Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 2

Module- 26
Introductions of Electro-chemical Drilling Process

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Hello and welcome to this manufacturing process technology part 2 module 26.

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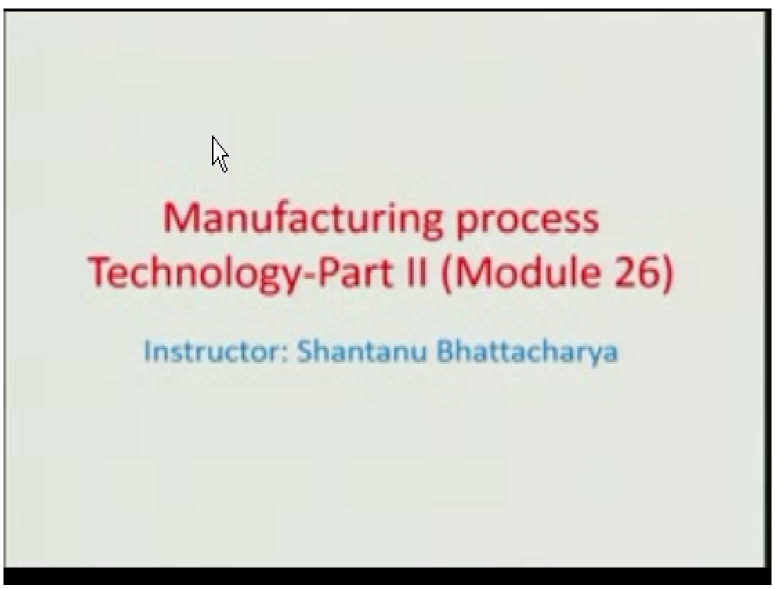

I was discussing in the last module about the ECM process and then today we are supposed to discuss about some additional processes which are directly or indirectly related to mechanical and electrochemical removal material removal.

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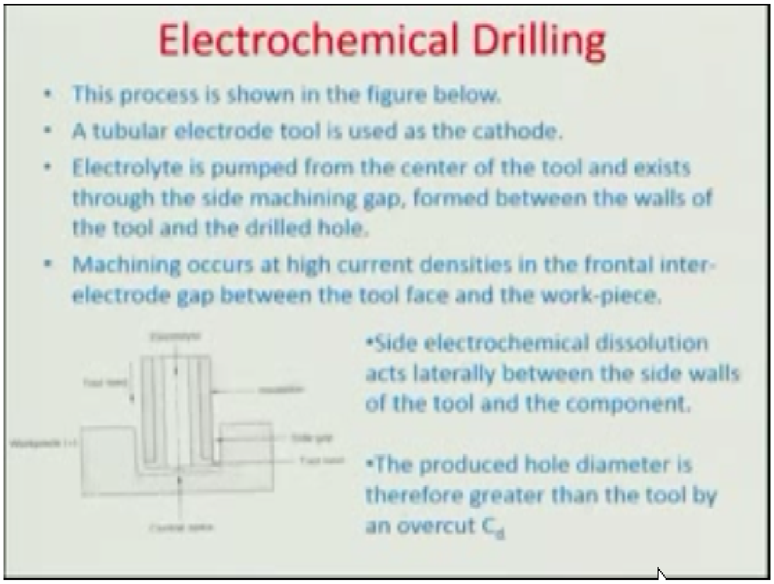

So the first process which comes to my mind when we talk about such associated processes is the electro chemical drilling the process is shown in the figure here right here there is a tubular electrode which acts as a tool and is normally used as a cathode the principles behind the process are very much same as ECM electro chemical machining only thing is it is a high aspect ratio drilling that we are executing using the CM process or electrochemical material removal process.

The electrolyte is pumped from the center of the pool and it exists through the side machining gaps so basically the electrolyte goes in this direction and in this direction and it is formed between the walls of the tool and the drilled hole machining occurs at a high current density in the frontal inter electrode gap between the tool phase and the work piece since electro chemical dissolution acts late early between the side walls of the tool and the component.

So the produced whole diameter will be obviously node or greater than the tool diameter so you have some kind of gap or tolerance between the final diameter and the tool even though the tool is insulated or well insulated so that is what electrochemical drilling is.

