Advanced Manufacturing Processes

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Module - 03
Advanced Machining Processes
Lecture - 16
The Subsystems in ECM, advantages and applications

Welcome to this session on electro chemical honing electro chemical grinding and some other variant processes in the electro chemical machining systems. Under the course advanced manufacturing processes in previous two sessions, we have discussed about the basics of electro chemical machining process its working principles and its subsystems. The advantages limitations and applications of the ECM process have also been discussed. In the present session we will study about some other variant process of the basic ECM process these include electro chemical grinding process also in short is known as ECG process, which is a combination of electro chemical and conventional grinding process.

Then electro chemical honing in short ECH process which is again a combination of a basic electro chemical process as well as the conventional mechanical honing process. And two other variants like ECDE electro chemical dividing process and STEM process. Let us first discuss electro chemical grinding process electro chemical grinding or ECG is a variant process of the basic ECM, it is a bar free and stress free material removal process, wherein material removal of the electronically conductive material takes place through the combined action of mechanical, which is nothing but conventional grinding process in which the tiny chips will be removed through scratching and electro chemical process.

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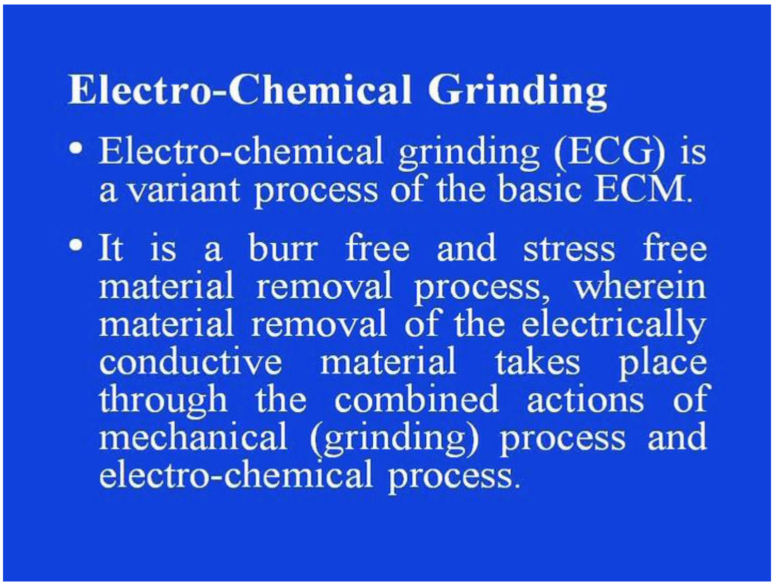

In which material will be removed through electrolysis as we have already discussed during the ECM process. In this process the abrasive lead and grinding field is connected to the cathode and the work piece is connected to the anode. They are separated by an electrolyte fluid the fine chips of the material that is removed from the work piece which are also called debris stays in the electrolyte fluid which is further filtered out.

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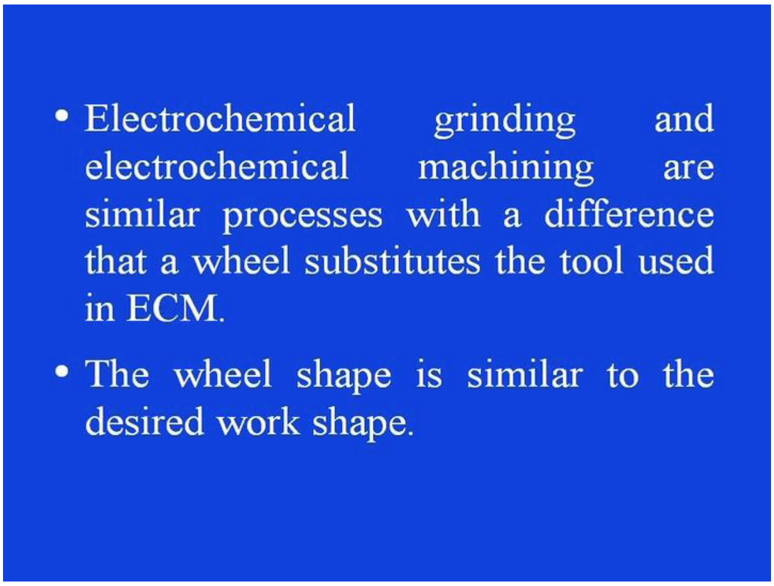

