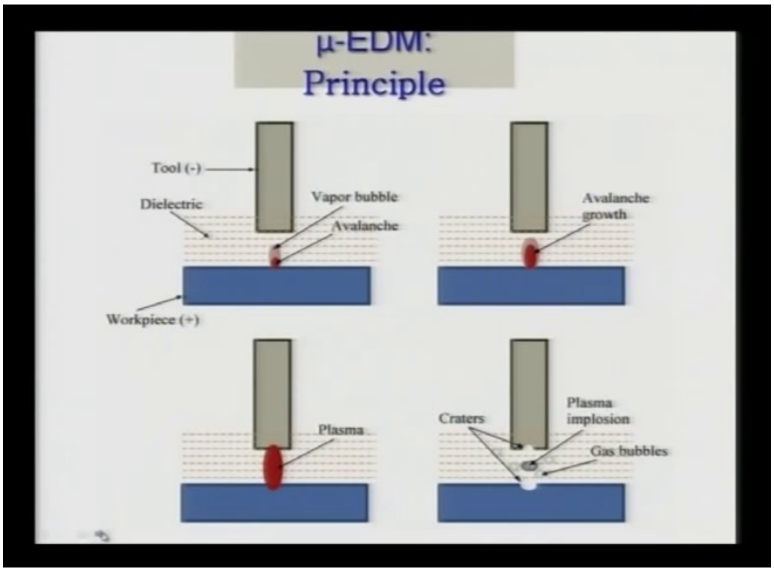


Here you can clearly see how the spark evolution takes place, here is the tool that is cathode work piece and dielectric is over there and in the initial phase of sparking you know vapor bubble is there and it avalanche and you can see the avalanche growth takes place, plasma formation takes place and full plasma formation is there between the cathode and the anode and this plasma has intense heat energy which is responsible for removal of the material from the work piece as well as from the tool at the same time that's why wear of the tool as well as wear of the work piece takes place.

Now those craters are shown over here, in the last figure there is a smaller crater at the cathode and larger crater at the anode this indicates that more amount of material is removed from the work piece and less amount of material is removed from the tool. However theoretically we want that the removal of the material from the tool should be 0, if not 0 as low as possible, so that degeneration of the shape of the tool does not take place.

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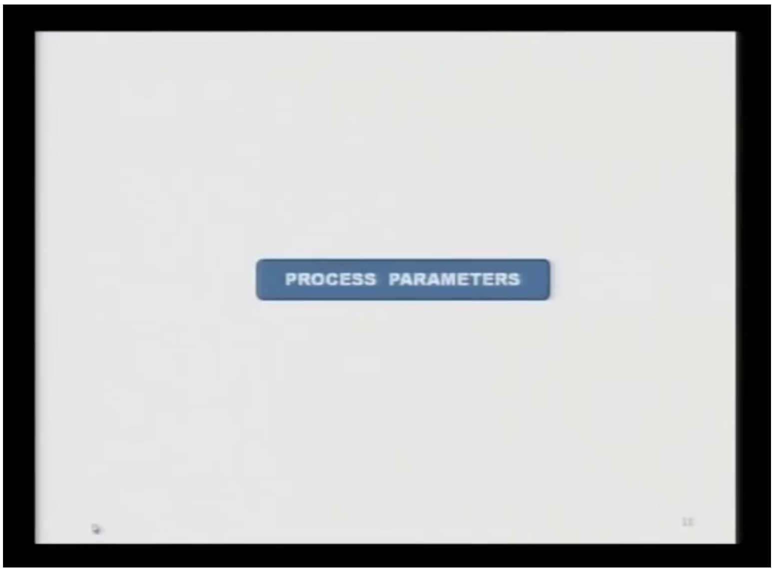


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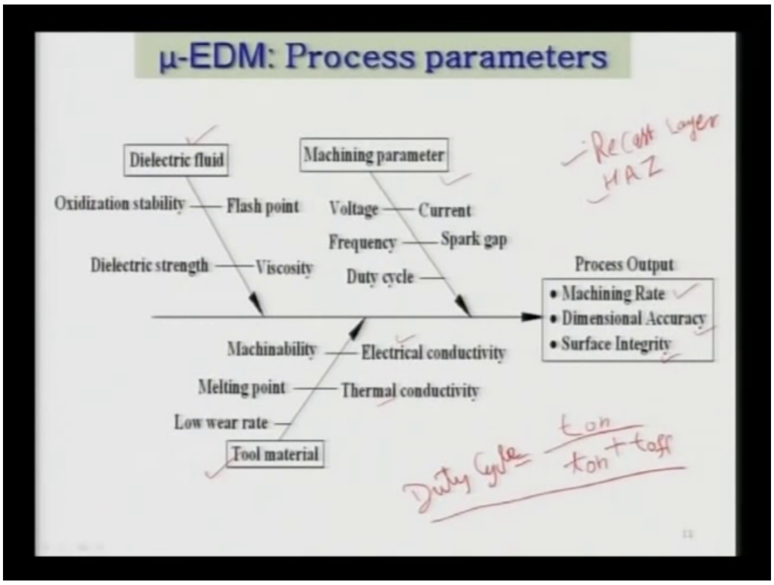


Process parameters, here you have a fishbone diagram of the process parameters, we have already seen that dielectric fluid is there then oxidisation stability and flashpoint of the dielectric fluid play an important role. Dielectric strength is there which will decide the voltage required for breakdown of the dielectric and the viscosity of the dielectric is also important because it determines the flow ability of the dielectric and especially in case of complicated shapes the dielectric should flow in all in accessible areas of fine features, so that sparking will take place over there and you get proper machining.

Then there is a tool material, tool material should have easy machine ability, so that you can give complicated or any desired shape to the tool because what you're going to get on the work piece is a replica of the tool, very close to the replica and I don't say exactly the replica and tool material should definitely be electrically conductive, melting point of the tool material should be as high as possible. So that the wear of the tool is minimum and it is also the function of thermal conductivity that will decide the temperature of the tool and definitely tool material should have low wear rate.

And then you have the machining parameters, voltage and current they will decide the spark energy and that spark energy will decide the size of the crater to be formed on the tool as well as on the work piece and frequency of sparking is another very important parameter it will affect accuracy and surface features or morphology that you're going to get after machining and then duty cycle that is nothing but T on that is the on-time of the pulse divided by T on that is the on-time plus of time of the pulse that decides that duty cycle and this plays an important role in case of EDM as well as electric discharge micro-machining.

The output of the surface are measured or the performance of the process can be measured in terms of machining rate, dimensional accuracy that you are getting and surface integrity that is again very important parameter that will decide the surface finish, the micro cracks if any on the surface that has been machined and morphology or texture of the surface again play an important role and how much is the recast layer? How much is the surface damage? I'm not going to discuss that but these are all the features that we have seen while we were discussing the electric discharge machining there I have told you in detail or the heat affected zone that is H A Z recast layer under the features.

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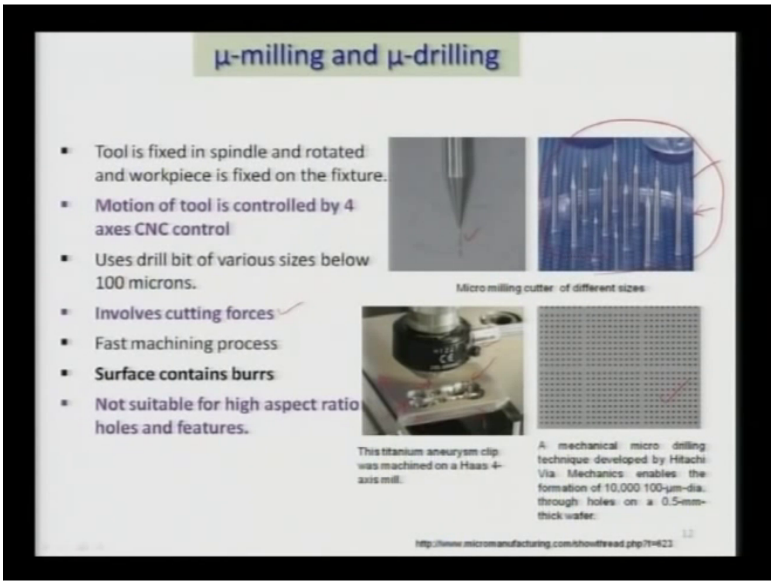


You can perform various kinds of the operation using the EDM process; you can do micro-milling operation as you can see here. Here is the micro-milling tool or cutter and you can see here micro-milling operation is being performed the feature is being created with the help of the Micro tool, these are enlarged view of this figure and then you can have different kind of the tools as you can see on the top right-hand side figure.

And then here is the titanium, aneurysm clip was machined on a Haas 4 axis milling; this milling machine is a 4 axis milling machine. Then you have a mechanical micro-drilling technique developed by Hitachi via mechanics enables the formation of 10,000 hundred micro-meter dye meter through holes on a 0.5 millimetre thick vapour. You can see the kind of the holes that have been developed thousands in number formed and with and the diameter of these holes hundred micro-meter diameter and the thickness of the vapour is 0.5 millimetre.

So this is very useful for finding hole drilling in large quantity. Again note that there is no physical contact between the tool and the work piece. So mechanical forces are not working either on the tool or on the work piece and tool is fixed in spindle and rotated and work piece is fixed on the fixture you can see here, the tool is fixed in the spindle and this rotates and work piece is fixed in the fixture and sparking is taking place.

So you have the uniform hole or uniform milling taking place over there. You are giving x and y motion to the work piece, so that you can create these kinds of the features as shown by arrow over here. Motion of tool is controlled by 4 axis CNC control of the machine. It uses drill bit of various sizes below hundred microns, you can see here on the top right-hand side figure various sizes of the drill bits are shown over there and these are all micron size tip.

Any way these tools can be made by the EDM process also and you can perform the mechanical cutting when you are performing a mechanical cutting over here then cutting forces are there, you can perform the fast machine process, surface when you are doing mechanical machining then definitely it will consist of burrs and it is not suitable for high aspect ratio holes and features because the probability of breakage of the tool is high.