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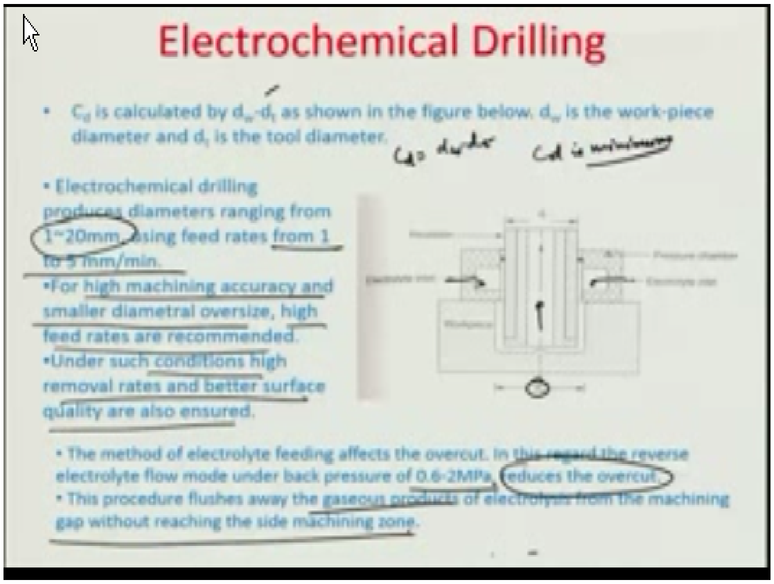

So CD can be calculated by looking at what is going to be the final work piece diameter and what is the tool diameter so CD is basically DW-DT and this process produces diameters ranging from about 1 to 20 millimeters feed rates are extremely small varying from 15millimeters per minute for high machining accuracy and smaller diametric over size high feed rates are recommended and under such conditions high removal rates and better surface qualities are also ensured.

So you could also have a reverse flow system where the electrolyte is generated from an outside region through these electrolyte chambers and it goes into the main workspace and goes back through the center channel of the two these are normally generated to create the backpressure the back pressure can be varying from 0.62 mega Pascal and back pressure is normally given to ensure that the total amount of over cut is reduced you know the CD is minimum.

So that is how the gap between the final diameter of the workpiece on the tube diameter can be controlled also because of the high pressure there is a tendency of the gases or the gaseous products which are generated in this region because of the presence of hydrogen etcetera to sort of go out of the machining region without really affecting the machining zone very much because obviously if the pressure is of the pressure of infusion of the electrolyte is high there is a very limited possibility of death of hydrogen that may happen.

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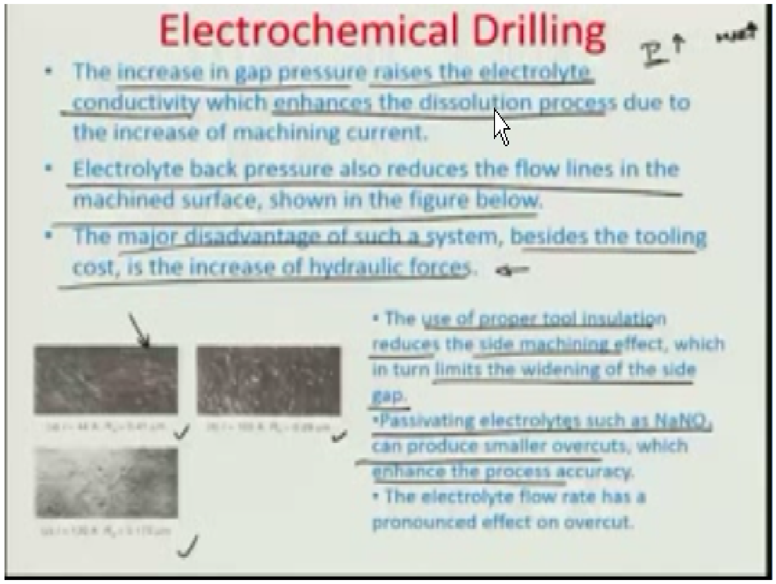

So the increase in gap pressure obviously because the hydrogen has been now eliminated would raise the electrolyte conductivity and this would enhance the dissolution process so therefore if we were to plot there is a directly sort of proportional rise of the mr are if the pressure of the electrolyte feed is increased in the machining zone the electrode back pressure also reduces flow lines in the machine surface.

You can see for example here the different surface roughness which have been mandated because of the ECM process and if you were to operate on a higher pressure these lines which otherwise come because of the resolution on the direction of the electric flow would get minimized the major disadvantage of such a system beside the tooling cost is the increase of hydraulic forces.

So they may need to warping cetera of the tool holding if we wanted to do electrolyte back pressure further I like the use of proper tool insulation reduces the side machining effects which in turn would limit the widening of the gap at least over and above the working zone there is at least major portion of the tool which is covered or insulated I think I had given this illustration here the installation starts somewhere here in this particular region and below it is still the tool material okay.

