Introduction to Abrasive Machining and Finishing processes
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Lecture - 19
PMEDM & ECD & ELID, ECH

So, now we are into the hybrid abrasive machining process. Till now we have seen the electric discharge machining, basic mechanics before we entering into the electric discharge grinding, then electric discharge diamond grinding other things, ok. So, we are moving into the same section where we will look into the other parts like powder mixed EDM, then we move on to electrochemical machining and its abrasive light processes and other things, ok.

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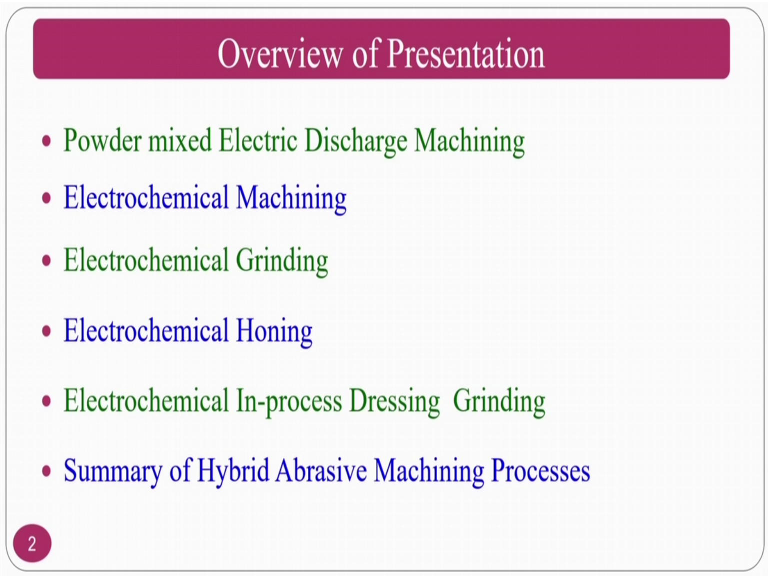

So, overview of presentation in this particular class we just start to with the another variety of electric discharge machining process, that is called powder mixed electric discharge process because some of the powder seen are abrasives also. That is why we are incorporating this particular process into our course which is called as abrasive based machining and finishing process.

So, then we move on to the electrochemical machining process that is another variety of the processes, then we will see how electrochemical machining will be blended with the grinding and it is called electrochemical grinding and how electrochemical machining is blended with the honing process which is termed as electrochemical honing, then we will also see electrochemical in process dressing based grinding process and other things, ok. So, the summary of all this hybrid abrasive finishing processes we will see first one powder mixed electric discharge machining process.

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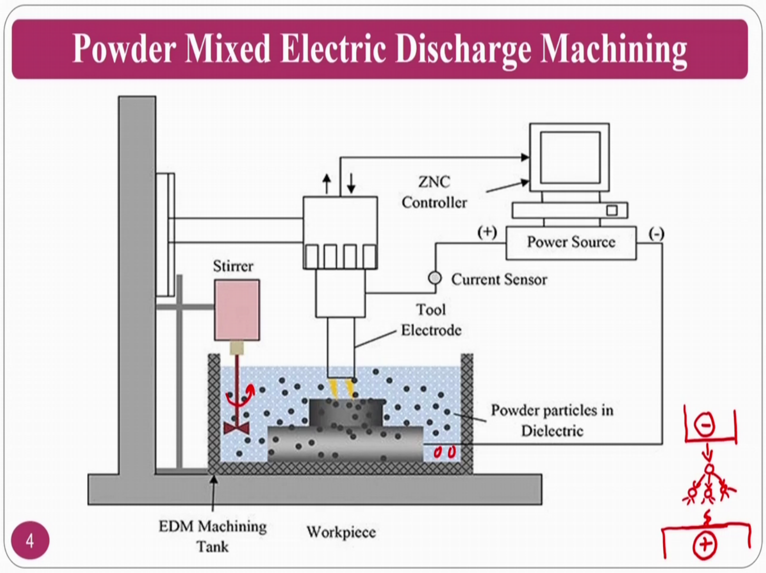

If you see the setup where you have seen already the electric discharge machining where you have a negative terminal, you have a positive terminal. This is a negative terminal and this is a positive terminal. The electrons will try to move from negative terminal and hit the dielectric fluid. So, it will emit multiple electrons and these electrons will hit then next set of dielectric molecules and it will give you again multiples of big electrons. In that way, some millions and millions of electrons will go and hit the work piece and there will be a spark, ok. This spark will generate. So, that is a basic mechanics of electric discharge machining process, ok.

So, similarly if you are incorporating the particles between these two electrodes that is a negative electrode and a positive electrode, what is going to happen is what we are going to see in this particular class, ok. So, the mechanism, everything is same. Only difference is here you are going to add some of the powder particles in the dielectric medium and the powders will have high density compared to your cut fluid. For that purpose what will be happening here is because of the density difference, the particles has a tendency to settle down at the bottom, ok.

To avoid the settlement of this particular particles we have to use certain sterol, so that it will completely rotate and keeps on flushing. It will also keeps on moving the particles, so that it will be uniformly placed in the dielectric fluid. At the same time this turning action also provide some dynamic motion to the dielectric fluid flow also because of which the electric discharge machining process performance will increase.

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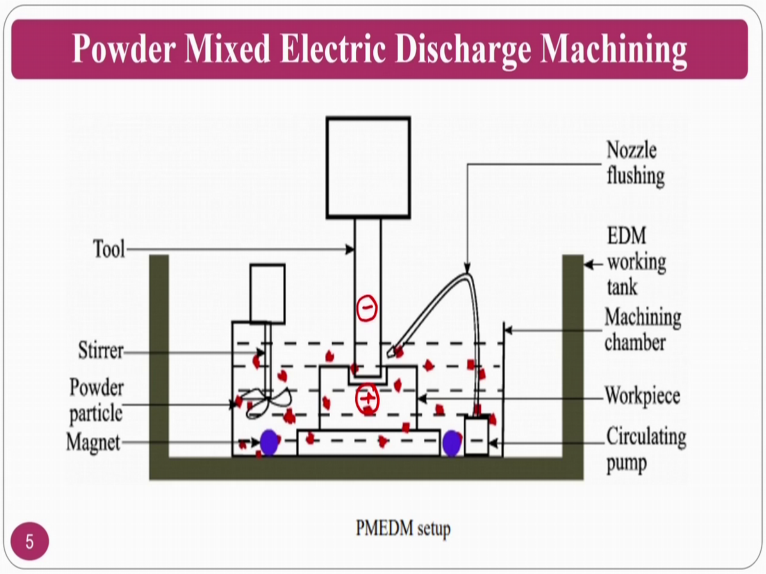

Now, you can see here the sterol is there. It is assumed version of what we have seen in the previous slide, we are going to see only the machining zone, ok. So, the electrons will move in this one and electrons will try to hit the work piece. Electrons have chances to hit the particle and particle also. So, there are varieties of chances will be there in this particular process to enhance the material removal rate. So, some of our researchers suggested to go for electric discharge machining along with the powder to go for coating also. So, the applications can be like machining also applications can be for coating also. So, how you have to utilize will depend on what the polarity is that you are going to give, what the density of the particles is you are going to put into the dielectric fluid, I mean to say volume fraction of the particles along with the dielectric fluid.

So, steering also will help in the flushing of the material that has to be removed under the same time to not sediment the particles that are going to use.

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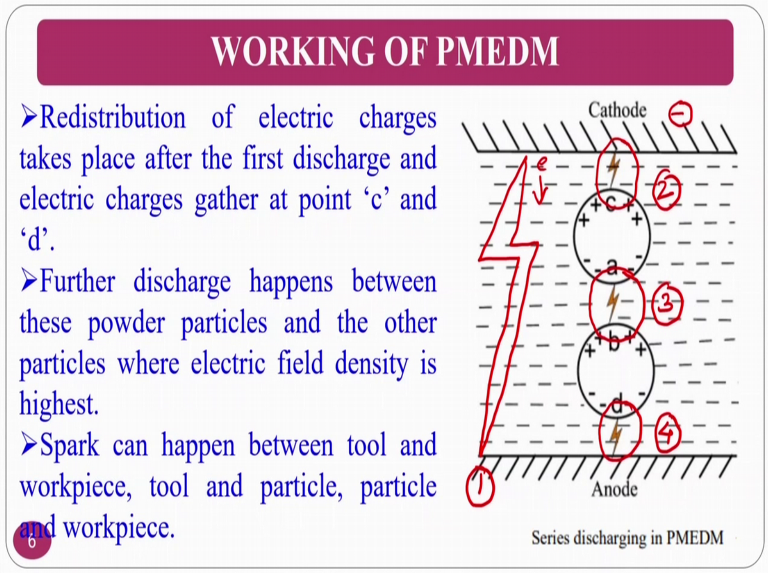

As I said if you see here the cathode is there, anode is there, so the electrons will move from here and it start moving and because of this what will happen, it will hit first the dielectric molecules and many electrons will emit, these electrons will also hit the power powder particles. There will be always chance that the spark will generate between negative terminal and positive terminal also and the spark can take place between particle and the negative terminal and there will be a chance that it will take between particle and particle and there will be a chance that it can take place between your positive terminal and your path particle.

So, there is a probability of chances will increase because of which what will happen, there might be enhancement of sparking intensity and the material removal rate will increase, ok. So, if you can change the polarity, so your particles may also coat on top of it. There will be a possibility, but it may not be always true, ok.

So, what you have to see here is in electric discharge machining process, you have only sparking one that mean that you have at the sparking between negative terminal as well as positive terminal, but in the powder mixed EDM you have the chances of 2, you have chances of 3, you have chances of 4 also, ok. That means that it can happen anywhere depend on particle location, particle distribution and volume fraction of the particles and other things ok. So, that is the difference between EDM and powder mixed EDM.