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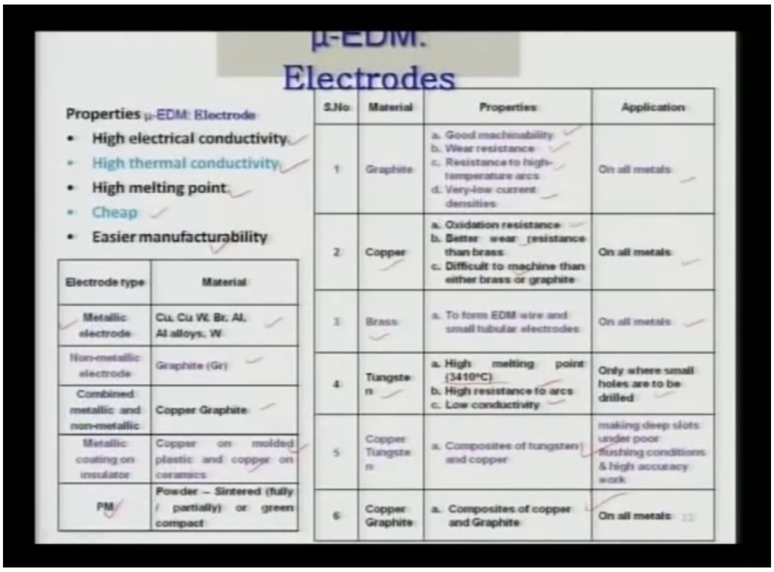


You can prepare micro-EDM electrodes, properties of micro-EDM electrode it should have high electrical conductivity, high thermal conductivity, high melting point, it should be less expensive and manufacturability should be easy, so that you can make the electrodes of different shapes and sizes. Electrode type and material are given here, you can have the metallic electrode where you can use copper, copper tungsten, brass etc. various kinds of the materials.

Then you can have non-metallic electrode like made of graphite, please note that graphite is electrically conducting material. Combined metallic and non-metallic like copper and graphite you can have the electrode made of these materials. Metallic coating on insulator can be made so that you can use that insulator tool as a Micro tool in micro-EDM process because you have the coating on the outer periphery which will work as a conducting material, electrically conducting material.

So you have copper on moulded plastic and copper on ceramics these tools can also be used for electric discharge micro-machining and then you can make the tool with the help of powder metallurgy PM. Powder sintered fully or partially or green compact can be used as the tool. There are various kinds of the tool materials as I have just mentioned and they have certain properties as I have elaborated over here like graphite it has good it is good Machinability, wear resistance is high, resistance through high-temperature arcs is also high in very low current densities and it can be used on all metals.

Copper is very commonly used tool material and it has oxidation resistance, better wear resistance than brass and difficult to machine than either brass of graphite that is one of the weakness of this particular material as the Micro tool for EDM process. Again it can be used for all kinds of materials than brass it is used to form EDM wire and small tubular electrodes and again this can be used in combination with all other materials.

Then there is tungsten it has very high melting point just like 3 thousand 410 degrees centigrade it has high resistance to arcs and low connectivity and it is used where small holes are to be drilled because it is much stronger than copper and brass, so that it can resist even mechanical forces and definitely it can resist high thermal load because its melting point is 3400 degrees centigrade like that.

Copper tungsten again used as composites of tungsten and copper making deep slots under poor flushing conditions and high accuracy work. Then you can have combination of copper graphite it's composites of copper and graphite and again it can be used for all metals. This way you can see these are the various kinds of the materials which are used for making the tool or the electrode and they are the same as you use in case of macro-EDM process.

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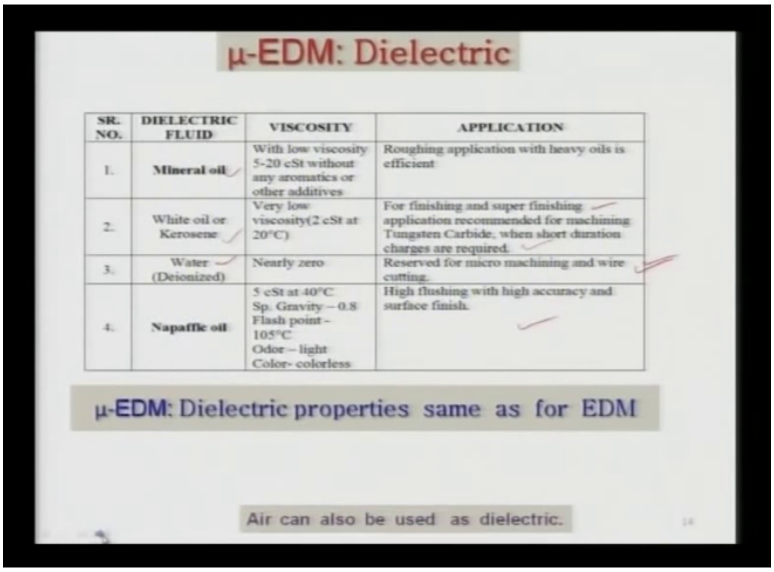


Then there are various kinds of the dielectric which are used in micro-EDM like mineral oil which has low viscosity and then roughing application with heavy wise is efficient. White oil or kerosene is very commonly used in the past; it was very commonly used in the past. It has very low viscosity so that it can easily reach to the complex geometry area or features, for finishing and super finishing purposes it is commonly used.

You can use tungsten Carbide when short duration charges are required when you're using the tungsten Carbide. Water again you can deionised water as dielectric and viscosity is very very low and it is reserved for micro-machining and wire cutting, this is very important to note that water deionised water invariably used for electric discharge wire cutting and also mostly used for electric discharge micro-machining. (())(21:28) Oil can also be used it as high flushing with high accuracy and surface finish. Air is also being used as the dielectric in macro EDM as well as in some cases of micro-EDM.

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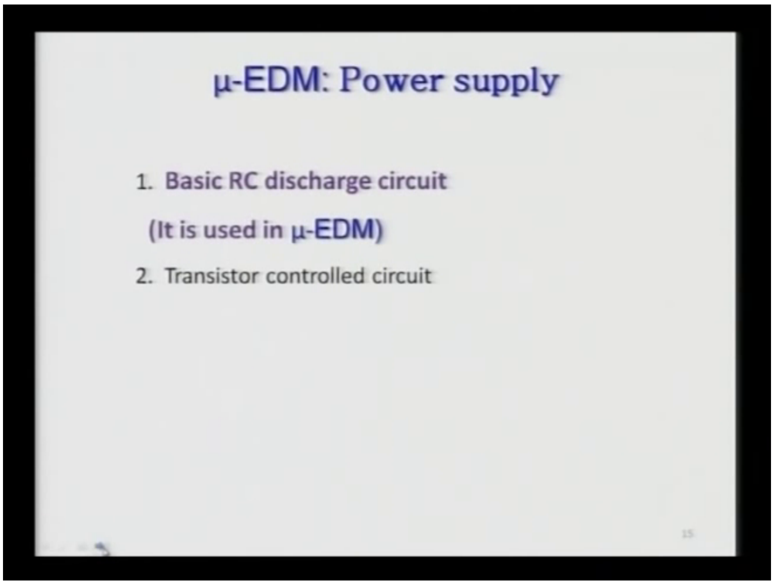


Power supply, normally in electric discharge micro-machining basic RC power circuit is used in the power supply and transistor controlled circuits are normally used for macro EDM but please note that initially it was only the RC circuit which were used in EDM process but later on researchers developed transistor controlled power supply and nowadays in EDM most of the cases you are using transistor controlled circuit for power supply.

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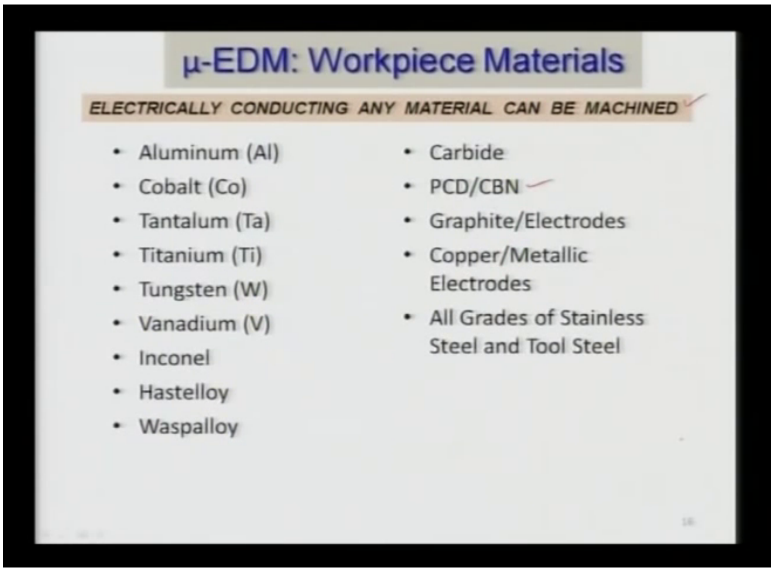


Again work piece material should be electrically conducting and all kind of work pieces materials which are electrically conducting they are listed here you can use them like aluminium, cobalt, tantalum, titanium, tungsten, vanadium, Inconel alloy, Hastelloy, Wasp alloy, Carbide, PCD poly crystalline diamond or cubic boron nitride that is a PCD or CBN, graphite then copper, metallic electrodes are used for the copper also and all grades of stainless steel and tool steel. Now the basic requirement here is as I have mentioned here at the top is that they should be electrically, so you can use them either for making the tool or as a work piece depending upon the designer.