So it helps to some extent in reducing the overall taper which might otherwise be obtained if there were no installation and as such passiveting electrolytes such as sodium nitrate can produce small over cuts which enhances the process accuracy so overall we can conclude by saying that in electrochemical training processes the back pressure is of substantial importance in the electrolyte flow rate may be able to produce a pronounced effect on the overall over cut size etc.

And in fact if you reverse flow the electrolyte at a certain pressure it has been found that the CD value or the lower cut value can be minimized quite a bit because of the controlled machining rates that so happen so the machining current that that actually comes up really is a function of the total tool feed rate if the tool feed rate is I the machining current would increase sort of proportionally and there is also a possibility that there may be sparking because think of it that if the electrode is approaching the workpiece.

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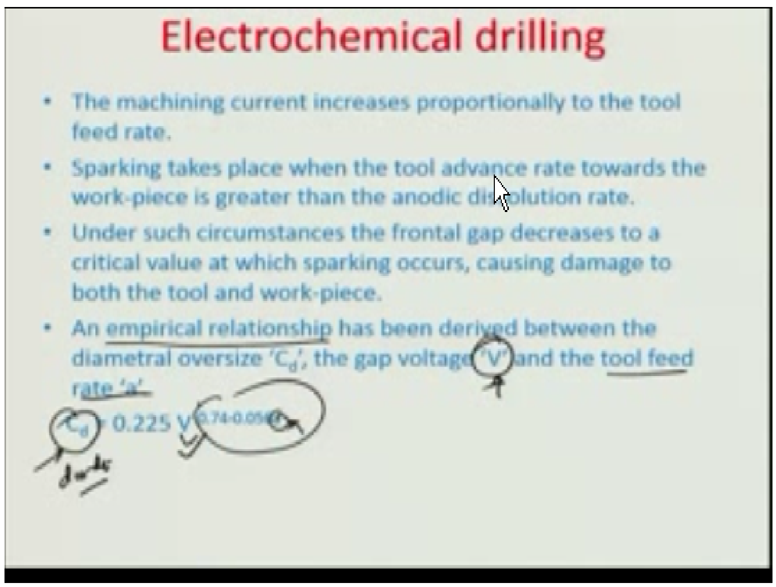

And there at this happen sat certain let us say at once rate of let us say some kind of a you know the rate of gap closure the electric field also apparently is increasing and so if supposing there is a breakdown in the electrolytic media which may happen and a certain small gap value there canal ways be at a very minimal gap a spark that is created and this spark may be damaging as such and therefore it is always better to avoid such parks which may be bad for the overall electrical system that is supporting the electrochemical operation.

So there is an empirical relation obtained by researchers which has been able to correlate this diametric gap DW - DT as I had shown earlier with respect to the total voltage which is being applied so this is the electrochemical voltage that is being applied and the tool feed wait a at which the process of you know may happen and so if the is high if the tool feed rate is I so obviously the gap would be higher because the V to the power of 0.7 4 - 0.05 6 A in that event would be higher and vice versa.

So you must try to optimize the tool feed rate in electrochemical drilling process it is a very important parameter to be controlled apart from the overall electrolyte pressure that is existing.

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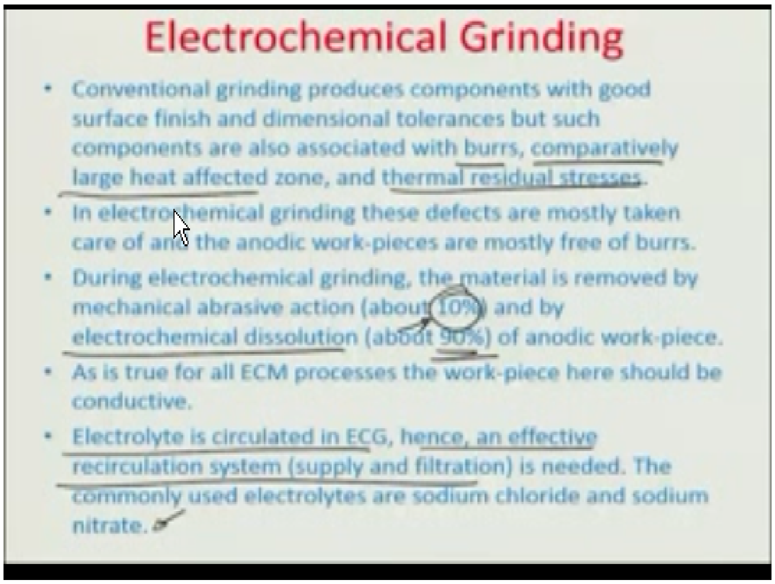

So we can also talk about another application of the electrochemical machining which is about electrochemical grinding so this is the process again we are part of the job is done through mechanical action of the small abrasive grains which are there on the surface and a major part of the material removal takes place because of electrochemical dissolution so the electrochemical grinding is little different from the normal grinding process.