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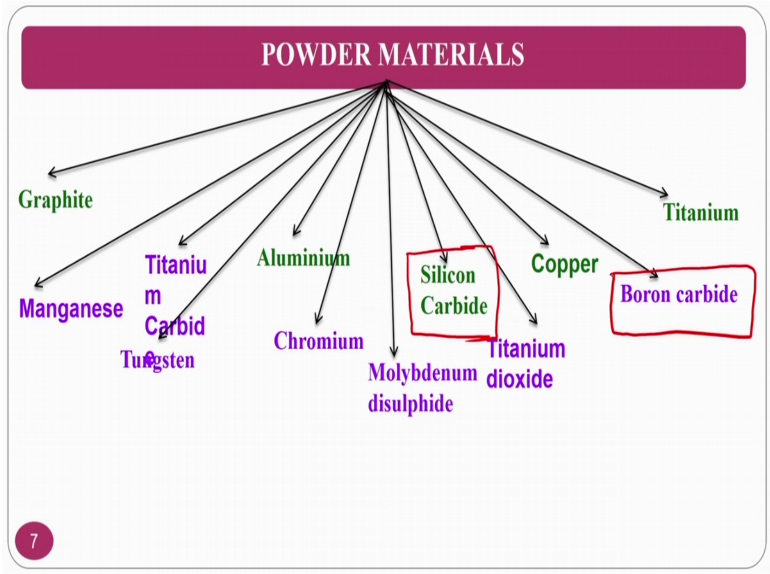

Why we are studying this particular process in our abrasive machining and finishing process is some of the powders that are used by people are ceramic particles and that will also act as an abrasive, but very less chance is there still people are using abrasives. That is why this particular process is considered and I am not going to explain in deep this process because this process has little influence for our course. That is why we are studying this particular process in brief only.

Boron carbide is another abrasive particle and aluminum is another particle, and titanium carbide, many things are there. This is about the powder mixed EDM process the beauty about this process is it will enhance the sparking ability and material removal can enhance by this particular process, ok. Now, we move on to another advanced machining process which is electrochemical machining process, ok. Till now we have seen electrical discharge machining process or electric discharge machining process. Some people they will call as electrical discharge machining, some people they will call as a electric discharge machining and both are same, ok.

So, now we move on to electrochemical machining process. Those people who do not know about advanced machining processes, you should be able to differentiate between electric discharge machining and electrochemical machining, ok. There there is no chemical will because you are using the dielectric fluid like deionized water, kerosene this type of things here you are going to use electrochemical, ok so, chemical you will be using here in this particular process.

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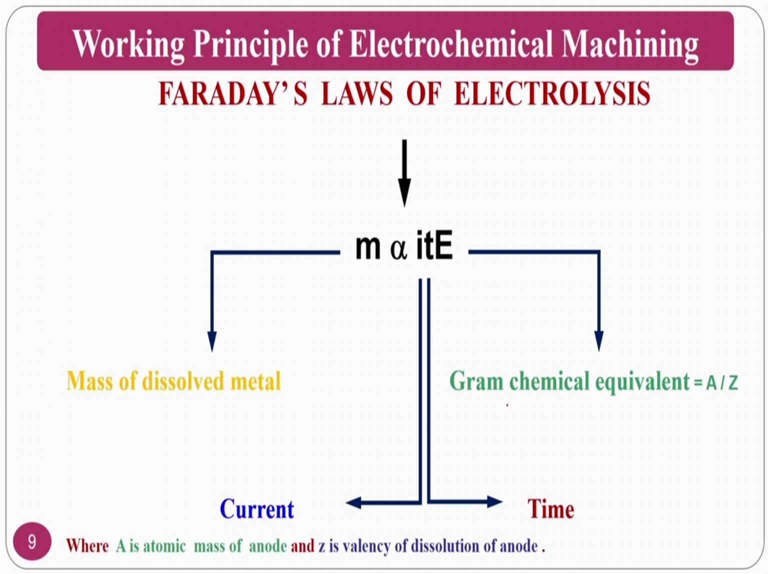

So, working principle of this particular process works on Faraday's Laws of Electrolysis, where m is proportional to iEt where m is nothing, but mass of dissolved metal, where iEt stands for i stands for current, t stands for time and E stands for gram chemical equivalent.

So, this is how the Faraday's of Laws of Electrolysis works and how it is going to help in the electrochemical machining process, we will see the setup.

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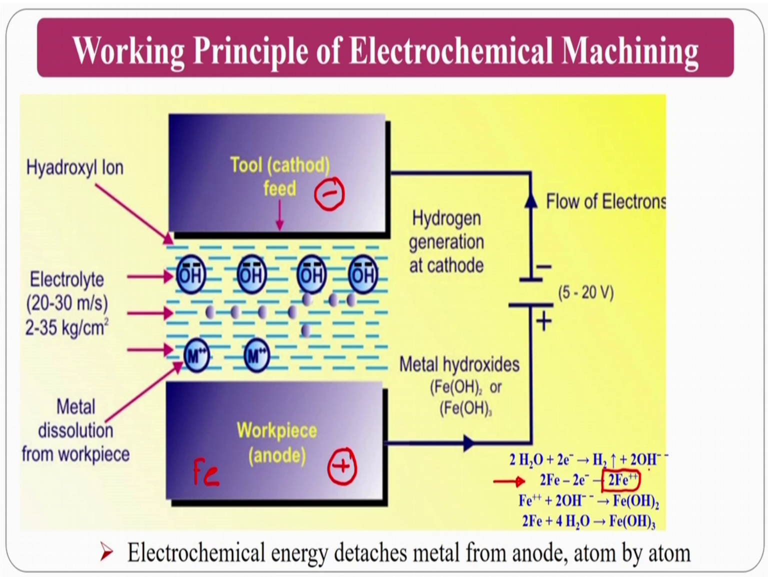

This is the electrochemical process where in you have a cathode, negative terminal will be there and the positive terminal will be there. So, first your tool will add electrons to the water. What will happen you can see here in the first equation. Water gets electrons and it will dissociate into hydrogen plus 2 OH minus ions. This OH ions that you can see in the picture tries to move towards the anode that is a work piece. What will happen at the positive end? The 2 Fe this electrons will be minus.

So, it will become ions and these ions are readily available. Assume that this is iron, ok. So, Fe plus and OH will add on at the centre or whenever this will meet, then there will be a reaction between these two and Fe 2 plus r metal plus plus ions will add on to OH minus minus ions. So, that it will give rise to Fe OH twice, then still more if you are going to add because the water is there. Fe OH thrice these Fe OH thrice and Fe OH twice is undissolvable materials. This is how the material removal will take place, ok.

So, let me explain again for better understanding because you have a tool. What will happen here is your electrons will add to the water and you will get OH minus ions and H2 gas; gas will be evolved out and at the same time the anode what is going to takes place is Fe will gives out the electrons and it will become ions, ok. These ions are there. So, Fe plus plus will be there on one side and OH minus minus is there another side. Whenever these two reacts, what will happen Fe OH twice, then further reaction it will takes place Fe OH thrice, ok.

So, these what you have to understand is Fe OH twice and Fe OH thrice are undissolvable materials. These are sediments in this will flow along with the electrolyte, ok.

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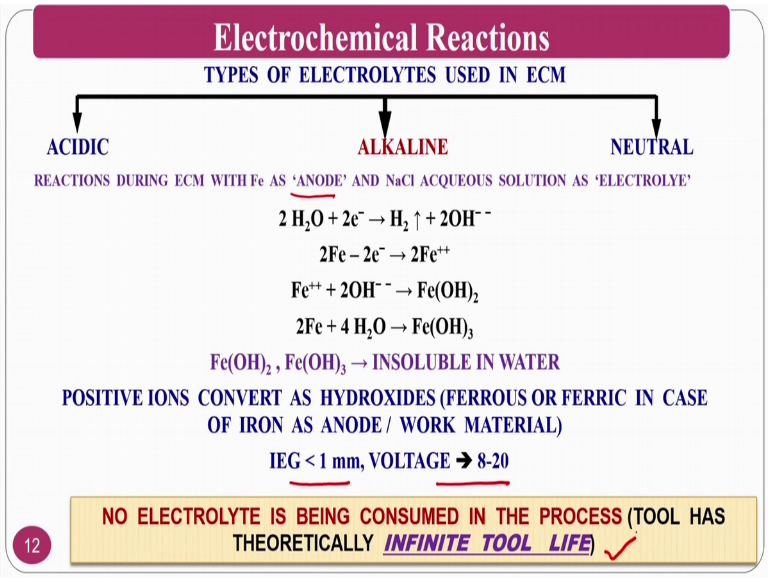

You can see here what is going to happen here. So, type of electrolyte used in ECM, the acidic alkaline and neutral. So, reactions during ECM normally as Fe as anode and NaCl aqua solution is a electrolyte that will be used. So, of the first equation that you have seen in the previous also, so 2 H 2 O plus 2 e gives rise to hydrogen which goes out as a gas 2 OH minus minus will be there as this will be taking care at the negative terminal. At the positive terminal what will happen to Fe gives out the electrons and becomes the Fe 2 plus and these Fe2 plus and OH whenever it combines it will add to Fe OH twice on further reacting with water, it will become Fe OH thrice.

These Fe OH thrice and Fe OH twice which are insoluble in the water or the electrolyte that is flowing that is why this will come along with the flow as the particles, ok. Positive ions converts as hydroxides and normally intern electrode gap internal electrode gap that we can see in the EDM also the distance between positive terminal and negative terminal is nothing, but inter electrode gap because you have electrode on one side, you have electrode on another side. The gap between these two is inter electrode gap, ok.

So, normally it will be less than 1 mm. At the same time, the voltage in this electric electro chemical process, the voltage in electrochemical process normally ranges from 8 to 20 volts. So, in this one no electrolyte is being consumed in this process. That mean that tool has theoretically infinite tool life. That is the beauty about this particular ECM process current density distribution because you are machining will takes place or this Fe OH thrice or metal hydroxides that are forming will be function of current density distribution, ok.

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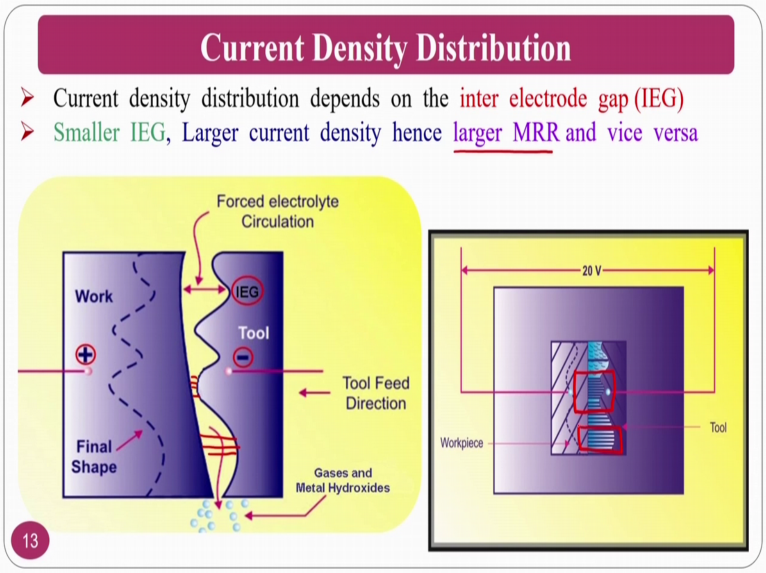

If you see the current density, distribution depends on the intern electrode gap. If the intern electrode gap is low, what will happen is the current density will be high, ok. The smaller i is, the larger the current density and larger the MRR and vice versa. If at all I want more material removal, then what I want is internal electrode gap should be maintained minimum, ok. If you can see here, there will be a tool which is having irregular surface and the current density here is very high and the current density here will be, it will be very low because the inter electrode gap is low in some cases and inter electrode gap is high in some cases. That is why you will get the replica of the tool, ok. You can see here the current density is the density is very high in this location and the current density is very low in this the.