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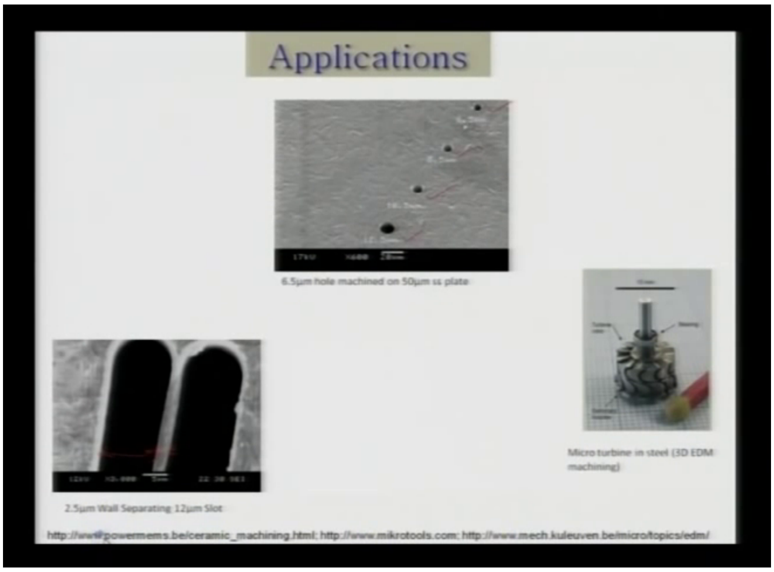


Now there are specific applications of this particular process. Now you can see here that 6.5 millimetre diameter hole is machined in the 50 micro-meter stainless steel plate and you can see the diameter 6.5 over here, 8.5 micro-meter diameters, 10.5 micro-meters and 12.5 micro-meters. Now 2.5 millimetre wall separating 12 micro-meter slot is there, this is the 2.5 millimetre wall and this is the slot which size is 12.5 micro-meter then here is a micro-turbine in steel this was prepared with three-dimensional EDM process.

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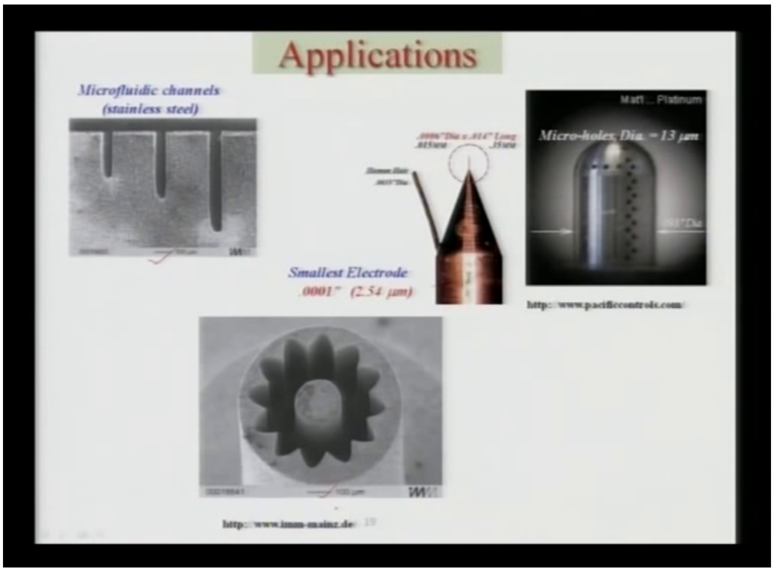


You can create the micro fluidic channels in stainless steel as shown over here and here is the scale that is the hundred micro-meters, so you can see the size of the micro fluidic channel. Now this is one of the very small size electrodes that can be used for micro-EDM applications and its size is 2.54 micro-meters as you can see there. Now here you can see the micro-holes that have been drilled, the size of the micro-whole is just 13 micron and you can see the enlarged view of the holes as well as the work piece. Now here you can see the internal gear that has been made and this is the scale.

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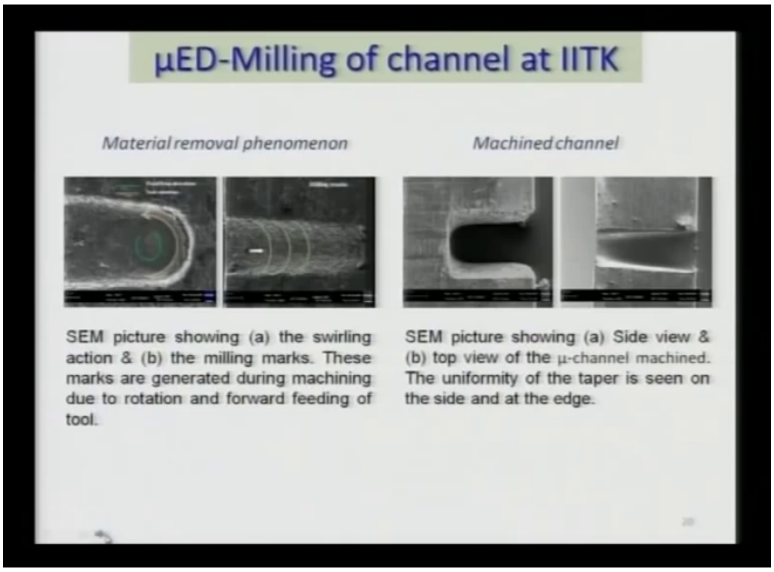


Now you can see SEM picture showing the swirling action and the milling marks these marks are generated during machining due to rotation and forward feeding of the tool. Again machine channel is there these are the SEM pictures.

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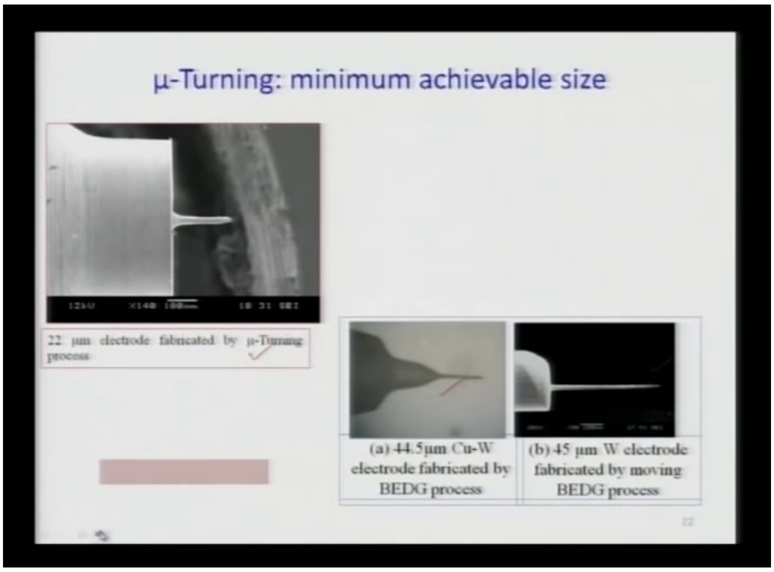


Now this is micro-turning with the help of which a tool is being prepared and this tool can be used for electric discharge micro-machining purposes. 22 micro-meter electrode fabricated by micro-turning process. Here tool is fabricated by the conventional micro-turning and this tool can be used for the purpose of electric discharge micro-drilling operation.

Again here 44.5 micro-meter copper tungsten electrodes is fabricated by block electric discharge grinding process here it is fabricated by electric discharge grinding, again this is also fabricated by block electrode discharge grinding process and the tool diameter is 45 micro-meter. So these tools can be used for electric discharge micro-milling operation also.

They can be prepared by BEDG process or micro-turning process and that can be used for electric discharge micro-machining of micro-drilling purposes

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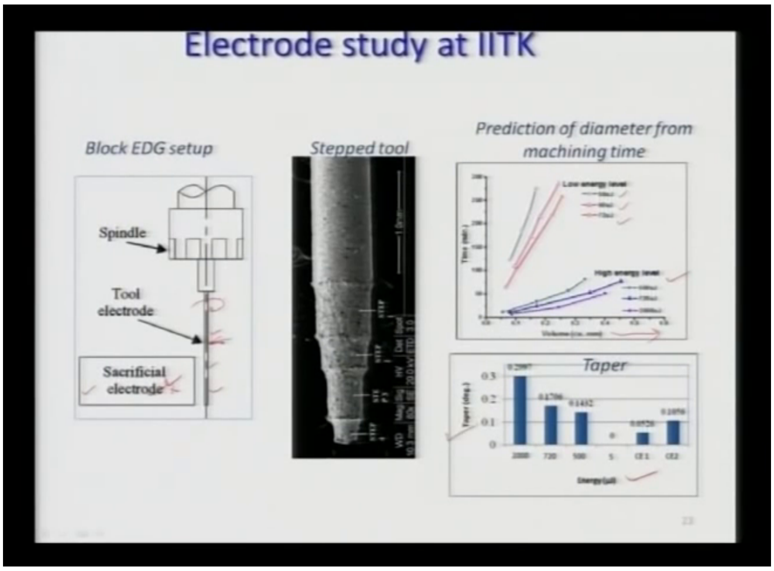


Now you can see BEDG process that is performed and some of the work has been done at IIT Kanpur. So you can see here, here is the tool which is being made and this is the sacrificial electrode, what you can do? You can keep rotating it the tool and bring this tool is very close to the work piece over here that is sacrificial electrode, so because of sparking the material will be removed from the tool as well as the work piece.

Now since the diameter is continuously reducing of the tool and it is rotating, so that you will get finally a proper diameter tool made over here. However this is a scrap kind of the piece that is named as sacrificial electrode which is used which is electrically conducting and it is used to create and it is used to create the sparking between the tool as well as the work piece. So here this tool which we are calling as the tool is working as the anode and this is working as the cathode.

In the same way you can prepare the stepped stool, you can see different steps have been created with the similar process. Now here you can see the time required and volume removed from the work piece material. If you have low energy level say 50 joules, 60 micro-joules, 72 micro-joules then definitely does going to take very long time to make the same feature, if it is a high-energy level 500 micro-joules, 720 micro-joules, 2000 micro-joules then definitely does going to take much lesser time to remove a certain amount of material that is given here on the (())(28:31). So this is the kind of the taper that you can produce while you are micro-drilling the hole with different kind of the energy level of the sparks that is shown over here and this is the taper that you are going to get.