Electrochemical grinding and electro chemical machining are similar processes with a difference that a wheel substitutes the tool used in ECM. The wheel shape is similar to the desired work shape. Now, let us see the process of grinding in ECM the main feature of electro chemical grinding is the use of a metallic grinding field which is embedded with insulating abrasive particles. Such as diamond abrasive particles are set in the conducting material.

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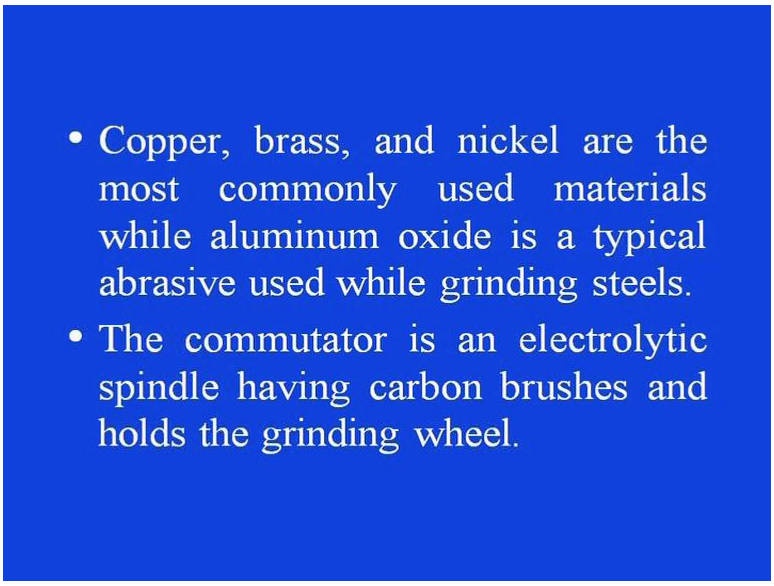

Copper brass and the nickel are the most commonly used materials while aluminium oxide is a typical abrasive used while grinding steels. The commutator is an electrolytic spindle having carbon brushes and holds the grinding wheel it receives a negative charge from the D C power supply and work piece is connected to the positive terminal in the ECG process. The grinding will slightly touches the work piece and the electrolyte is supplied on to the grinding wheel near the work piece. The wheel carries the electrolyte through the grinding process. It is there by results in an electro chemical action a nozzle similar to the one which carries coolant in a conventional grinding process is provided.

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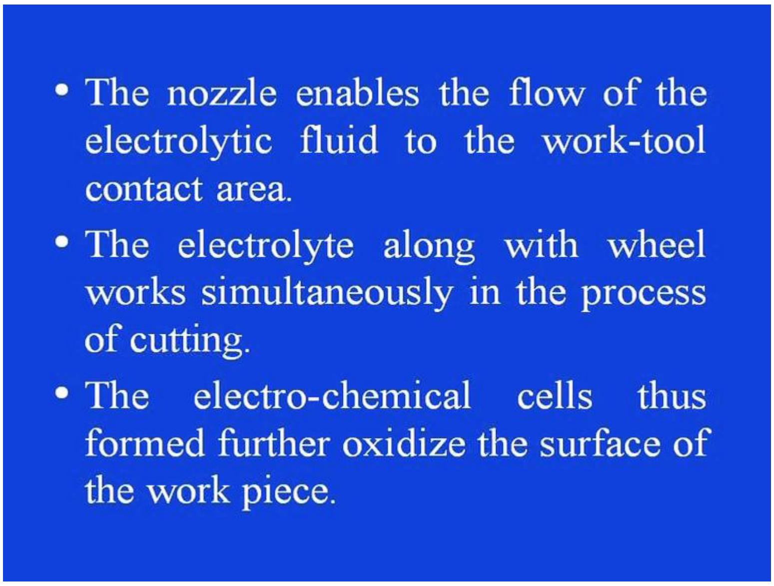