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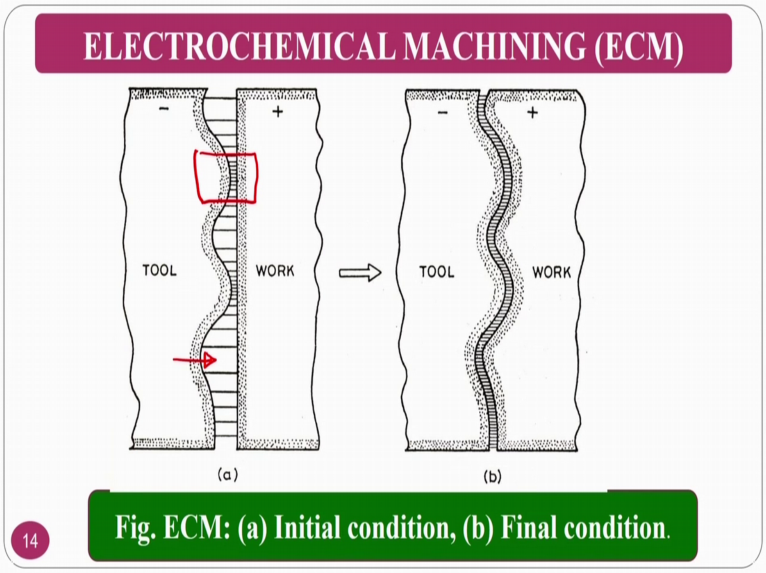

The same thing in before machining and after machining what will happen you can see in this one the current densities are dominating here and the current densities are very low at these locations because of which what is going to happen is you are going to get the replica of the tool. Because of the current density variation wherever the density is more, there metal hydroxides formation will be more and this metal hydroxides will flush by the electrolyte that is flowing across the sections or across the intern electrode gap.

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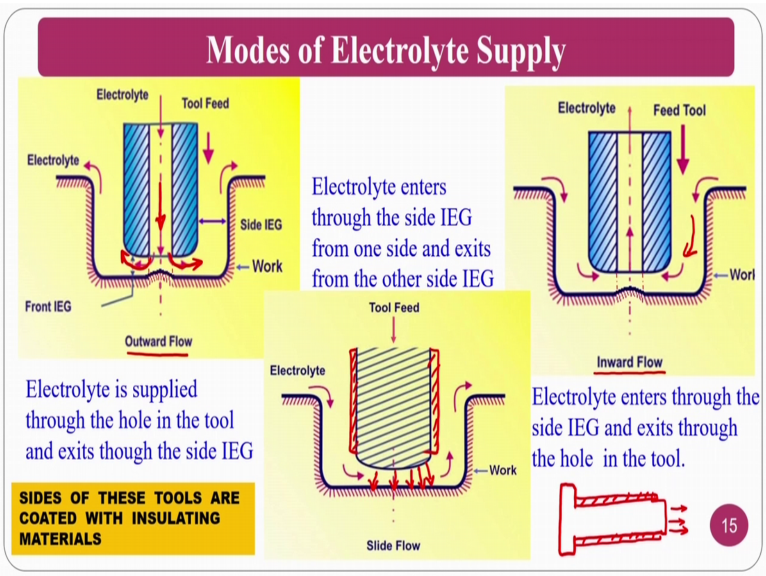

Modes of electrolyte supply in ECM process if you see the first one is outward flow in this process electrolyte is supplied through the hole in the tool and exits through the inter electrode gap. That mean that it is fed from this and it goes outside from the sites. This is one way of feeding and the another way of feeding is your inward flow that mean that electrolyte insert enter through the sites of intern electrode gap and it will go through the hole provided in the tool. This is called inward flow and the 3rd one is side flow, ok. Electrolyte enters through the sites of tie easy way from one side and exits to the other side. So, normally for economically developed electrochemical processes that people normally developed in the laboratory will be like side flow.

So, from one side, just you feed the electrolyte and it will come out by flushing the metal hydroxides from other side. That is what is most of the people will use side flow technique for the ECM process, but one thing you have to see here is sides of these tools are coated with insulating material because if you take the side flow picture here, what is going to happen is if you are not coating the surface, there will be metal hydroxides reactions, chemical reactions or the electrochemical reactions will be from sideways also.

For that purpose to avoid that what you are going to do is, the insulating coating will be done from on the sideways of the tool, ok. So, people will get how to do the insulating coating on the tool, ok. So, if you can insulate it what will happen, the electrochemical reactions will take place in this direction only and you will get whatever the required shape. Now, the question is how to coat it? There are simple techniques. Assume that if your electrode is a normal pin that safety pin or some type of a round pin.

So, just make the coating of some polymers for example you can coat with prospects. So, just put the prospects pieces into a chloroform then it will become a liquid, then you just rotate it small round pin and you take out after sometime it will dry. That means that there is insulating coating just you chop of or you just remove the tip of the pin. Assume that this is my pin which I want to do the thin, ok so, what I want this is the coating.

So, you just place this in the liquid prospects and just roll it, so that it will get all the place the coating. So, you just remove here this portion, you have to remove and keep only this particular portion, ok. Suppose you do not uniform whole, then you can chop it off this part portion also, and you can have your tool like this.

So, the electrochemical reactions will take place in this direction only because this complete portion is insulated. This is a simple way that you can coat on the tool, ok. So, that is how the coating will be done. Anyhow as we have seen in the previous slides, the life is infinite.

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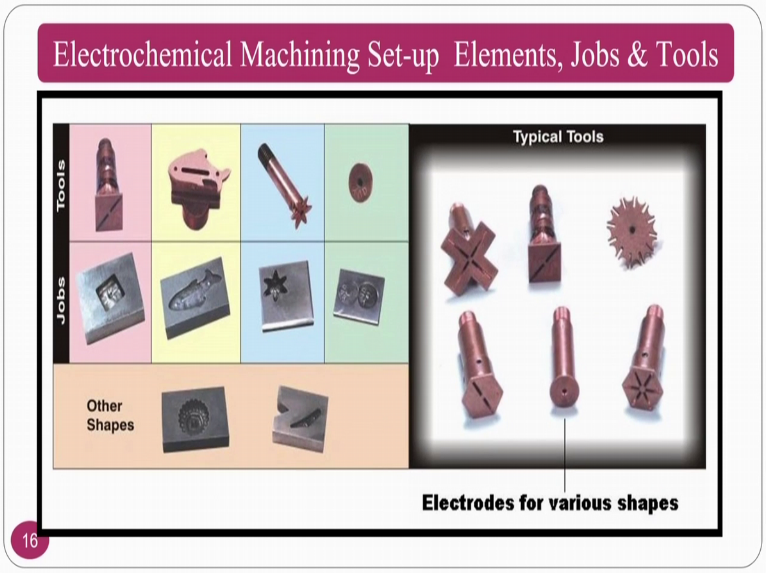

So, electrochemical machining setup and the jobs as well as the tools if you see here, tools these are the tools that are used and these are the final outputs on the jobs, ok. You normally what you are going to get is the converse shapes, ok.

So, you can see various shapes that are generated on this one using the tools that are generated. Other shapes can be generated and this is what we have taken from Professor Jain, slides. Most of the things we have taken from the eminent people like Professor V.K. Jain in this particular class whatever I am dealing. So, I am very thankful for Professor V. K. Jain, Professor P.K. Jain, Professor N.K. Jain. These are the people who have done extensively in this particular area apart from these scientists also many people have done many things, ok. Most of the things are done by this Professor Jain.

So, typical tools, other tools you can see here. These are the tools that you can use and you can generate that converse shape because your current densities will be high where the inter electrode gap is less. So, if you see the slots are provided in this particular thing, if the slot is there, what will happen wherever there is a slot in the center there the density is very less. That is why you will get the peak there, ok.

So, that is what I want to specify is that you will go, you are going to get the converse shape that are simply mentioned in this slide.

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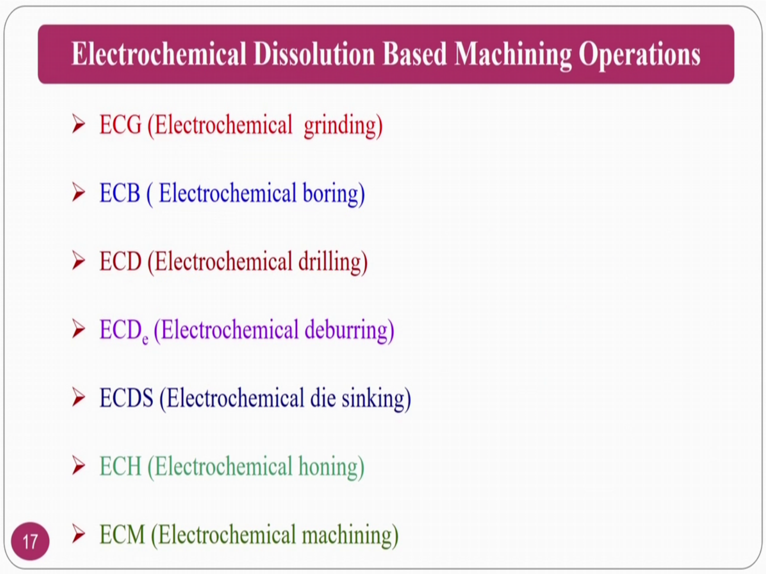

Now, we move on to various processes that can be clubbed along with a electrochemical process. Those are nothing but electrochemical grinding, electrochemical boring, electrochemical drilling, electrochemical debarring, electrochemical die sinking, electrochemical honing, electrochemical machining is the common process.