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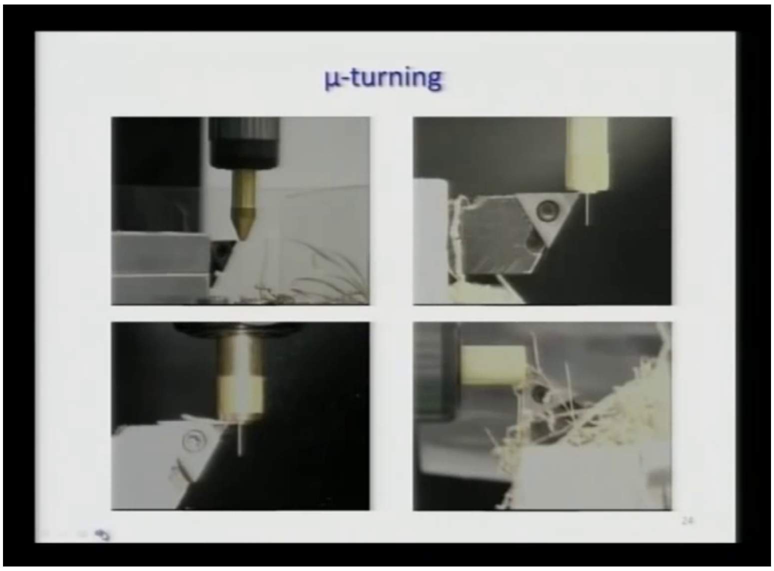


Now this is a conventional turning with the help of which you can prepare the micro tools as you can see 4 different phases, this is the micro-tool that is being prepared and later on these tools can be used for electric discharge micro-drilling operation.

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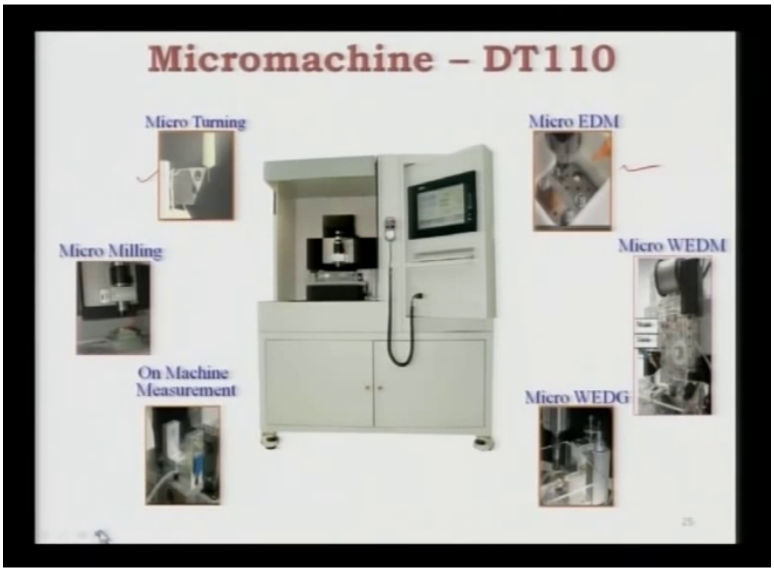


Now this is the electric discharge micro-machining or rather I should say micro-machining machine that is available at IIT Kanpur and its name is DT 110. Now micro-turning operation you can perform on this particular machine itself and that figure is shown over here then you can use the same machine for conventional micro-milling purposes, tool is here and this is the work piece this particular one and then you can do the milling operation over there.

Here is on machine measurement can be done then you can see micro-EDM process being performed over there. Here you can do the micro-wire EDM process and wire is running around and you can see and that is cutting the work piece into the desired shape and then micro-wire EDG electric discharge grinding operation is shown over there.

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Thank you very much, now Mr Kartike will give the demonstration of the electric micro-machining machine which has the features as I have shown to you in the last slide that it can do conventional micro-turning, conventional micro-milling and then it can do the electric discharge micro-machining. It can also do the electric discharge, soaring electrochemical micro-machining operations which I have not shown there, thank you very much.

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Welcome I will demonstrate the micro-machining facility at IIT Kanpur. The machine is DT 110 micro-tool which is capable of performing various operations which includes both conventional and nonconventional. In conventional operations processes such as micro-running, micro-drilling, micro-milling can be performed. In nonconventional operation processes such as micro-EDM, micro-wire EDM, micro-EDG and micro-wire EDG, block EDG can be performed.

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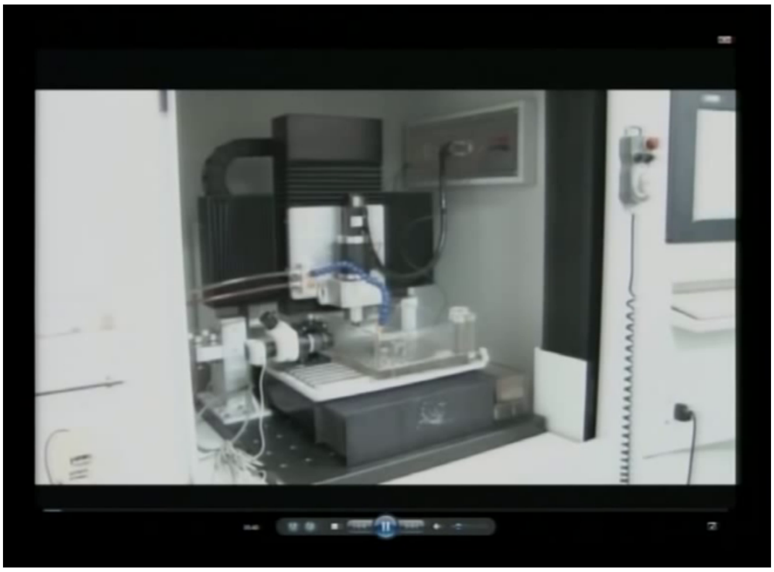

I will demonstrate the various features of the machine now. The machine has 2 tables, one is horizontal table and other one is vertical table. The availability of 2 tables makes the machine more flexible. The machine has 4 axes of motions; the axes are y axis, x axis, z axis and the rotational axis.

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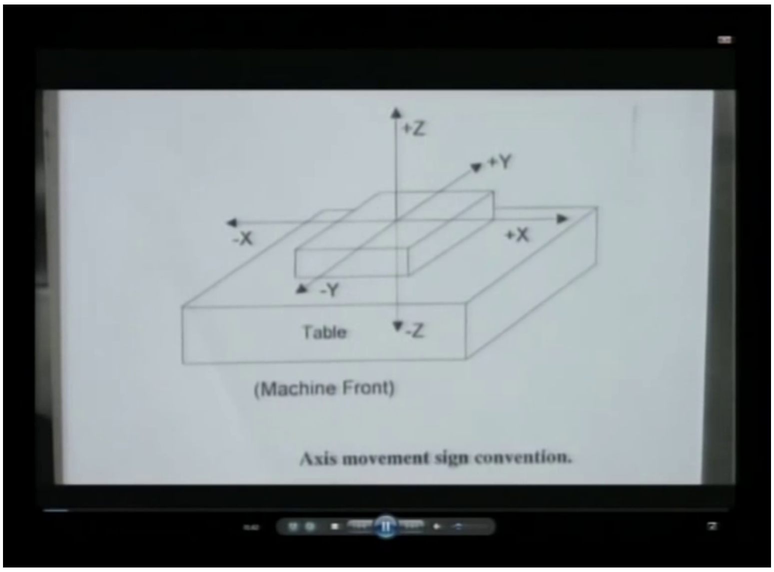


The direction of convention for all 3 axis is shown in a schematic diagram even though all the 3 axis are shown on a single table it is not so in the real machine. In the machine the horizontal table is controlled by y axis whereas the vertical table contains x axis and z axis as well as the rotational axis. The axis of travel for each axis is as follows, the x axis can travel the maximum distance of 200mm.

The y axis as well as the z axis can travel a distance of 100mm the accuracy of the 3 axis is plus or minus one micro-meter upon 100mm; the resolution is 0.1 micro-meters for all 3 axes. The repeatability is one micro-meter for all 3 axes; the fourth axis of motion is rotational motion.

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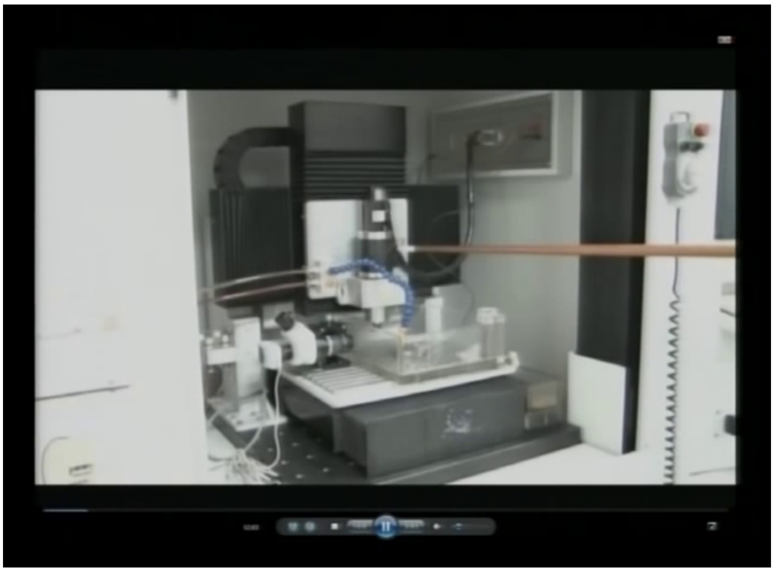

Rotational motion is performed by servomotor; the servomotor can rotate the spindle either in clockwise direction or in the clockwise direction. The speed of the symbol can be varied from one RPM to 5000 rpm. During EDM process since one of the electrode has to be electrical conductive the spindle is electrically isolated from the machine body. For EDM process to elements are very much essential one is the power supply another one is dielectric. For power supply the machine has 230 volts input supplied with 50 hertz frequency. For the feasibility an EC assessing of the electrodes to the power supply, a power board is kept closer to the table.