Which is basically used to produce normally components with good surface finish so conventional grinding produces components with good surface finish and dimension tolerances but also such components are associated with some burrs comparatively larger heat effective zone maybe some thermal residual stresses which may be always there because of the ill effects of the grinding origin.

So one of the main advantages of the ECG or the electrochemical grinding processors is that you have a butter free work surface which is produced because of the way that the material is being removed by partial resolution and partial mechanical action so the abrasive action in an ECG process is only about 10% in terms of its contribution to the overall material removal rate what is more important is the electrochemical dissolution part which contributes to about 90% of the material removal.

And how it happens is again the way that the ECG process is developed and the way that the wheel approaches the workpiece okay when such electrochemical grinding is carried out so obviously the electrolyte also has to be circulated in this case in the ECG process and hence an effective recirculation system with the supply and filtration needs to be developed and the commonly used electrolytes are again sodium chloride and sodium nitrate as have been used in any other machining operation as earlier.

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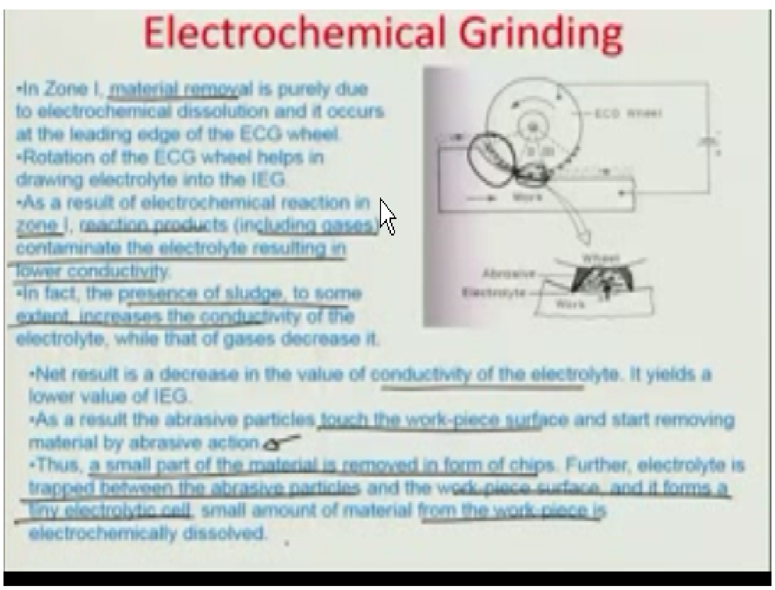

The ECG process is sort of represented in this figure right here you have a grinding wheel as you can see which is more on the similar to the conventional grinding wheel except that in this case the material which bonds these grains which are sticking out of the declining wheel is conducting in nature okay so I can say that the bonding of the abrasive grain is electrically conducting electrolyte is normally flown through the IEG the inter electrode gap.

And in this case as you can see the wheel is rotated in anti-clockwise direction with respect to the workpiece and the height of the abrasive particle protruding outside this for example is the height that is protruding outside bonding material of the wheel helps in maintaining a constant IG because the oppressive particle sort of act as spacers and you know there are typically three rooms in such ECG processes the any I am which machining is normally taking place can be divided into a pre zone.

You know where the pre zone which is typically the material normal mechanism in the pre zone is mostly electrochemical and the rotation of the wheel helps in you can say drawing the electrolyte from this zone 1 into drum2 where there is a partial mechanical partial electrochemical dissolution which is taking place in fact the advantage of the zone 2 is that whatever deposits have happened in zone 1 because of the resolution and the material coming out of the electrolyte and as a result of which the deposit formulates along the surface of the workpiece.

Herein this zone the mechanical action from the grains which are now touching in the zone 2 may create a carry forward or maybe scratching of the deposited material on the zone 2 so as the result of electrochemical reaction in zone 1the reaction products including gases contaminate the electrolyte and that generally reduces the conductivity in zone 2 so there is also a sludge deposition to some extent which may increase the conductivity further and as a result you know there is a net decrease in the value of conductivity and value of material removal rate in zone 2.