So, you can also do electrochemical micromachining and other things, but what we have to look into this particular course is that we have to use those particular processes where the abrasives are involved. Those particular processes where the abrasives are involved is electrochemical grinding process and electrochemical honing process.

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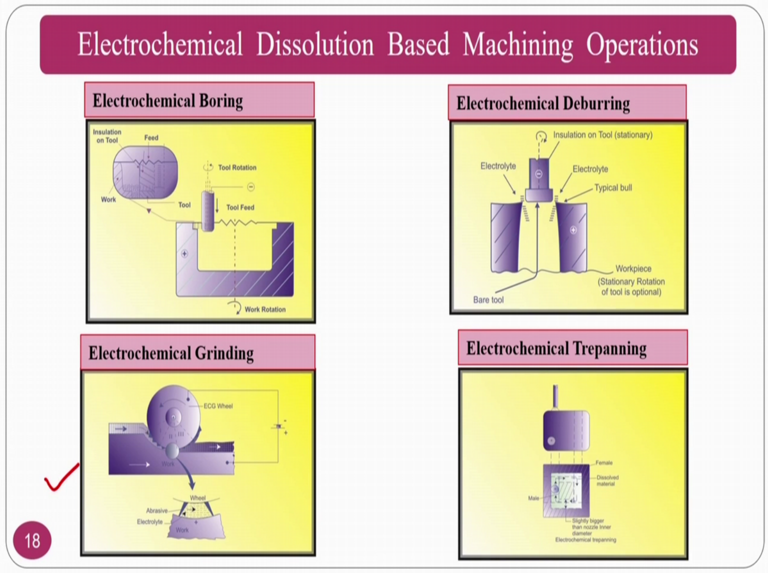

Even though we are going to study about electrochemical honing and electrochemical grinding process, we will see the overview of other processes like electrochemical boring. This is how the boring will take place. Electrochemical deburring will take place. Electrochemical grinding we will see this particular process in detail and at the same time electrochemical trepanning also can be done.

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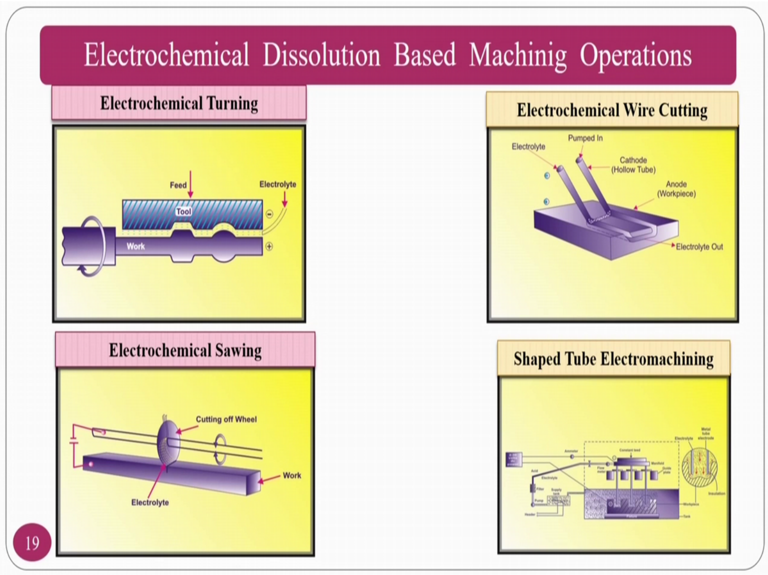

Electro chemical turning process is another variety. Electrochemical wire cutting process, electrochemical shaping process and shape tube electro machining process also can be done, ok.

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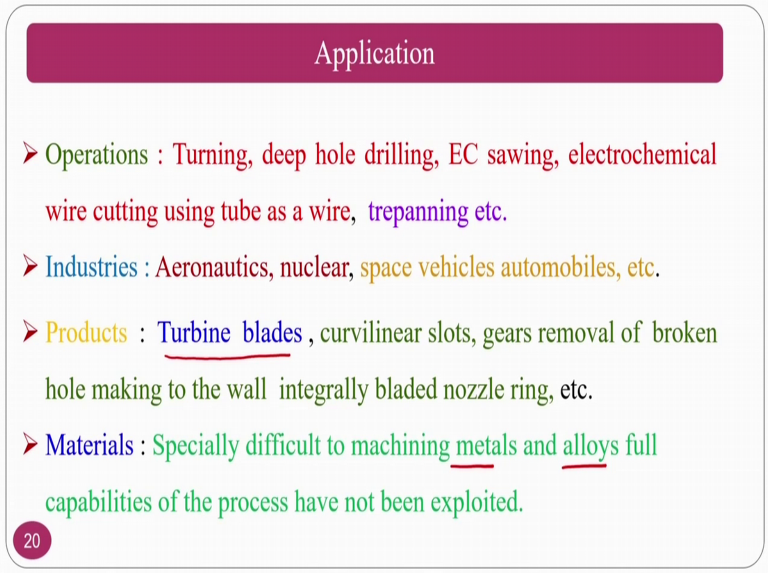

So, the applications of these process is you can do in many ways like turning and other things and aeronautics, nuclear, space vehicle automobiles these are the mostly used industries, then the products basically this particular process is used in turbine blades, cantilevers slots and other things. Materials these are specifically to machine the materials that are metals and alloys which have capabilities to pass normally, this particular process is used for the metals and alloys, ok.

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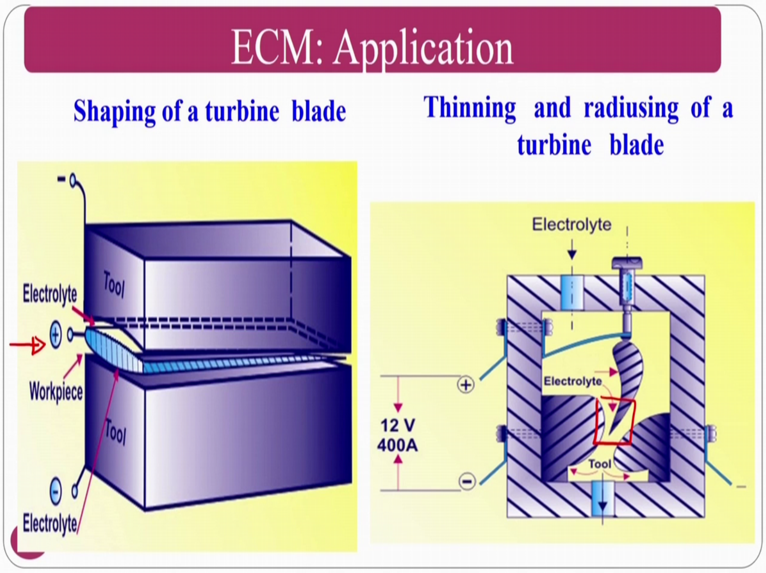

So, applications we will see here shaping of the turbine blade. Normally the turbine blade will have an aero file structure that you can see at the cross section here. So, you can generate this type of turbine blade shapes as well as you can also use for thinning and radiusing of the turbine blades. You can see the thinning and can be done using this process.

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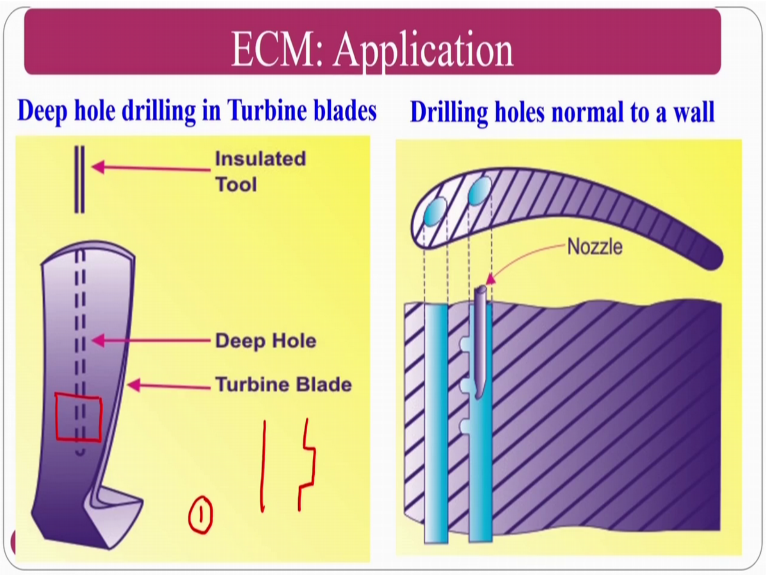

At the same time if you can see, you can use this particular electro chemical machining process generating the deep holes in the turbine blades. Normally turbine blades will have deep holes. These are provided for better heat transfer applications in the aviation industry, ok. So, at the same time this possible process also uses for drilling the holes normal to the walls. In this case 1 what you are going to drill is a normal one, where in case 2 in this particular hole itself you are going to generate the normal to the wall, ok.

What I mean to say is that here there is if you are if you zoom the surface, I have this hole where in I am generating in this wall also hole, ok. This type of hole you can generate. If you can generate this type of holes, what will happen is your heat transfer will enhance, ok. There is some concept. If at all some people want to study, that is called turbulent holes generation using electrochemical micromachining process. This particular thing is done by Mr. Ashish Chavan along with Professor V.K. Jain.

So, those people who are interested in studying about turbulent holes generation using electrochemical micromachining process, you can see and whenever you go to IIT Kanpur they are available on the net also within the IIT Kanpur and outside also it may be available and if can go to the library and you can access the hard copies and you can read about it, ok.

Now, we move on to our particular process as we always deal with the abusive processes. So, we do study about electrochemical grinding process.