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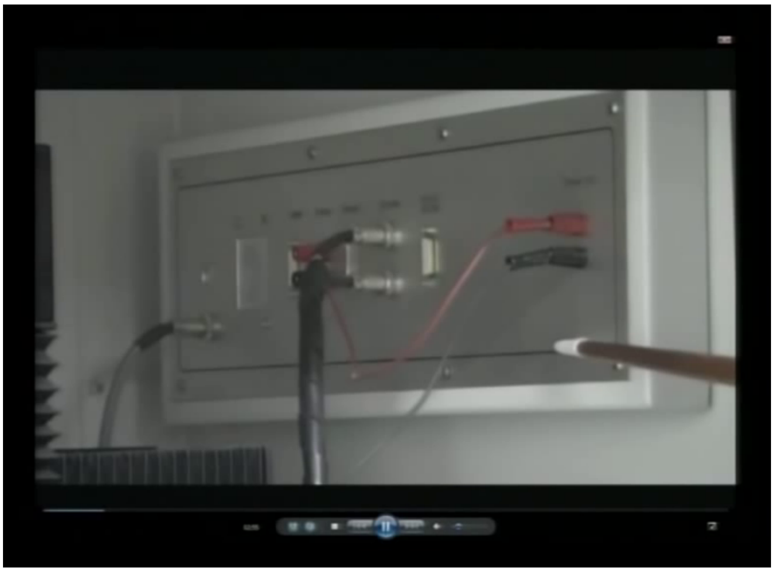

This powerboat contains a port for EDM, port for by wire EDM, port for spindle, port for touch probe and port for OMM. The other element of EDM is dielectric; the machine has very good dielectric circulation system, the dielectric from the tank through the pump filter and enters to the nozzle through a regulator.

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Regulator controls the pressure of the dielectric fluid. The fluid from the pump goes via regulator to the nozzle to the time. The regulator controls the pressure of the fluid. The fluid as enters into the tank will get filled in the tank till a certain level is reached. Once the level is reached the dielectric, it overflows through this wall to another time which i contains the filter.

All the debris which are formed during process is filtered in this filter under filter dielectric will enter into the tank which is under the table. In this way the dielectric is re-circulated continuously during the process ensuring fresh dielectric for the process.

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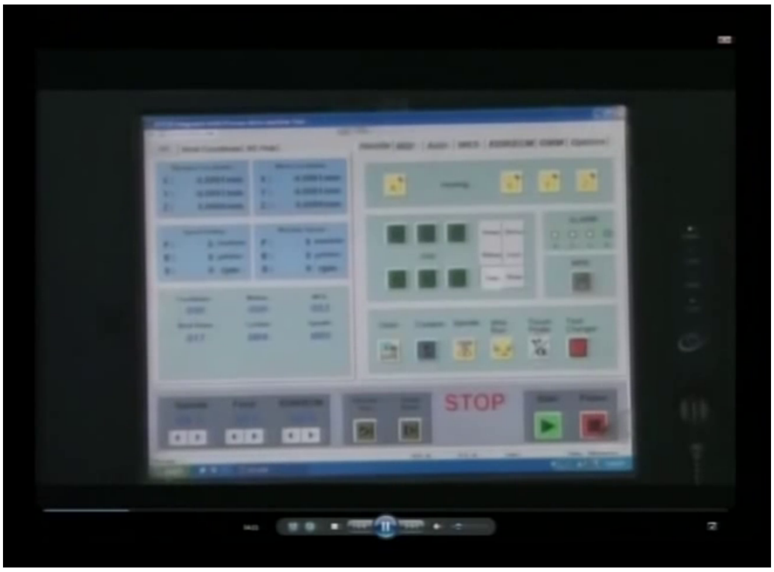


Now I will demonstrate the Control Panel of the machine. This portion of the Control Panel is the display part which shows the machine coordinates, the work coordinate, the speed setting and the machine sitting. The machine coordinate refers to the machine origin point that is machine well coordinated system. The work coordinate refers to the origin point on the work surface.

The other side of the Control Panel contains various switches which operate various parts of the machine, the first part is called honing and this is used to initiate the machine. When the machine is switched on the honing operation is performed, so that the machine works without any error. This operation is called job mode this is used to move a particular axis in either positive direction or negative direction to a specific value.

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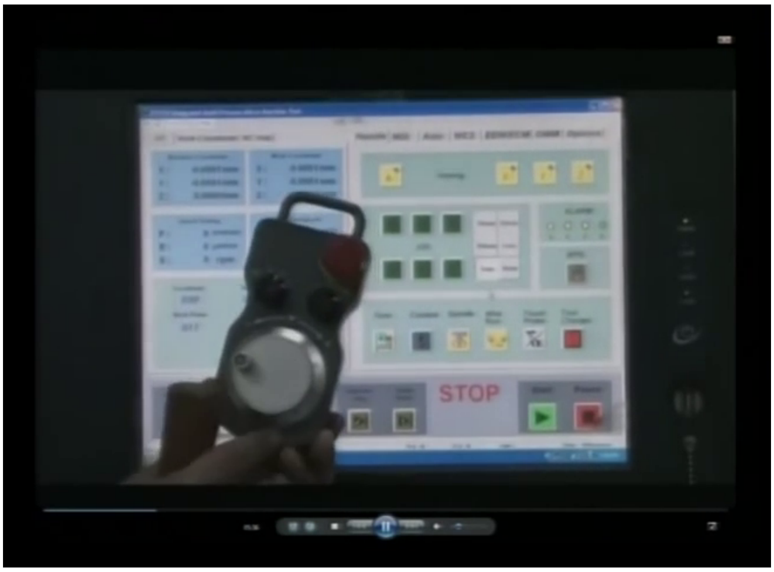


6 different specific values are available for job mode, the third switch is MPG this is manual pulse generator. A manual pulse generator will operate by a device which is interfaced with a controller. The device is as shown here. The fourth command in the front panel has 6 options. All these are 6 different switches which performs 6 different operations. These 3 options are used to change the value of speed, feeds or EDM feeds during operations, that is during execution of programs the speed or the feed or EDM can be varied with certain percentage.

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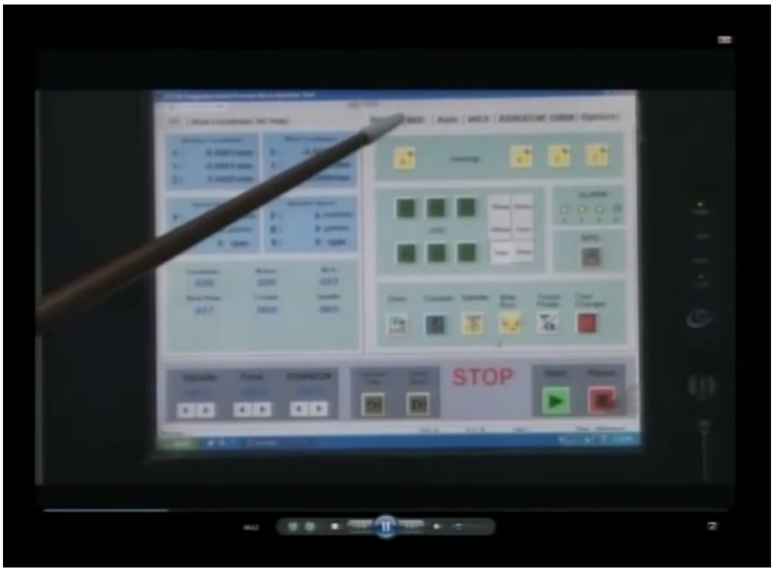


The next window is MDI. MDI is manual data input, this window will help the user to execute a individual block of command, the third window is auto, this is the window where the program is executed. Here there are 4 options given for the user, to open a new file, this is to open a file which is already available in the library, it is to save the file, it is again another option for saving a file in different name.

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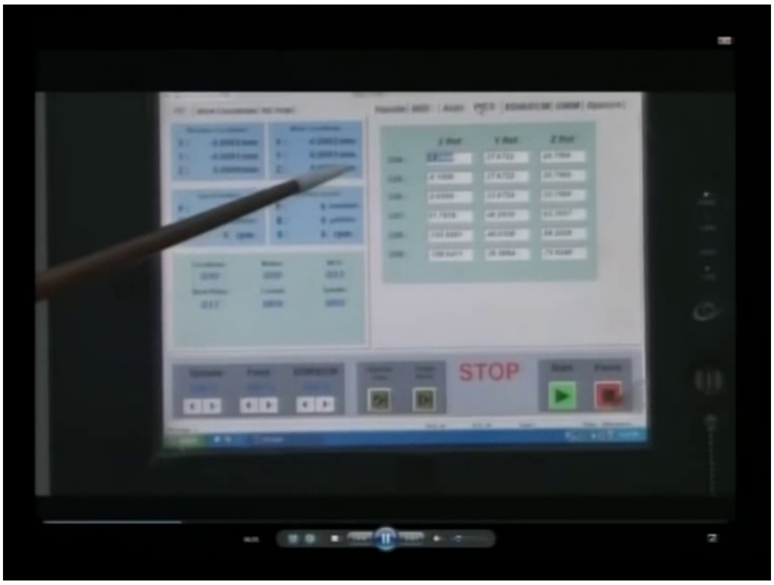


The next window is the WCS. WCS refers to world coordinate system, in this machine there is feasibility for having 6 different origins on the work piece. So the origins can be G54 to G 59. Each G code will have a corresponding point which is called P1. So G54 is called by P1, G 55 is called by P2, G 56 is called by P3 and so on and G 59 is called by the 6. So by calling these points the present point will be converted into an origin which is of 6 different values. So by this user can set 6 origins on the work piece surface and these origins can be called during the program.