The nozzle enables the flow of the electrolytic fluid to the work tool contact area the electrolyte along with wheel works simultaneously in the process of cutting. The electro chemical cells, thus formed further oxidize the surface of the work piece. The wheel carries away the formed oxidize there by exposing the fresh metal layers beneath the oxide layer. In this process the major material removal activity takes place by the electrolytic action which is around 90 percent the rest of the material removal around 10 percent takes place due to the mechanical grinding action.

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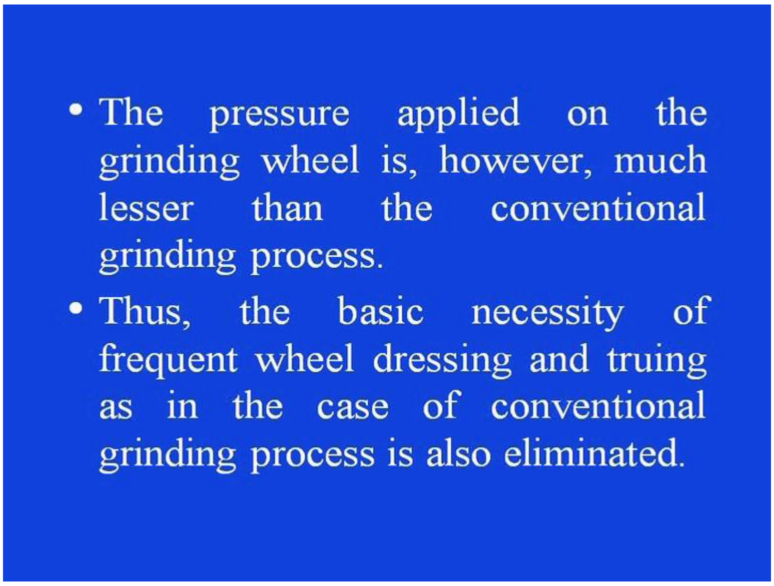

The pressure applied on the grinding wheel is however much lesser than the conventional grinding process. Thus the basic necessity of frequent wheel dressing and truing as in the case of conventional grinding process is also eliminated. The basic mechanism can be explained something like this, this is the work piece, which will be connected to as we have already said to the positive terminal of the supply. Here the other terminal will consist of the grinding wheel.

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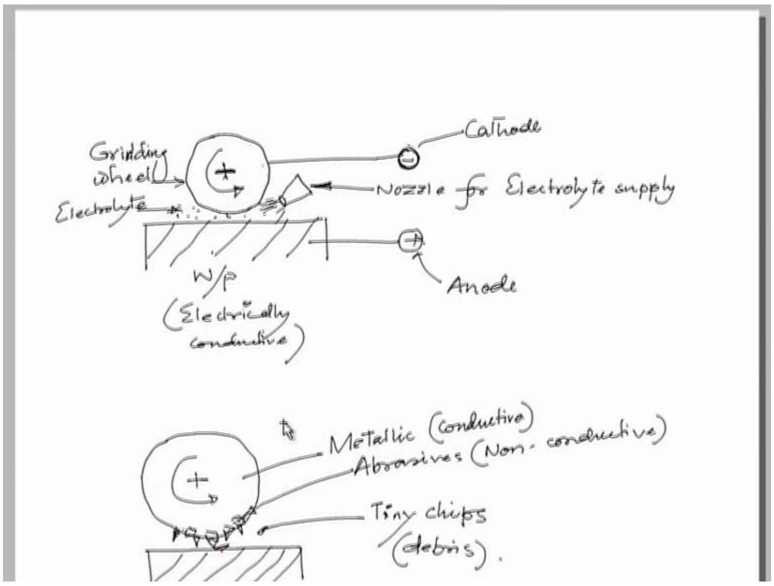