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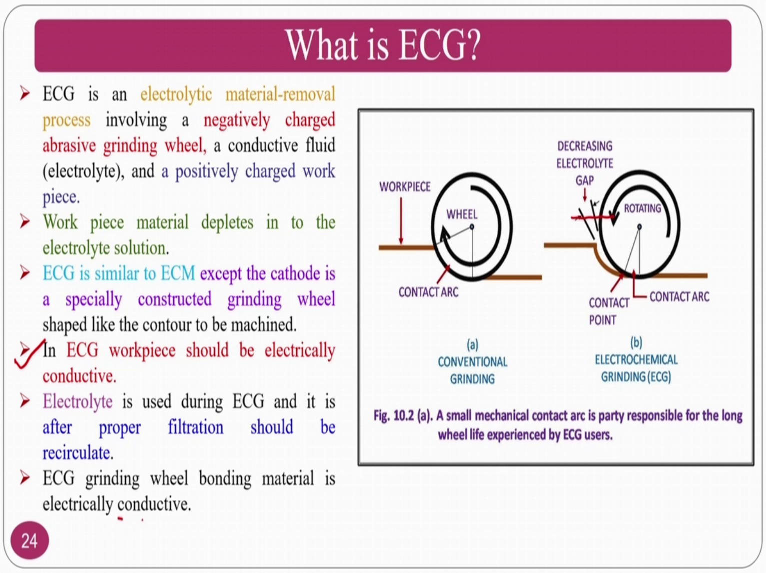

If you see what is the electrochemical grinding, what is the difference between grinding and electro chemical grinding, so in the grinding process what you can see here is there is no gap between grinding wheel as well as the work piece surface. However, if you see here there is a decreasing electrolyte gap, ok. So, the electrolyte will pass through this one and the proper abrasion will take place in this region. This region will have contact, but not in this first region, ok. Electrochemical grinding is an electrolytic material removal process involving negatively charged abrasive.

Grinding wheel in a conductive fluid that is called electrolyte is a positively charged work piece will be there, ok. There will be a positive charge and negative charge in electro chemical grinding, but there is no charge has that are involved in conventional grinding process. The work piece material depletes into the electrolyte solution by the action of electrochemical reaction as well as abrasion also takes place.

Electrochemical grinding is similar to electro chemical machining process except the cathode is specially constructed like a grinding wheel. Normally what you have seen in the previous slides in the electrochemical machining process, you have a shape, the converse shape you are going to achieve, but here you are going to use the grinding wheel itself as your electrode ok, but for that purpose what you have to do is like electric discharge grinding process, your bonding material should be conductive material, ok that is what you have to take care about. In ECG process, work piece should be electrically conductive. That means that work piece also should be electrically conductive on bonding material also, should be electrically conductive electrolyte used in ECG and its after proper filtration should be recirculate. That means, that if at all I want to recirculate, you just need to do the filtering action.

If you do the filtering, what will happen is the particles that are generated during ECG process can be eliminated. So, electric chemical grinding wheel bonding material should be electric, electrically conductive. The bonding material normally you can use any type of conductive materials you have see in the grinding process where wheel specification is taught to you in the previous classes their metallic bonding is one. We have seen vitrified bond cell of bond, other bonds and other things. Along with that you have studied the metallic bonding. I told you the metallic bonding is normally used in case of electric discharge grinding, electric discharge diamond grinding at the same time electrochemical grinding other process where you required the conductivity to the grinding wheel, ok.

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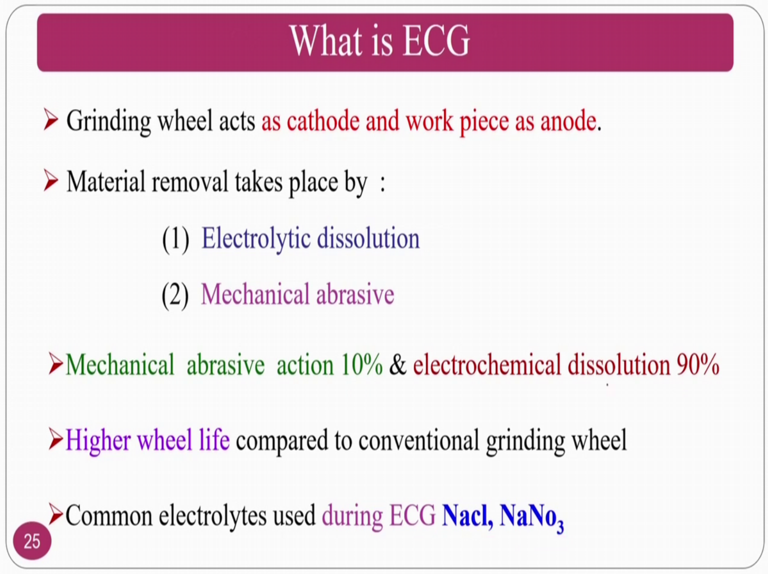

What is ECG? Grinding wheel act as a cathode and work piece act as anode. Material removal takes place by electrolytic dissolution as well as mechanical abrasion action, ok. So, mechanical abrasive action normally it will be 10 percent, electrochemical dissolution will be 90 percent. How this particular 10 percent and 90 percent will come that we will see in the upcoming slides. Higher wheel life compared to the conventional grinding process because electrochemical dissolution is dominating not the abrasion action. That is why the mechanical forces on the abrasives that are there on the grinding wheel will be much much less. That is why the life of this electrochemical grinding wheel will be much higher. So, common electrolytes will be used or NaCl and NaNo 3, ok.

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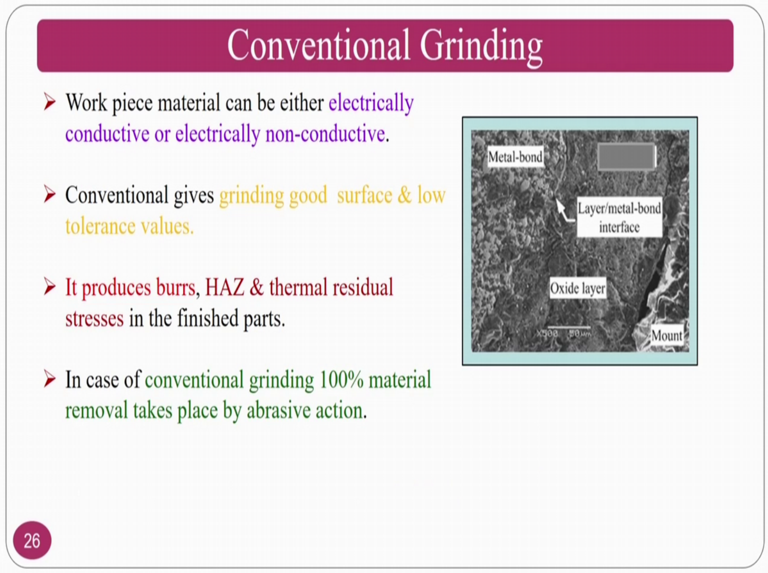

If you see here metallic bonding and other things, so work piece material can be either electrically conductive or electrically non conductive that can be used.

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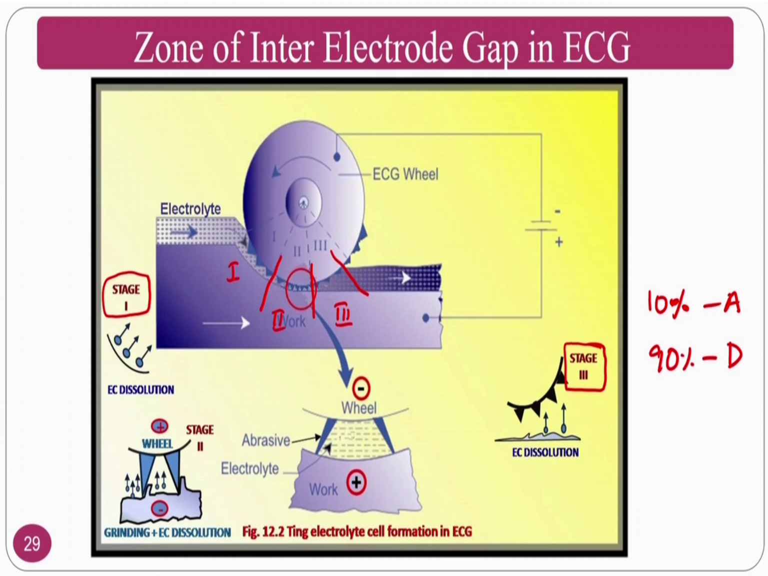

So, now we move on to the zones of inter electrode gap that we have seen that 10 percent and 90 percent. 10 percent will be taken care by the abrasion action are the same time 95 percent by the electrolytic dissolution, ok. So, how it will take place? This is a stage 1 where the dielectric where the electrolyte is moving. This is called stage 1, stage 2 and stage 3. In the stage 1 completely it is electrolytic dissolution because of which what will happen the metal hydroxides will be formed and material removal will take place. In the stage 2 dissolution will be taking place along with that abrasion action will take place. In stage 3 again it will be a dissolution process, electro chemical dissolution process. That is why 10 percent will be abrasion and 90 percent will be like electro chemical dissolution process. That is why that grinding wheel life will be enhanced greatly.

Depend on these 3 stages I will explain how these 3 stages will take place in the material removal process, ok.

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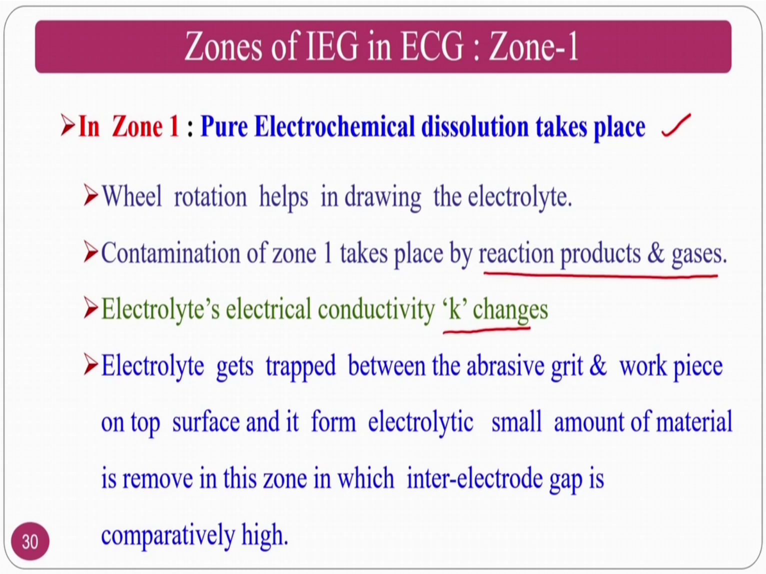

So, coming to the stage 1 or the zone 1 the zone 1 is purely electro chemical dissolution takes place; wheel rotation helps in drawing the electrolyte. That means that your wheel is rotating because of which what will happen, electrolytes will be drawn into the inter electrode gap. Contamination of zone 1 takes place by the reaction production gas. That means that electro chemical dissolution takes place, so that metro hydroxides will be forming. The electrolyte electrical conductivity k changes because you are getting metal hydroxides so, the conductivity will change.