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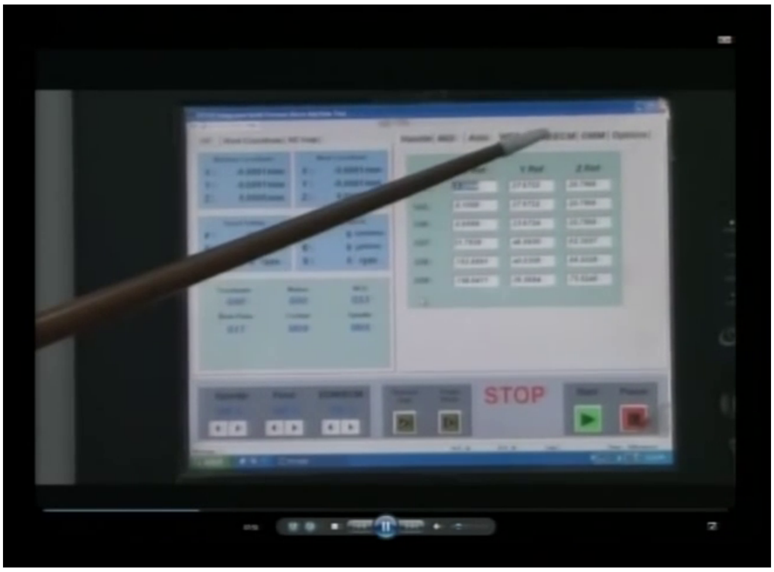


The next window is ECM; this window will help to set the parameters used for the process. In EDM as it is well-known for RC circuit the parameters are voltage, capacitor, polarity and threshold. The Voltage can be varied from 80 volts to 140 volts. The capacitance has 5 different values which can be 10 picofarad, 0.2 nano farad, one nano farad, 10nano farad, 0.1 micro-farad, 0.4 micro-farad.

5 different values of parameters can be set simultaneously and called in the program. These are represented by M codes which are M211, M212, M213, M214, M215.

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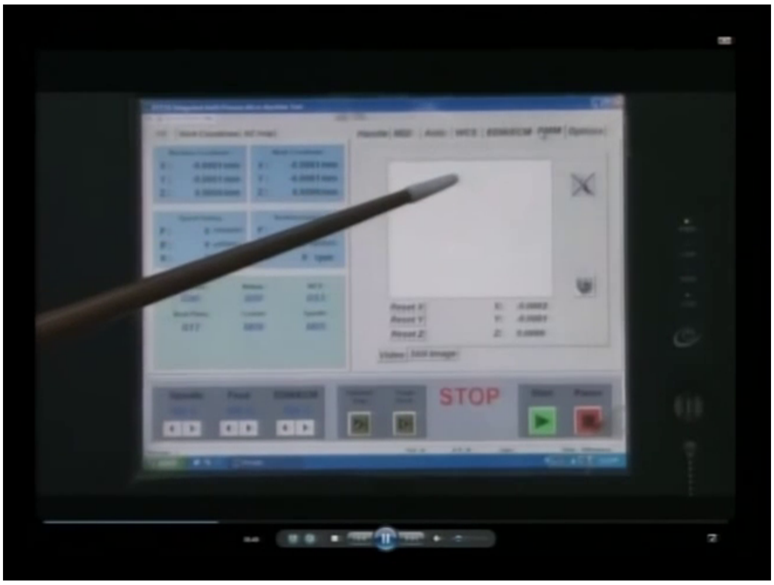


The next option is OMM online machine measurement option using this window the camera can be interfaced to the controller, whatever image recorded by the camera can be seen in this window.

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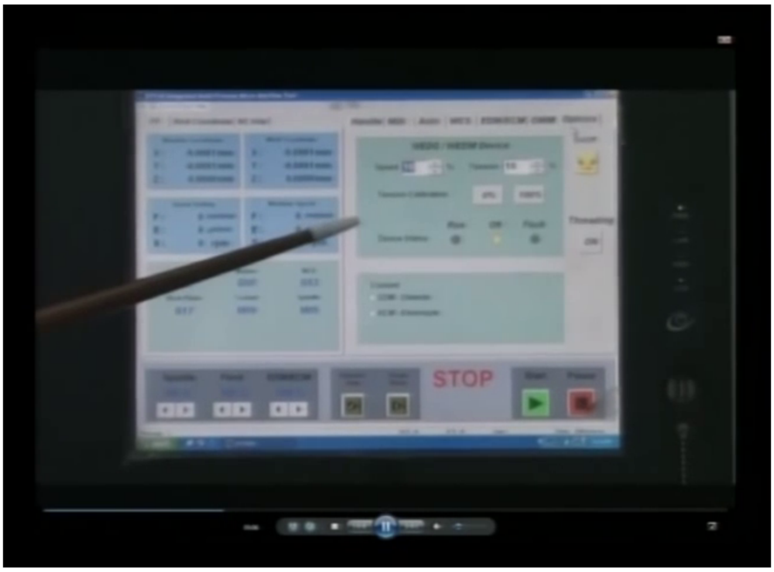


The last option is, this is to set wire EDM parameters. The parameters are the speed and the tension. Another box available is for coolant. Here the dielectric is chosen for the process. So these are the various features of the Control Panel of this machine.

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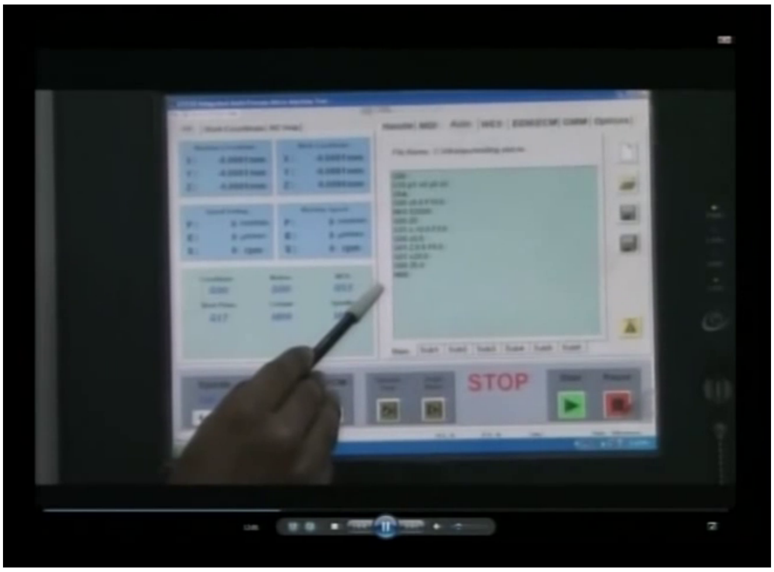


Now I will demonstrate an example of a program. Open, this program is used for making a slot in conventional building process. The command starts with G90; G 90 refers to absolute mode, G10, P1, x0, y0, z0, G54 this command is used to set the present position of the tool as the origin point. G00 shows the rapid transverse motion through G00 (())(40:56) is lifted by 5 MM from the origin.

M03, S 2000 is to rotate the tool with 2000 rpm in clockwise direction. G 00, z0 will bring the tool back to the 0 position in a rapid transverse mode. G31, is it minus 10.0 F3.0 is a touch probe command, in this command the tool moves down to maximum of minus 10mm till it achieves the work piece surface when this tool touches the work piece surface due to short-circuiting the motion stops.

This senses the 0 point on the work piece surface. G00 is a 0.5 it lifts the tool back to 0.5mm in rapid mode. G01 is at minus 0.5, F5 this is a linear interpolation motion where the tool moves down by distance of 0.5mm in downward direction. G 01 is at minus 0.5 F5 this is linear interpolation in z-axis which makes the tool to move at depth of 0.5mm.

G 01, x20 this is again a linear interpolation in x axis direction this makes a tool to cut the work piece along the distance of 20mm in x axis. G 00 is at 5 is a rapid transverse mode where the tool is lifted to 5 MM from the origin. M05 which will switch off the spindle motion and the program. So these are the blocks by which a program is executed in any process.

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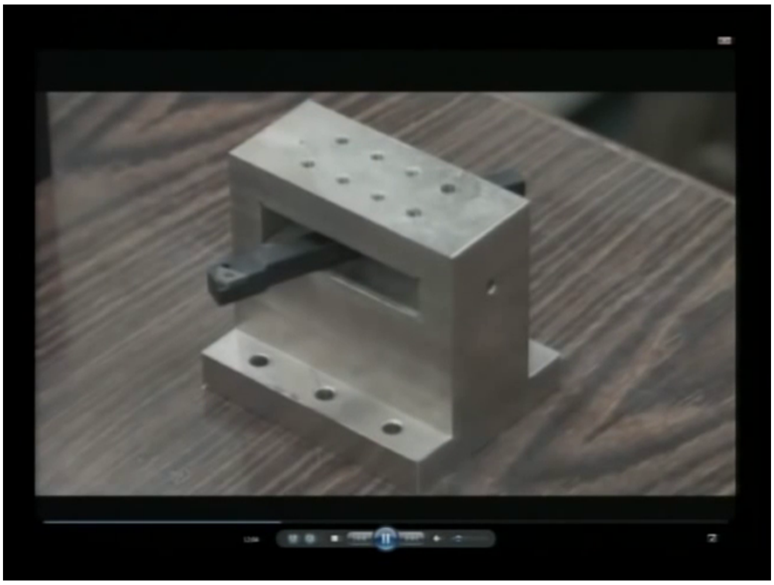

Now I will demonstrate the various processes which can be performed in this machine by explaining the attachments. The first process which I am going to explain is micro-turning. Micro-turning as a single point cutting tool and the tool post.