So, this is the grinding wheel this will be connected to negative terminal or this will form the cathode here in between there will be a nozzle which will supply electrolyte. This is nozzle for electrolyte supply there four there will be a continuous supply of electrolyte here. And thereby, it forms basic ECM cell electro chemical machining cell in which there will be a tool which will be connected to the cathode this is the cathode and the work piece which should be of course electrically conductive should be eccentrically conductive and this will be connected to the anode of the power supply. Now they will be separated in between by the electrolyte.

So, this nothing but the electrolyte and there are like conventionally used electrolytes as per the material specification or the material to be machined. Now, this grinding will as we know this will consist of generally 2 phases 1 phase will be of the binders and at on to this binders there will be abrasive particles upgraded on this embedded on this. These abrasive particles actually will be responsible for scratching the work piece like this. So, this abrasive particles, in fact will take take part in taking some materials away from this work piece surface.

So, this is the work piece and this will take away some tiny chips from this. So, this are tiny chips, also we can call as debris this tiny chips this will be rotating like this will be rotating like this. Now, this matrix part or the binder part will be metallic material and therefore, they are conductive. However, this abrasives parts these are abrasives these are abrasives and they are generally non conductive non conductive thus these due to this presence of this abrasives in the cutting zone. So, this is if we consider this as the cutting zone.

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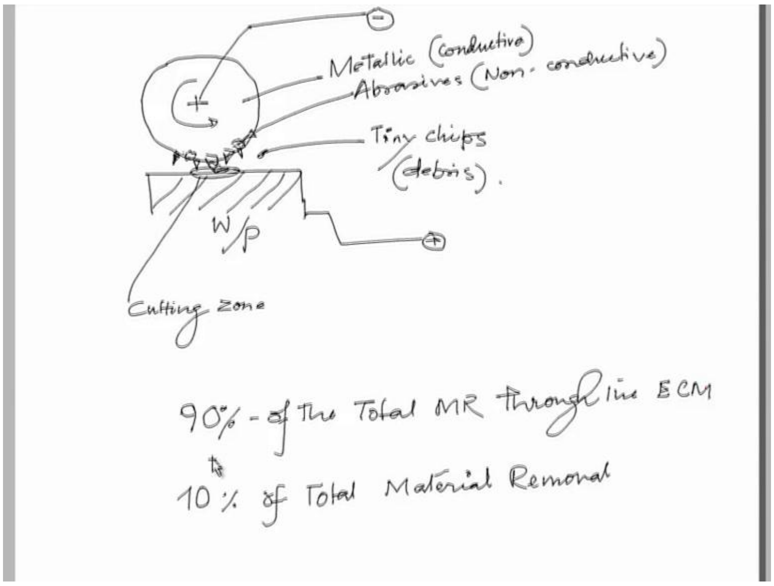

So, the direct contact between the anode and the cathode will be prevented due to the abrasives which are non conductive in nature. This as we have already told this will be connected to the cathode and this will be connected to the anode and the direct contact between this cathode and anode will be prevented by this abrasive particles, which will take part in abrasive actions and this abrasives will be responsible for machining only 10 percent of the total 10 percent of the total material removal where as 90 percent of the material removal of the total material. Removal will be through the conventional ECM process.