However the abrasive particles in this particular case touch the work surface and start removing the material by impressive action while the electrochemistry is going on between the per piece on the conducting material of the bonded V in fact what happens is that if the zone 2 there are small cells which are formulated you could see these clothes cells which are packed with electrolyte okay.
So on one hand the abrasive grain tips or the sharp corners of the grains are sort of grazing on the surface and trying to remove the deposits of the sludge on the other hand there is also a resolution of the sludge into the pocket which is formulated between the wheel in the workpiece so there is a part a small part of the material is removed in form of chips and further the electrolyte stop between the impressive particles in the work piece surface it forms a tiny

electrolytic cell where small amount of material from the workpiece is electrochemically dissolved.

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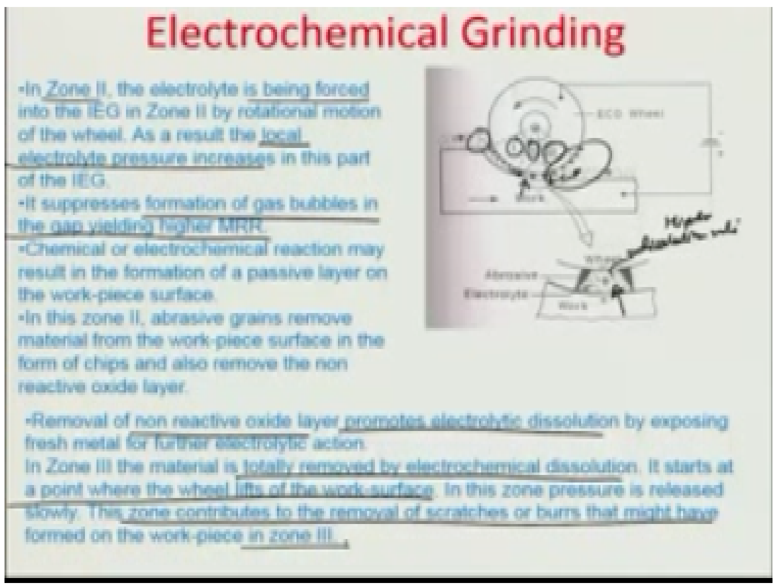

So in zone 2 you can also say that the electrolyte is being forced because obviously there is a carry forward of all this electrolyte which is pumped in this IEG regenerate electrode gap from zone 1 and all the residuals also are going to flow in the zone 2 so zone 2 by rotational motion of the wheel sort of pulls in the electrolyte from zone 1 and there is a tendency of the increase in the local electrolyte pressure in this part of the inter electrode gap.

So one thing which is interesting here in this case is that because of a self increase in the pressure value the dissolution levels of the hydrogen may reduce because it may simply out gasps the hydrogen so it suppresses the formation of the gas bubbles in this gap and that may result in a higher resolution rate sometimes in this zone two.

So there is a high resolution rate there is also a mechanical action in the zone two also important is the fact that because of the mechanical action the nonreactive oxide layer which may sometime get deposited here because of sludge from the previous zone it may promote electrolytic dissolution further by exposing fresh metal to the electrolytic action so next is 13 in the line and in zone 3 the material is totally removed by electrochemical dissolution obviously.

Because there is no other contact mechanism or mechanical abrasion mechanism it starts at a point where the wheel lifts off the work surface okay so typically this particular point here there is noncontact anymore between the grains and the work surface. and there is a sudden depressurization in this particular zone which may lead to the fast carry forward of whatever sludge etc.

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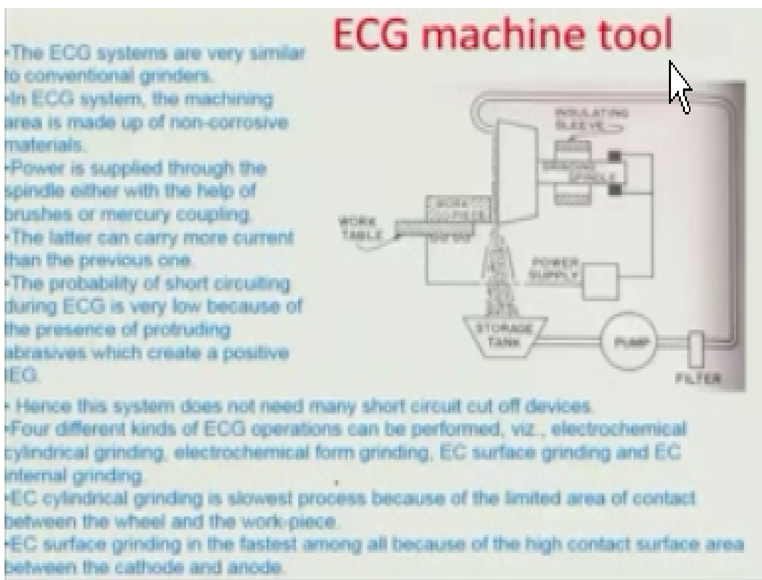

Or whatever you know pieces of metal the electrochemical dissolution as well as mechanical action may have removed in the zone one zone to so in a way it is good that this depressurization may happen at the zone three level of a electrochemical grinding process so that's how the zone contributes to the removal of scratches or bursts that might have be formed on the work piece in zone 3 and also zoned end zone 1 so ECG systems are typically.