Electrolyte gets trapped between abrasive grids and the work piece on the top surface of it from the electrolytes small amounts of material is removed in this zone which is inter electrode gap comparatively high. That means that what we were going to get is here the material removal mechanism is completely dominated by electro chemical dissolution process because there is no abrasion action.

If you can see here what is happening is you have completely gap here. In the stage 1, there is no abrasion action. The abrasives are not at all touching the work piece. That is why the material removal mechanism is completely by the electro chemical dissolution only.

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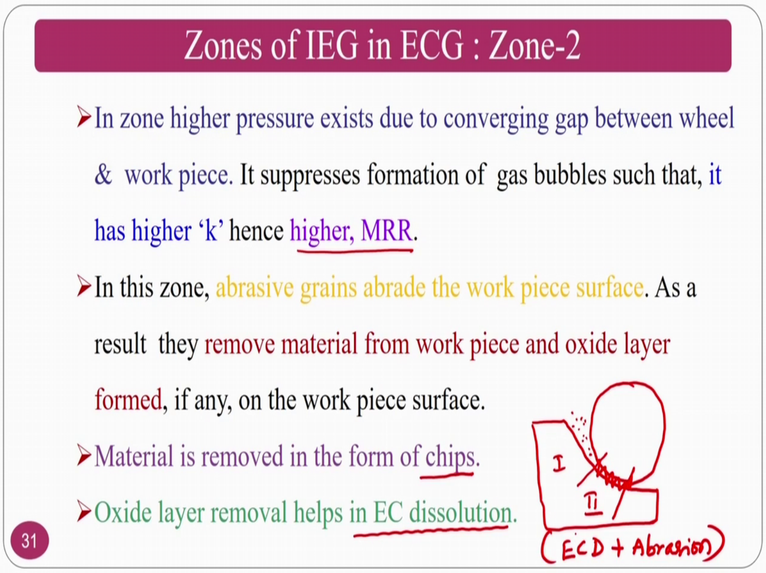

In zone 2, higher pressure exists due to converging gap between the wheel and work piece. It suppresses the formation of gas bubbles and has a high risk of k hence the material removal will be very high, ok.

So, in the zone abrasive grains abrade the work piece surface. As the result they remove the material from the work piece and oxide layer formed and the material is removed in this form of the chips also. That means that oxide layers removal helps in the electrochemical dissolution. That mean that in the stage 2 what is going to happen here is, you have the gap, your abrasive, your wheel is like this and you have the abrasives like this, ok. That mean that what you are going to see here is in the stage 2, your electrolyte is flowing. In the stage 1, you have seen the electrolytic dissolution. In stage 2, electrolytic dissolution will take place where the bonding material as well as the work piece material will have the electrochemical reactions. Apart from it, abrasive particles also will involve in the abrasion action.

That is why here in this stage 2 you will have electrochemical dissolution plus abrasion. That is why material removal will be higher, however the point to be noted is here the material removal action also involve electrochemical dissolution in the first stage also electrochemical dissolution completely.

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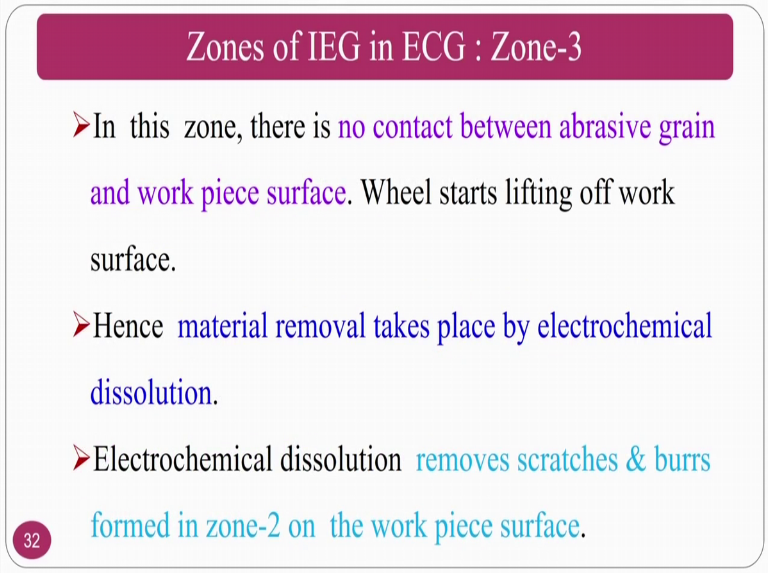

In the 2nd stage electrochemical dissolution plus abrasion and in the 3rd stage it will be purely again the electrochemical dissolution. In the 3rd zone what is going to take place is there is no contact between the abrasive grains and the work piece surface. That means, that your material removal is completely again by the virtue of electrochemical dissolution, ok. So, the entire material removal takes place by electrochemical dissolution. Electrochemical dissolution remove the scratches was formed on the zone 2 of this work piece.

That is the beauty about this particular process that whatever the burrs that are formed, what are the scratches that are the formed during the abrasion action of the zone 2, also will be electrochemically dissolved, ok. That means, that stage 1, stage 2, stage 3 or the zone 1, zone 2, zone 3, what is going to take place is zone 1 purely electrochemical dissolution, zone 2 electro chemical dissolution plus abrasion and zone 3 electrochemical dissolution. That means, that 3 zones you have electrochemical dissolution and at the same time you should note that if there is a burr that is generated by the abrasive action, that burr will be removed by electrochemical action.

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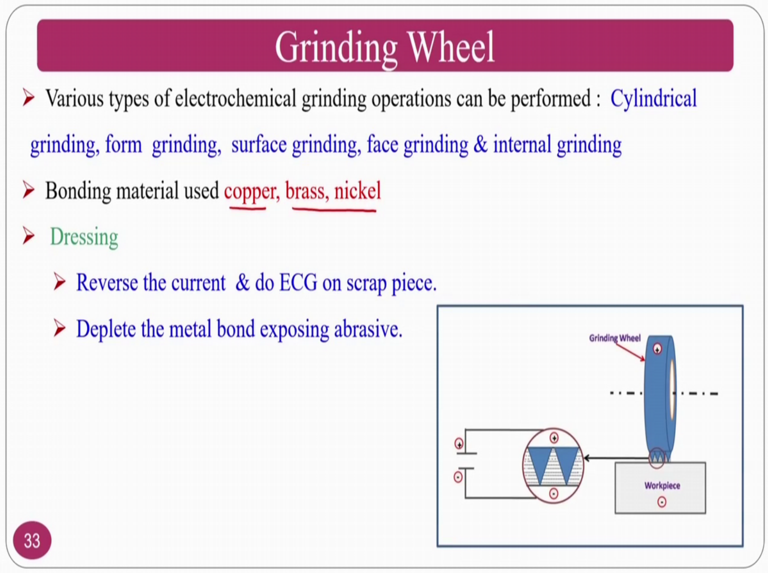

So, the grinding wheel if you see various types of electrochemical grinding operations can be performed. So, the cylindrical grinding form, grinding surface grinding, phase grinding can be done at the same time. Bonding material normally will be copper, brass, nickel and other things because you need these particular materials for conductivity, so that dressing will be taken care by this particular process. If you do the ECG process, then the material that is loaded between the abrasive grains can be depleted or it can dissolve and is goes off along with the electrolyte. You can see here the dressing automatically you can do by changing the polarity and if you perform what will happen is the material that is loaded is drust.

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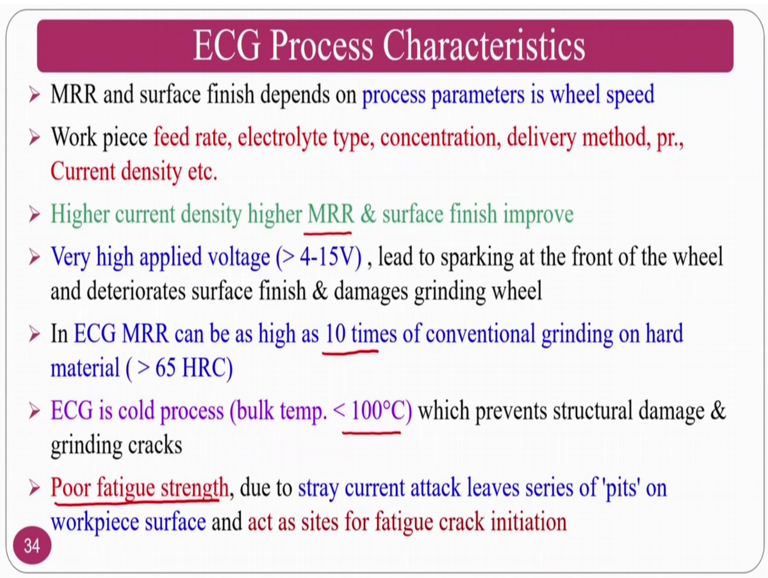

So, electrochemical grinding process characteristics MRR and surface finish depend on the process parameter is the wheel speed. Work piece feed rate, electrolyte type concentration, delivery method, pressure current density also will play major role in electrochemical grinding process. High current density means you will get a high material removal rate and the surface finish also improve. Very high applied voltage lead to sparking at the front of the wheel and retrieve the surface finish and damage. That means that you should not go for higher voltages. Electrochemical grinding MRR can be as high as 10 times that of the conventional grinding process.

In terms of hard work piece materials where the HRC that is rock, well hardness scale above 65. Electrochemical grinding is a cold process. Normally what is bulk temperature? That you are going to achieve is less than 100 degrees. That is why there will not be any hematological changes or structural changes for the poor fatigue strength due to stray current attacks on this one because of the other wall surfaces. There will be a stray current formation and other thing because of which there will be a poor fatigue strength, ok.

Now, we move onto another process that is called electrochemical honing process.