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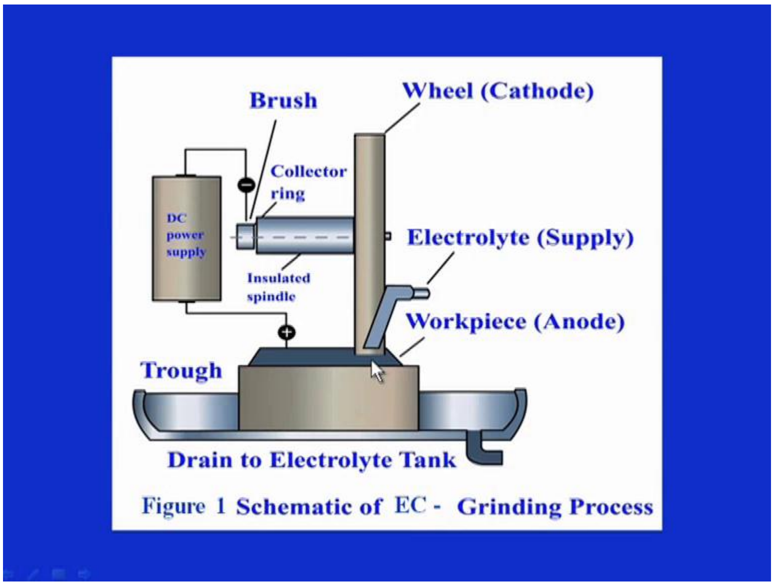

So, here in the screen also it is shown the schematic of the electro chemical grinding process. In which this is the work piece to be machined, which is connected to the positive terminal of the power supply DC power supply and the other wheel the other terminal is connected to the wheel the grinding wheel, which will act as the cathode. There will be some brass arrangements here bush some brash arrangements commutater arrangements, which will prevent the direct contact with the electrical connections to the machine body. And as we have already explained, so there will be a nozzle which will supply the electrolyte through this nozzle though the machining zone.

So, here this will be the machining zone in which the distance between the cathode as well as the anode will be minimal and there the actual electrolysis will takes place. And then in addition to that as we have already discussed there will be the mechanical scratching action, which will be responsible for removing some of the materials in the form of tiny chips. Moreover, another important thing in this is as we have already discussed there will be a gas layer formation gas layer formation or oxide layer formation on the work piece surface.

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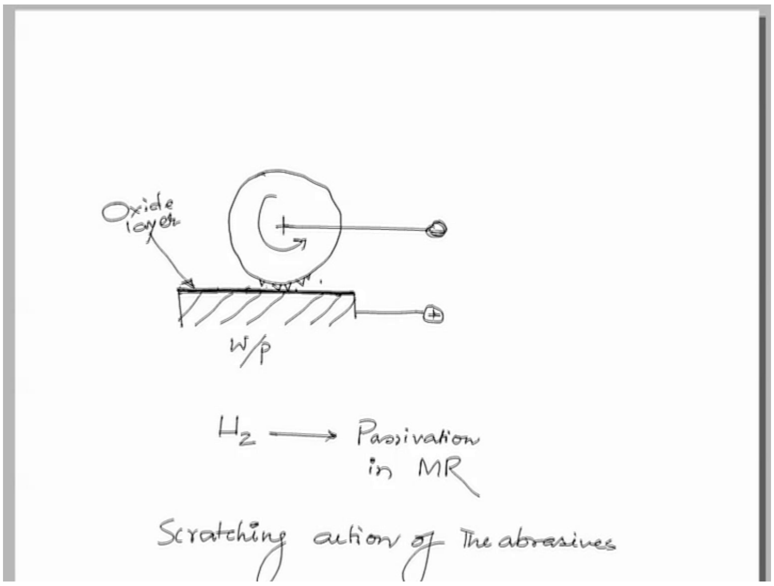

So, if this is the work piece then if this is been ground this is the work piece this is connected to negative and this is connected to the positive terminals. Now, during machining there will be an extremely small oxide layer formation because of the electrolytic electrolysis action. Now, this is the oxide layer and this oxide layer prevents or minimizes the electro chemical action further therefore, in ECG process because of this grinding action. This small scratching this grinding abrasives they removes this oxide layer and it reutilizes the electro chemical action there by the continuation of this electrolysis process takes place otherwise it slows down more over one more phenomena.