More or less similar to what conventional grinding systems have they were spindle they have a veal and there is an inter electrode gap created an electrolyte flow across the veal work piece gap the machining area normally has to be made out of noncorrosive materials because obviously it should not be degraded electrochemically because of reaction of the electrolyte.

Power can be supplied through the spindle either with the help of brushes or with mercury coupling as you can see here in this region and one good advantage of the whole ECG processes that it has very less chances of short-circuiting because remember there is a mechanical action and there is always a separating grain from the acting substrate so the distance that would be minimum electrode gap inter electrode gap would be dependent on what is the projection height of the various materials sticking out of the conducting surface of the grinding wheel the other issue is that there may be a possibility of some sparking because there is moment of time.

Where the gap is too small but then you have to understand that the wheel rotates and so the time amount of relaxation time that is given for this part to build up also is very low in this particular case so generally it is not needed that there may be any separate short-circuiting device the mechanism of the grinding process itself takes care of this short circuiting which otherwise may be a very critical issue in normal conventional electrochemical delaying or electrochemical processes other electron.

Wheel processes so there are also further several types of ECG processes for example you may have you know form grinding you may have surface grinding you may also have internal grinding or cylindrical grinding so these are the four different kind of processes.

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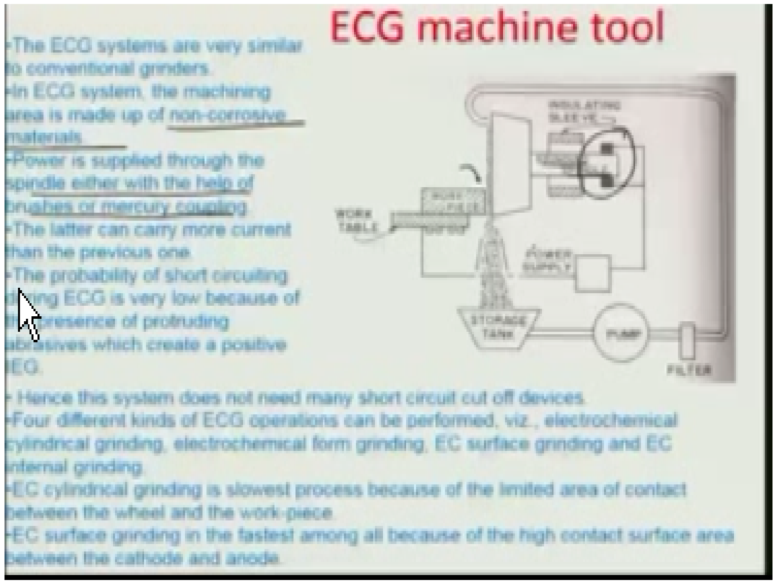

Here which is associated with the electrochemical grinding process further the eke cylindrical grinding maybe as lowest process because of the limited area of contact between the wheel and the work piece whereas the surface grinding may be the fastest among all because of the high contact surface area between the cathode to the anode in this particular case.

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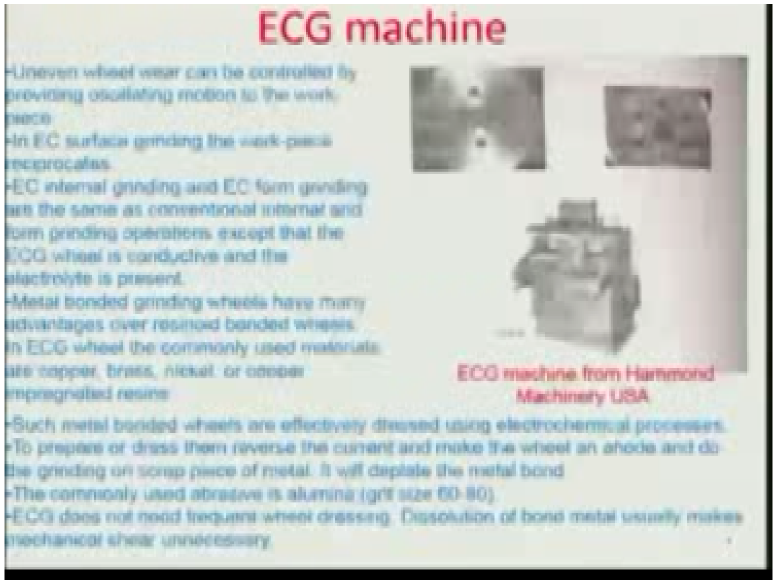