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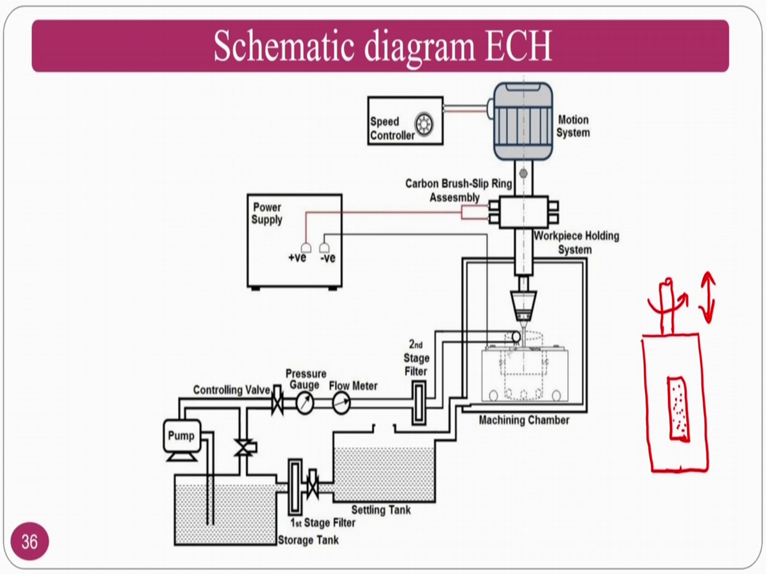

In electrochemical honing process, the mechanism of material removal that you have seen in electrochemical grinding is this same because the grinding and honing mechanisms are approximately same because the abrasives are there, there it is a wheel, here it is a strip,. You will have a 1 strip of abrasives that are there on a bonding material. Now, the strip here in the honing process will have abrasives.

Assume that this is my cylinder on which I will have some strips basically. These strips will be there. These strips will be made up of conductive material on top of it you will have abrasive particles, ok. So, the mechanism of material removal is approximately same as electrochemical grinding process if you see here the electrochemical honing process. So, you will have all the flow meters, pressure gauges and other things where you will supply the electrolyte and the motion reciprocating and rotary motion are provided for the tool as you can see in the normal honing process and this will reciprocate as well as rotate, ok.

So, the stages will be similar in this case also, where the material removal takes place by electrochemical dissolution as well as abrasion action.

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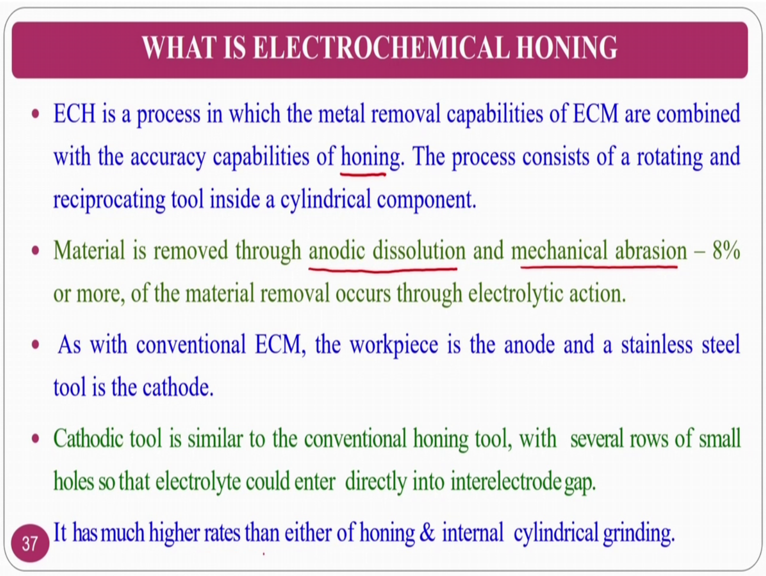

If you see here electrochemical honing process in which the material removal capabilities of ECM are combined along with the accuracy capabilities of honing, that means that ECM plus honing. That is why this particular process is called as a hybrid abrasive process where you are using the material removal mechanism of electrochemical machining plus honing process. This process consists of a rotating and reciprocating pool inside the cylindrical component material is removed through anodic dissolution and mechanical abrasion.

As the conventional ECM, the work piece is anode and stainless steel is a tool cathode. Normally cathodic tool is similar to the conventional honing tool, but the only difference is several rows of small holes are generated or kept on this tool for the dispensing of electrolyte through it, ok. So, it is much higher rates than the honing process and internal grinding process. That means, the material removal will be more in this one.

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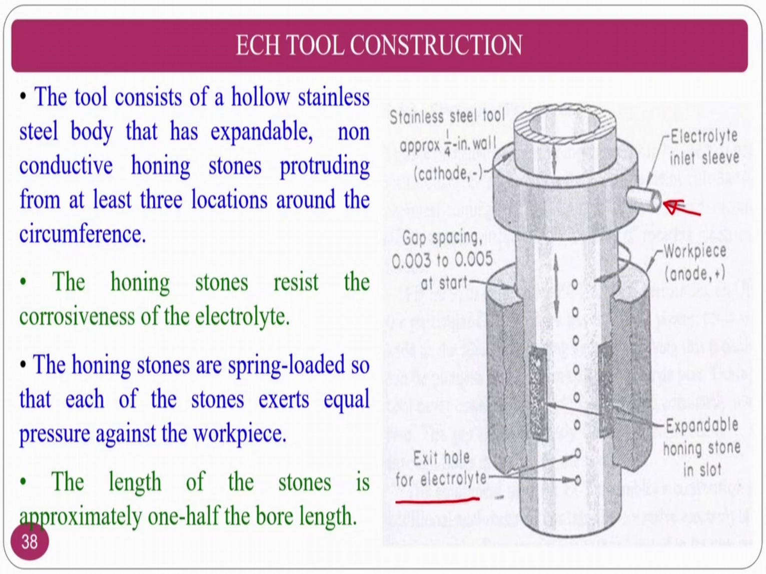

Tool construction if at all I was explaining you about there are small small holes are there in the tool. What will happen is here the electrolyte is entering and this will be dispensed into the machining region by these small small holes ok, so that the electrochemical dissolution plus abrasion action will take place. The tool consists of hollow stainless steel body that is expandable non-conductive honing stones protruding from the lease and 3 locations around the circumference.

At the same time honing stones resist the corrosiveness of the electrolyte. Normally honing stones should be designed with such a material, it should avoid the corrosion. The honing stones are spring loaded, so that each of the stones exert equal pressure against the work piece and the length of the stones is approximately one-half of the bore length, so that you can the reciprocation motion and other things, ok.

So, what you have to see here in the construction is in normal one what you are going to give is, you are not going to generate this type of small holes, ok. In the normal honing process, you do not get, you do not give these type of exit holes. In the electrochemical honing process, you are going to give these small holes through which electrolyte will come into the inter electrode gap of the electrochemical honing process.

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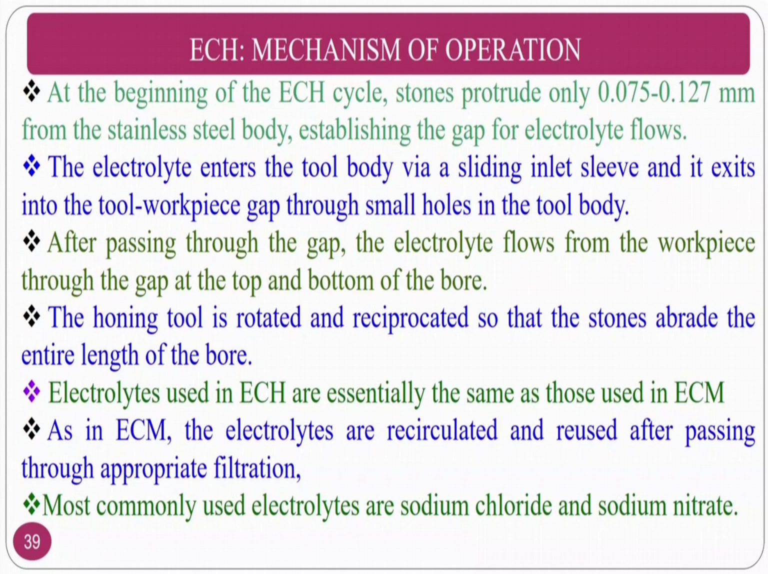

The mechanism of operation at the beginning of electrochemical cycle, electrochemical honing cycle stones protrude only by 0.75 to 0.127 mm from the stainless steel body establishing the gap of the electrolyte. The electrolyte enter into the tool body via the sliding inlet that you have seen in that one and it will enter into the inter electrode gap these small holes. After passing through the gap, electrolyte flows from the work piece through the gap and top and bottom of the bore. The honing trill is rotated and reciprocated as you can see in the conventional honing process. Also, electrolyte used in electrochemical honing or essentially same those are used in electrochemical machining process because there will not be much difference, ok.

If at all you want to use, you can use the same electrolytes that are normally used in electrochemical machining process as in electrochemical machining process electrolytes are recirculated and re used after passing through the proper filtration, ok. So, proper filtration should be done in this particular process also in order to remove the sledges. So, the most commonly used are sodium chloride as well as sodium nitrate that are commonly used in electro chemical machining process also. So, this particular process is used enormously for gear application and other things you can see here.

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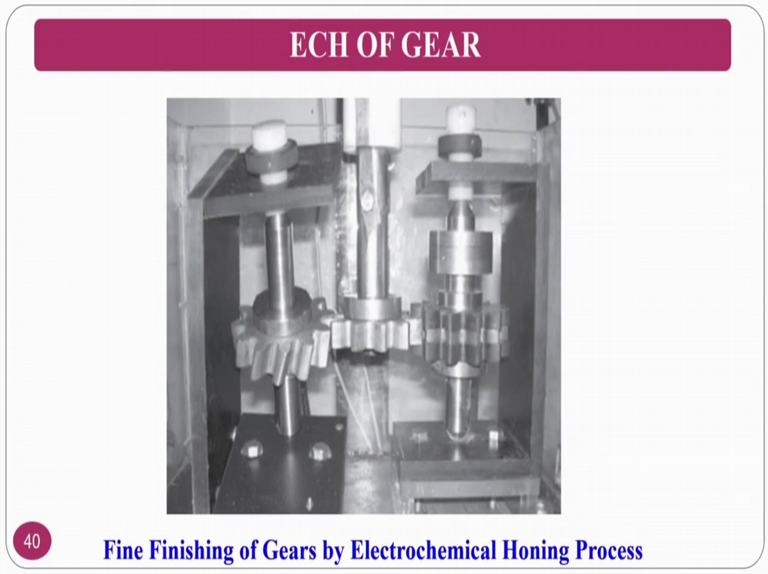

So, you can have the tool in the converse shape of the gear and you can have, you can do the finishing operations for the gears, so that the converse shape will act and the honing process will take place. Here you can give the reciprocation motion as well as a rotary motion also, ok. So, if you want you can avoid one of the motions like reciprocation motion can be avoided and only rotary motion can be provided here also, ok.