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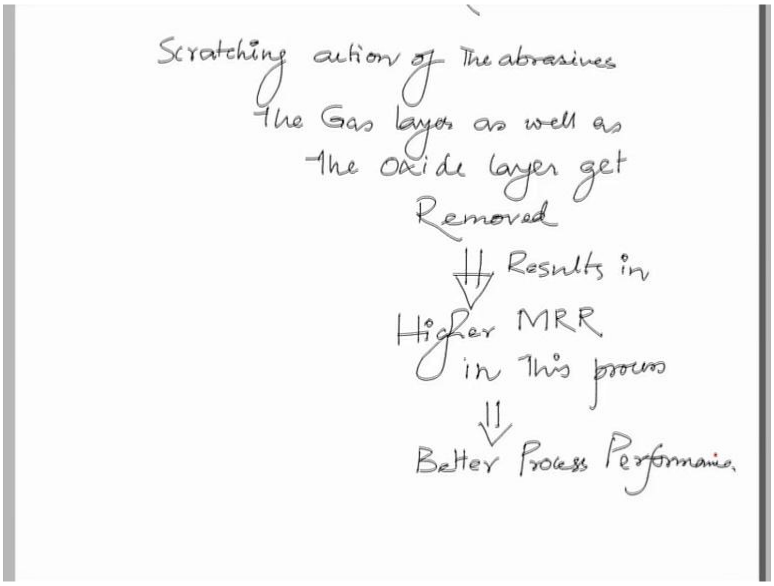

As we have seen earlier there will be the hydrogen, hydrogen gas evaluation. now this hydrogen layer also acts as the passivating agent. So, this causes passivation in the in material removal process. Now, because of this scratching action of this abrasive scratching action of the abrasive the gas layer gas layer as well as the oxide layer get removed, which enhances results in or we can say this results in in higher MRR in this process or we can say this results in better process performance.

Now, let us look at the process characteristics in the process the life of a grinding wheel in electro chemical grinding process is very high as approximately 90 percent of the material is removed by electrolysis action and only 10 percent is due to the abrasive action of the grinding wheel unlike in the conventional grinding process where 100 percent of the material removal is due to the grinding or abrasive action of the grinding wheel.

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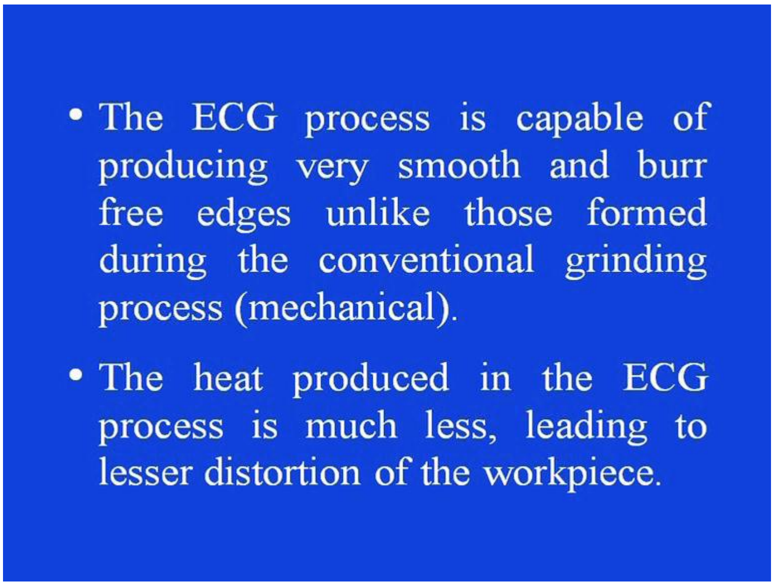

The ECG process is capable of producing very smooth and burr free edges unlike those formed during the conventional grinding process. The heat produced in the ECG process is much less leading to lesser distortion of the work piece. This also we have seen in the conventional grinding process (( )) aggressive there will be grinding bond because of the very high heat developed in the cutting zone and because of low conduction and convection of the heat from the cutting zone.