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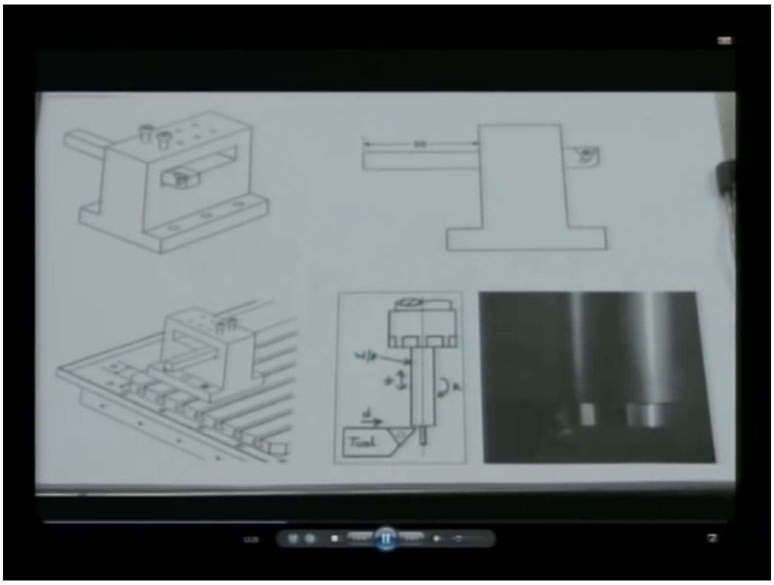

In Micro-turning the tool is fixed in the tool post like this, these are the screws which held tool and the tooltip portion is upward. It should be fixed such a way that 50 MM of the tool should be outside this and the cutting zone should be kept closer. The fixture and the tool are assembled on the machine horizontal table like this. In this operation the work piece is fixed in the spindle and the tool is clamped on the table.

The work piece rotates and it is even with the feed motion where as the tool is at only with depth of cut, this is slightly different from the conventional machine where the feed as soon as the depth of cut is given on the tool. This diagram shows the turning process during machining in the Micro tool machine.

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The next process is micro-milling or micro-drilling. In both the process the work piece is fixed on the fixture, this is the fixture. The tool is held in the spindle via a collet, these are hundred micro-meter cutting tools for milling or drilling operation.

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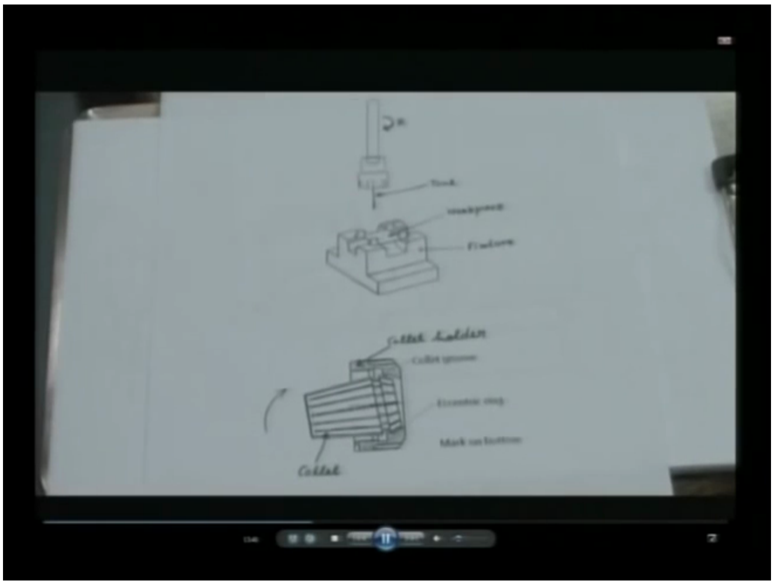


A schematic diagram for the milling process is as shown. Here this is the spindle which contains the milling cutter. The work piece is fixed on the fixture which is shown before. The tool is rotated and the operation the xyz motion is being performed through the program. This is a spindle collet holder the tool is attached to the spindle by means of a collet. The collet and the collet holder assembly or to which helps in holding the tool to a spindle. The collets are available of different sizes based on their size of the shank portion of the tool.

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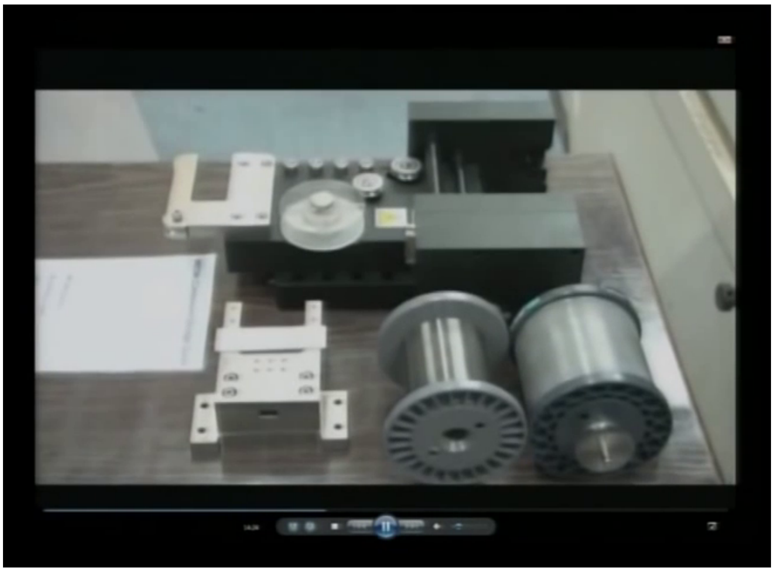

The next process is wire EDM, this is the setup for wire EDM process. This shows the wire which is used for the wire EDM process, this is the fresh wire and this is the used wire. This is the fixture which is used to plan the work piece. The work piece will be a thin plate and it is clamped by means of a screw or a magnet between these 2 points. So that the wire can easily travel in this area without touching the fixture.

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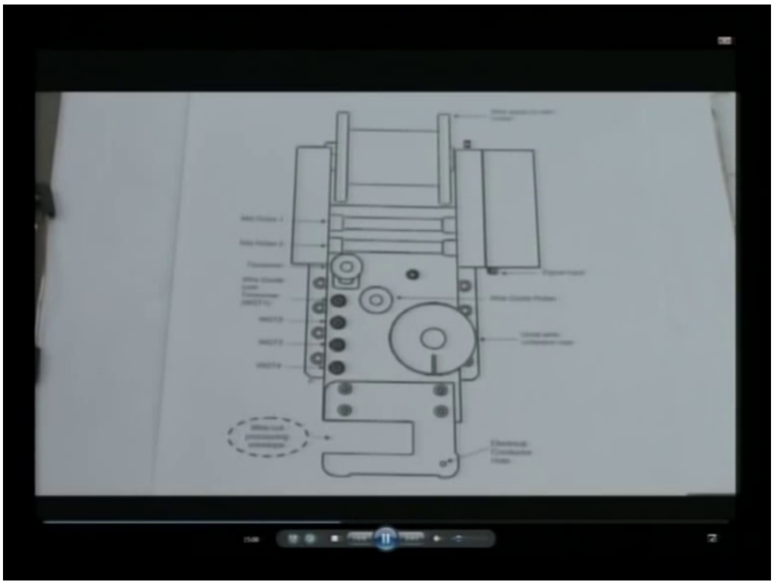

Now I will demonstrate how the wire is connected to the fixture here. The schematic diagram for wire EDM process is a shown. Here this is the portion where the spool is fixed these are 2 mid roles this is another guide roller, this is the tensioner, these are 4 guide rolls and this is a portion where the provision is given for the wire to freely move in contact with the work piece.

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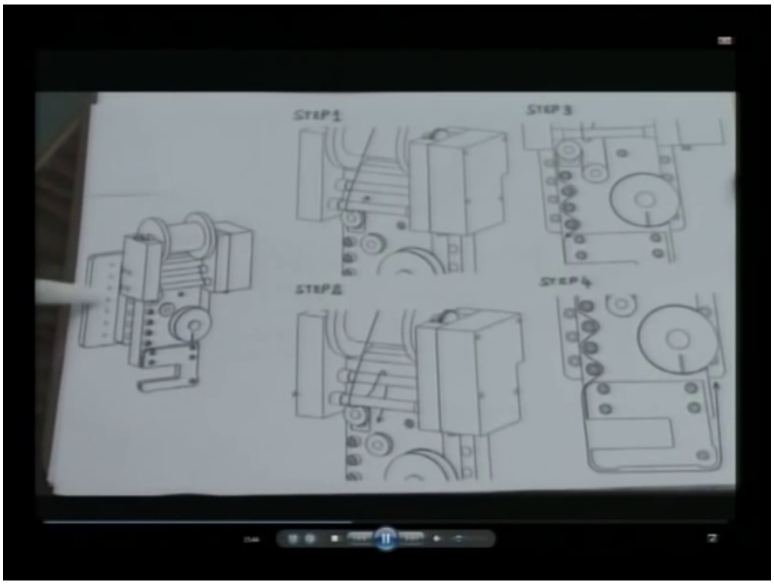


This is the take-up roll, this wire EDM setup is fixed on the vertical table of the machine. Once it is fixed these 4 steps are used to connect the wire from the spool to the take up roll. The steps are visibly seen in the figure. So through the mid roles then the tensioners then wire comes like this to the bottom portion and it passes like this to the take up roll. Now this wire is freshly available to be in contact with the work piece.

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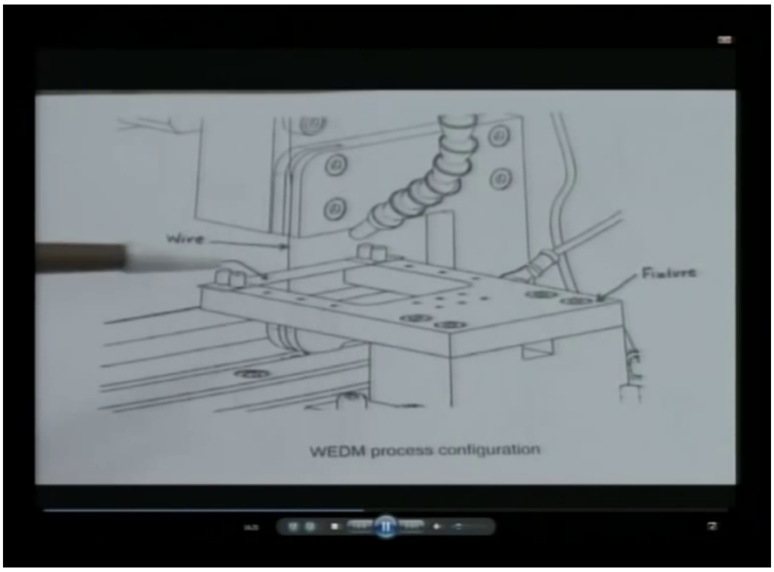


This diagram shows the contact between the work piece and the tool. So this wire EDM setup will as a wire which is continuously moving from the spool to the take-up roll and the work piece is contained in the fixture. So the wire comes in contact with the work piece edge and the required profile is being cut on the work piece. For wire EDM process another wire can start from the edge of the work piece or a predefined hole is required on the work piece, so that the wire can be inserted into that hole and process can start from that hole.