So that is about electrochemical grinding machine little bit details about how the tool is made or how you know overall the machine is built up what is the design so therein always a tendency of the electrochemical grinding wheel to wear out because obviously on one hand it is dissociating the dissolving the work piece material but its own conducting holding epoxy or overall you know the binding material is also getting degraded because of electrochemical dissolution.

So there is uneven wheel where sometimes which may happen because obviously at oneticular point there is more electrochemical dissolution where it is closest to the work piece so in order to prevent that you sometimes need oscillatory motions to be introduced where the grinding wheel which is in you know which is principally having rotation direction is also translated back and forth over a work piece surface.

So in lector chemical surface binding the work piece reciprocate normally so in internal grinding and firm grinding the mechanisms are same as conventional internal form lining operations except that the ECG wheel is conducting electrolyte is present the wheels are normally made out of materials like copper brass nickel or impregnated copper impregnated resins again you can trust the wheels in the same manner busing electrochemistry so in this case there is no mechanical dressing which is needed the electrochemical dressing may do it all.

So in order to prepare a dress prepare or dress them reverse current has to be float essentially and make the wheel an anode so that the solution starts happening from the anode and you could do this grinding normally on a scrap piece of metal which is unimportant so what it will do is actually deplete the metal bond and release some of the abrasives .

So that one layer is gone and the next layer is again full of protections of untouched grinding material or abrasive grains soothe one of the very commonly used abrasive is alumina maybe grid size of60 to 80 and unlike the conventional grinding the ECG will may not need much dressing it may not be frequently dressed because obviously the mechanical action very is very low in comparison to the electrochemical action oaf particular wheel.

So that is about thatch process more or less we have covered all the aspects of the process actually we will now turn to a different process which is actually about electro stream drilling and in line with that we can talk about a standard electrochemical drilling process.

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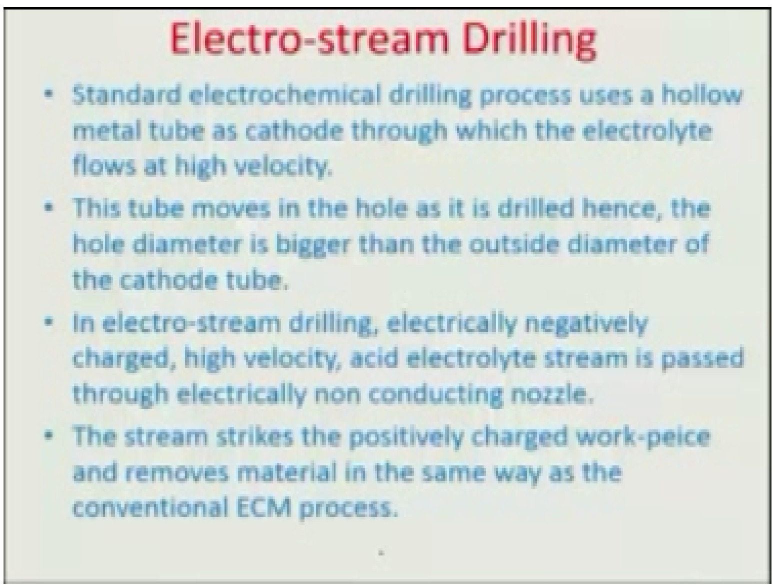

To use a hollow metal tube as cathode through which electrolyte flows at a very high velocity the two moves in a home as its drilled hence the hole diameter is bigger than the outside diameter of teethe cathode to you and the leprous stream drilling which is another variant of again the electrochemical machining temporally electrically negatively charged high-velocity acid electrolyte steam is passed the nozzle otherwise is electrically non-conducting.

So it is the stream which matters where it falls the stream strikes the positively charged work piece and in the process because its already charged and negatively it starts removing the material in the someway as the conventional ECM process does you can see it here in this particular example this is actually a case of electro stream drilling the main advantage that such drilling process may have is that you can make curved holes or inclined holes as you can see here okay.

So you have a sort of a guide you know which is now conducting and it is not an electrode really in this case but the stream which is being thrown out of negatively charged acid is the one which creates e the electrochemical dissolution ok so the dissolve material obviously is flushed out from the machining zone and this is in forms of metal ions and solutions there is no sludge to restrict the flow of the electrolyte obviously because it is a stream by spilling there is some limitation of the minimum diameter of the hole that can be achieved using this process.