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ECH OF GEAR

Comparison of Bevel Gear Finishing by ECM, Honing and ECH

Items	ECM	Mechanical Honing	ECH
PIR_a	12.7%	−8.5%	34.6%
PIR_{max}	12.3%	0.6%	35.1%
MRR	0.06 mm^3/s	0.05 mm^3/s	0.31 mm^3/s

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So, the advantage of this electrochemical honing in terms of gear finishing, you can see the R a value and R max value as well as the MRR other things, ok. So, comparatively if you can get very good percentage of improvement in roughness value as well as maximum peak to minimum value and material removal, that is why this particular process is anonymously done by Professor P.K. Jain as well as Professor N.K. Jain for finishing of the gears, ok.

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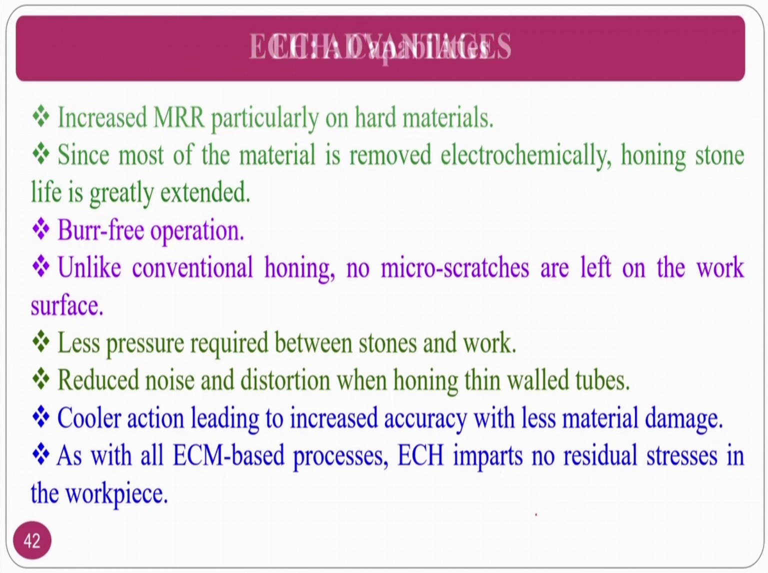

Advantages, the material removal rate will be enhanced particularly in terms of hard work piece materials. Since most of the materials are removed electrochemically, honing stones life normally will be high.

So, burr free operation because you have abrasion action and at the same time you have electrolytic dissolution. That is why the burrs will be reduced because whatever the burrs that are generated during abrasion action can be removed by electrochemical dissolution technique. That we have seen in the 3rd stage of electrochemical grinding process, ok. So, the burrs that are generated in the 2nd stage of electrochemical grinding will be removed in the 3rd stage of electrochemical grinding process. The same thing will be applicable in a electrochemical honing process also.

That is why this process can be burr free operation. Unlike conventional honing, no micro sketches are left out because this can be removed by electrochemical dissolution. Less pressure required between stones and work and reduce the noise and distortion when honing thin wall tubes and other things, cooler action leading to increase the accuracy with little material damage. That means that material metallurgical changes will be very less because the temperatures are very less in this particular process. Electrochemical honing imports no residual stress because the temperature is minimum.

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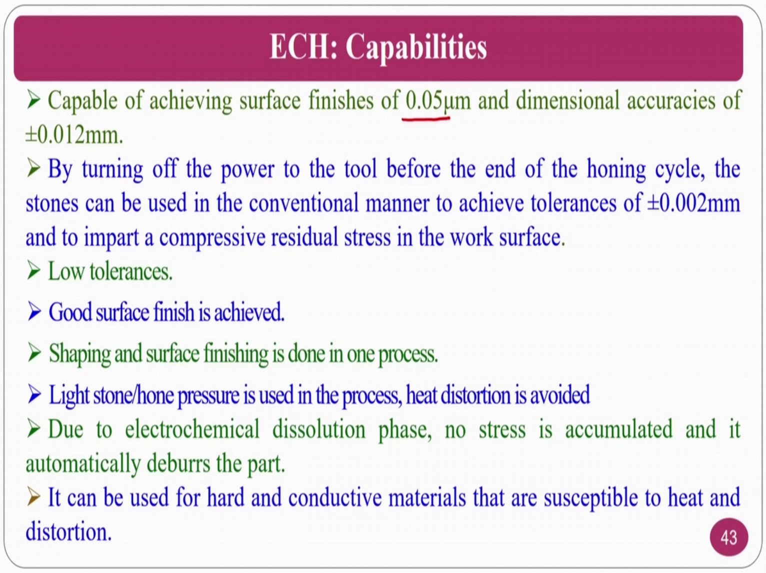

The capabilities, it can achieve the surface finishes of 0.05 microns and dimensional accuracies of plus or minus 0.012 mm. By turning off the power to the tool before the ending of the hone, you can generate or the compressive residual stresses and the low tolerances can be achieved, good surface finish you can achieve and the shaping and surface finishing is done in this particular process.

So, light stone or the hone pressure is used, so that heat distortion will be avoided. At the same time due to electrochemical dissolution faces, no stresses is accumulated and no the deburring action is not required because as I said everything will be taken care by this particular process by the electrochemical dissolution. It can be used for hard and electrically conductive materials, ok.

Hard machining of these materials will be very difficult because the forces in conventional grinding process or honing process whenever you are grinding hard materials will be enormously high, ok. For that purpose what you can use is this particular process can be used where electrochemical dissolution will be dominating. So, another process that we are going to see is electrolytic in process dressing based grinding process.

So, you can see here electrochemical grinding will be taken care and at the same time you have a dressing tool before it is going to for the grinding operation, ok. So, the grinding operation will be done here. At the same time, dressing operation will be done by this particular special location, ok. That is why this is electrolytic in process dressing based grinding process. Your grinding action is taking place at the bottom however before that one what you are going to do is you are dressing the wheel, so that the performance of the grinding wheel by the mechanical abrasion action will be very high.

If you see here these are the 4 stages. One will be like beginning of the dressing, at the ending of the dressing you will have the oxide layer. During or the beginning of the grinding, this oxide layer will worn out and the grinding wheel takes place and wear of oxide layer at the grinding ending, ok.

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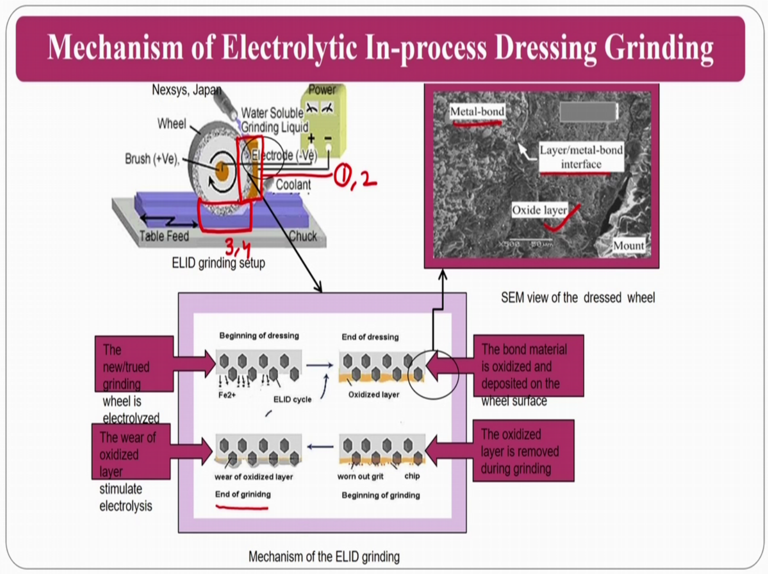

You see here completely the summary of this electrolytic in process dressing based grinding process.

So, if you see the dressing, what is happening you have seen here at the same time this is the beginning of the dressing means the stage 1 and the stage 2 is end of the grinding. End of the stage 2 is end of the dressing and stage 3 worn out of the oxide film and ending the process that you can see here. This is where stage 1 and 2 and this is where 3 and 4 will be done, ok.

So, you can also see here stage 2 which is most crucial where you have a metallic bonding will be there and metal bond interface is there and oxide layer is formed. This particular oxide layer will be started to worn out at the beginning of the grinding and at the end of the grinding wheel, this will be removed and the abrasive action will take place and material removal will be taken care by. This will be help in avoiding the wheel loading as you know wheel loading is a big problem whenever you are going to do the grinding of soft materials and other things. For that purpose you can use this in process dressing process for the grinding.

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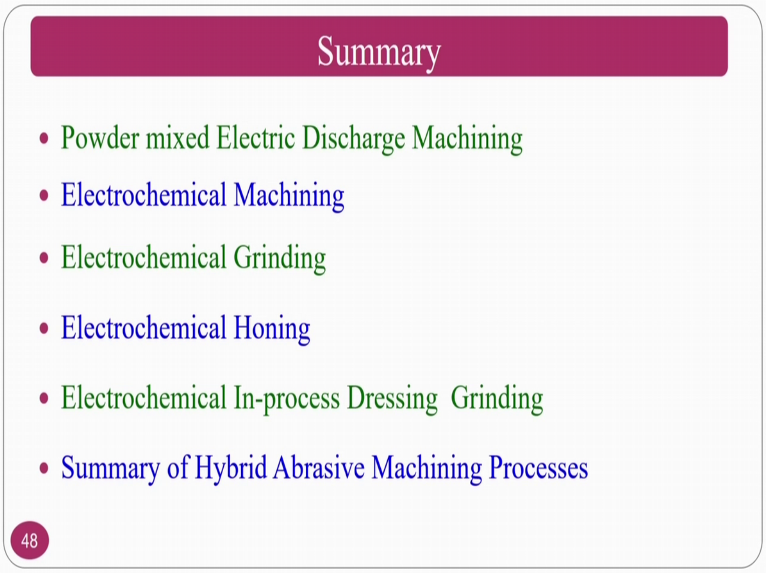

Summary of this particular class, we have seen the powder mix electric discharge machining which is only process that we have seen about, EDM allied or EDM hybrid process. Rest all we have seen electrochemical based and that is why we started with the basic mechanism of electrochemical machining process, then we moved on because we have to look into the abrasive processes. That is why we entered into electrochemical grinding process, then electrochemical honing process and electrochemical in process, dressing process and the summary that we are seeing in this particular class of board hybrid abrasive machining processes where electric discharge as well as electrochemical actions are clubbed along with the abrasive actions. This we have seen in previous class and this particular class.

Thank you for your kind attention.