In this way either a profile can be cut from the edge of the work piece or from any centre point of the work piece.

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The next process is wire EDG, this process is basically used to cut the tool. It is like a turning process. A setup for wire EDG is as shown.

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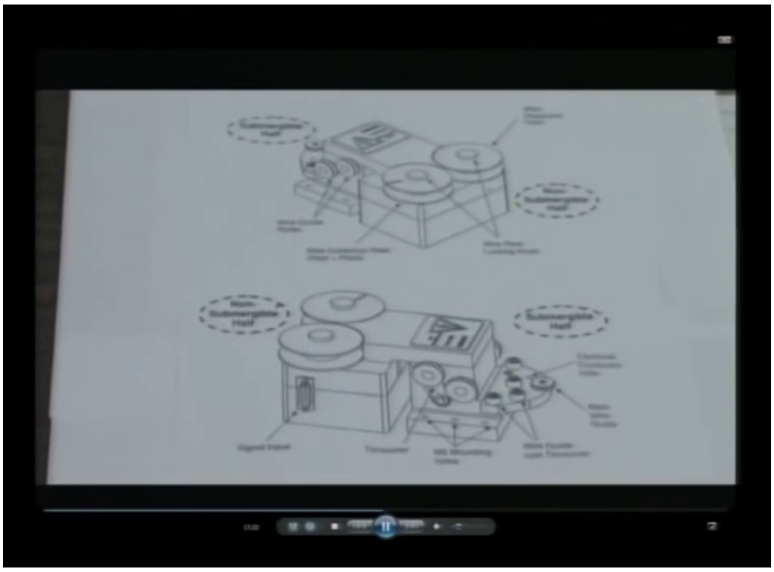

A schematic diagram of wire EDG setup is shown now. Here this is the feed roll, this is the take-up roll the wire from the feed roll is passed via tensioner through the wire guide to the main guide and again it is passed through another wire guide to the take up roll. This port is to connect the wire EDG setup to the power supply.

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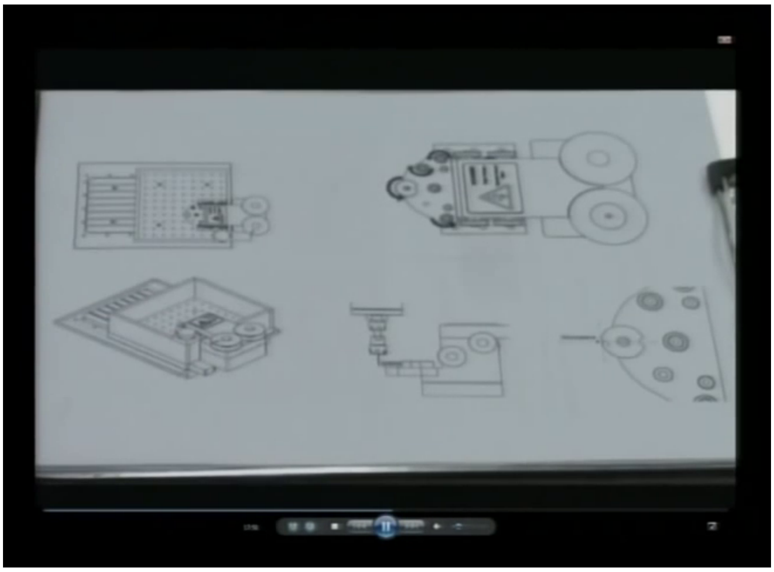

The wire EDG setup is fixed on the horizontal table which is different from the wire EDM setup. Here the wire EDG setup is fixed such that a part of the set up is outside the tank and the part of the set up is inside the tank that is the portion where the machine is going to take place is submerged inside the tank and the portion where the motor is there to guide the rollers is away from the tank.

The process happens such a way like this, the tool which is now the work piece is fixed on the spindle and rotator. Now the objective of the process is to reduce the diameter of the tool. To reduce the diameter, the tool comes in contact with the wire electrically. Same as EDM process the tool material is removed and thus the tool is turned to a specific diameter, through this process parameter of tool as small as 2 micro-meters can be generated.

This diagram shows the major wire guide, the initial diameter tool should be lesser than this curve which is approximately 4 MM. So any tool of initial diameter of 4 MM can be reduced to a diameter of 2 micro-meters by wire EDG process.

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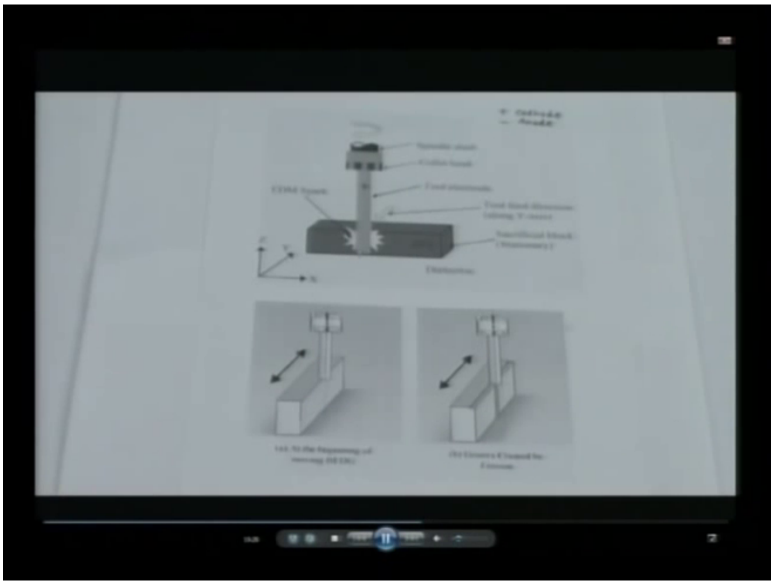

The next process is blocked EDG, this process is again used to turn the tool. The disadvantage of the previous process that is wire EDG process is it consumes a lot of time and the wire once used cannot be reused. In other case this block EDG process is much faster, the tool which is again the work piece here is fixed on the spindle and rotated, this is a stationary sacrificial block.

The tool is made to rub against the block electrically, it’s again an electrical process wherein the tool which is the work piece is positive charge and the block is negative charge. Since Positive is cathode the material is removed from the tool thus a tool diameter is reduced by this process from any initial diameter, a diameter of 10 micro-meter can be achieved. In block EDG process either tool can be stationary rubbing against the block or it can be made to vibrate.

The advantage of vibrating the block or vibrating the tool is it will reduce the wear on the block therefore the amount of material removed will be directly proportional to the material removal from the tool.

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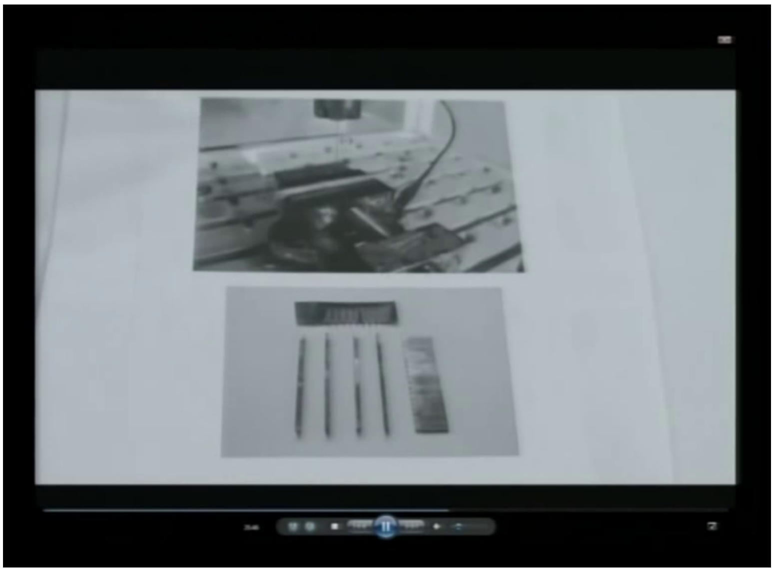

The next process which I'm going to explain is micro-ED milling. In micro-ED milling the tool is fixed on a spindle and rotated. It is negatively charged, the work piece is clamped on the fixture onto the table. So during machining operation the cylindrical tool is made to move in along 3 different axes, x, y, z. The figure shows a channel machining where the tool is made to move only along y axis.

So while micro-EDM milling any complex shape can be generated by simple cylindrical tool. These are the channels which are fabricated at IIT Kanpur or EM 24 material. The tools used for transformation is shown here, this concludes the various processes which are possible this machine.

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The setup shows a block, a work piece and the tool, using this setup the tool can be first turned by using block EDG process and the machine you told can be used in the work piece for cutting the channels of different dimension. The tool is rotated it is moved towards the block now. The spark is initiator; this spark will remove the material from the tool. In block EDG process as I mentioned earlier the tool is positive and the block is negative. So the maximum amount of material will remove from the tool.

Now once the tool is ready it is positioned to the work piece. Now the polarity of the tool is changed to negative and the work piece becomes positive this is the straight polarity. Now the tool of different diameter is moved towards the work piece. Now Spark has been started, now the material is removed from the work piece this is the advantage of this process. Simultaneously tool can be prepared from the block and can be used for the work piece to machine.

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Now I've shown you a small demonstration of the facility in IIT Kanpur, through these facilities various operations can be performed as I have shown you. Hope this presentation will give you some information for your future work, thank you very much.