So typically very small holes and holes which are curved or holes which are the angles which are very steep or you know even going deep into the work piece can be realized using the electro stream drilling process yes he can further we performed in two ways.

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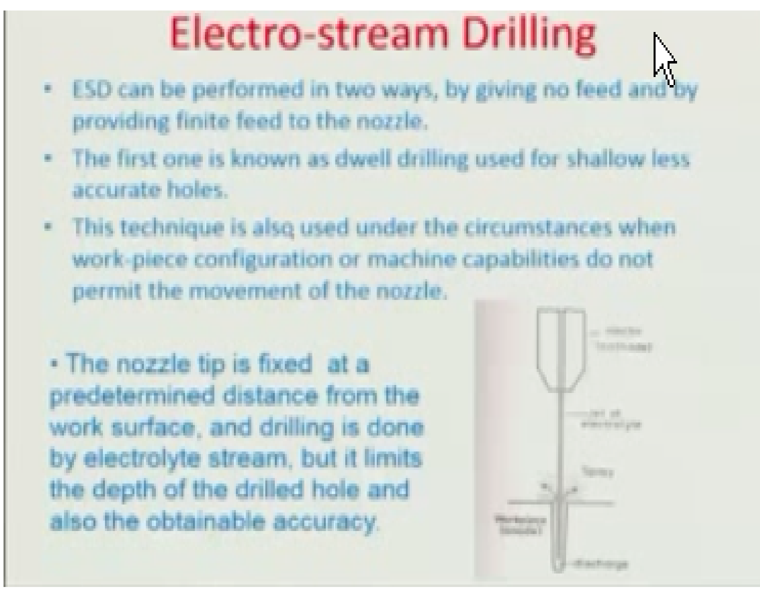

You could either give a zero feed to the nozzle or you could provide a finite fee to the nozzles if you have no feed given and typically only the stream which comes out of a nozzle which is at a fixed distance from the work piece as you can see here the process is known as add well drilling and the disadvantage is about oil drilling is that it cannot have a very high aspect ratio structure realized normally for less accurate and hallow kind of holes.

This is sort of conventional method which is used also maybe there are circumstances when theworkpiece configuration or machining capabilities do not permit the movement of the nozzle there may be a complex crevice or a cavity in which you are doing the drilling and that may not be enough space or enough capability forth machine to move where the drill in particular direction.

So in those kind of cases it is the stream which we do the job one of the examples could be internal cavities for example within engineering parts but the stream itself in the direction of the stream itself would ensure that the hole is drilled in particular direction so the nozzle tips fixed at a predetermined distance from the work surface and drilling is done by electrolyte stream obviously it has limited depth of drilled holes and also limited accuracy.
So the second kind of drilling as is more commonly used in the industry also is known as the penetration really just opposite to the dwell draining you have a nozzle not all there is a non conducting nozzle it is an insulator but you know it is capable of guiding the electrolyte to ozone very close to the workable region between the anode and the stream so this process on the contrary can be used for deep phones you know so you can have deep and accurate hole drilling using this particular technique the penetration drilling technique.

so normally it is a wise ideate have a gap sensing device just to monitor the current being drawn and this can also help you in giving a sort of closed loop feedback or closed loop control which can be used for slowing down the feed and when needed to get the full power so that the material removal and the rescission of the surface with respect to the point where the electrolyte is emitting.

That can be control so this gives you a proper nozzle to work piece gap although the nozzle is an insulator here but if wean monitor the voltage of the stream at the tip of the nozzle that could be as sort of a basis of a sutra nozzle okay and which could help you in giving potential gradient between the tip of the insulating nozzle as well as the work piece surface and that gradient can be utilized to calculate the gap given certain feed voltage into the system.

So that was another variant of the electro stream drilling process I would like to close here in the interest of time today but then maybe we can take up two more topics another module where we can talk about then what are the associated processes with the mechanical removal just as we have seen earlier abrasive jet machining or ultrasonic machining there are other processes like oppressor flow finishing which is a very widely accepted process of industrial grade.

So the next ND where in the next module would be to really look at some of those associated mechanical processes so in summary we have done all the electrochemical processes and the sister processes related to electrochemistry electrochemical removal and we have model the main processes related to the mechanical removal and we are now looking at the sixth processes related to the mechanical non conventional material removal so with this I would like to end this particular module thank you for being with me thank you goodbye.

Acknowledgement

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