Therefore, this is and associated problem with conventional grinding process. However, in this process the work piece will be always wet with the electrolyte system and most of the material removal will take place which we have already stated as 90 percent through electrical disassociation. Only 10 percent of the total material removal will be through the grinding process therefore, the thermal damage due to this grinding temperature development will be much lesser relative to the conventional grinding process.

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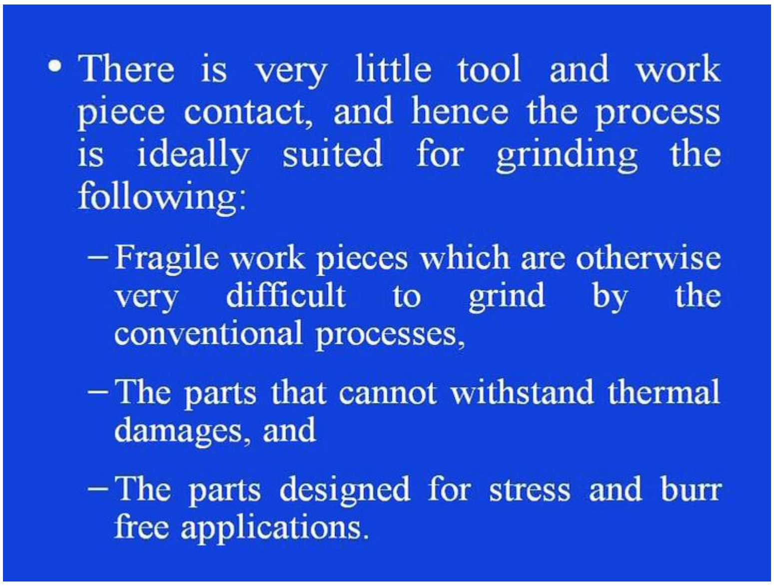

There is very little tool and work piece contact and hence the process is ideally suited for grinding the following number 1 fragile work pieces which are otherwise very difficult to grind by the conventional processes. The parts that cannot withstand thermal damages as we have already spoken about damages due to the thermal or the temperature development during the grinding process is minimal hear in this process. And therefore, those parts which are likely to be damaged because of the heat of machining can be machined in this process. The parts designed for stress and burr free applications can be very easily and very effectively machined by this process.

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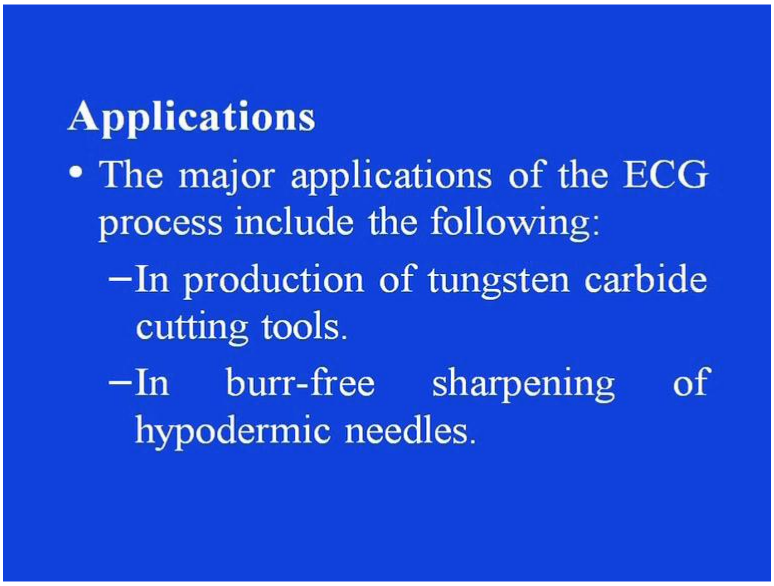

Now, let us see few applications of this electro chemical grinding process. So, they include the following in production of tungsten carbide cutting tools this ECG process is found to be very very effective. In production of burr-free sharpening of hypodermic needles in grinding of super alloy turbine blades in form grinding of aero space honcho metals. In the removal of factice tracts from steel structures that have been used for under water applications.

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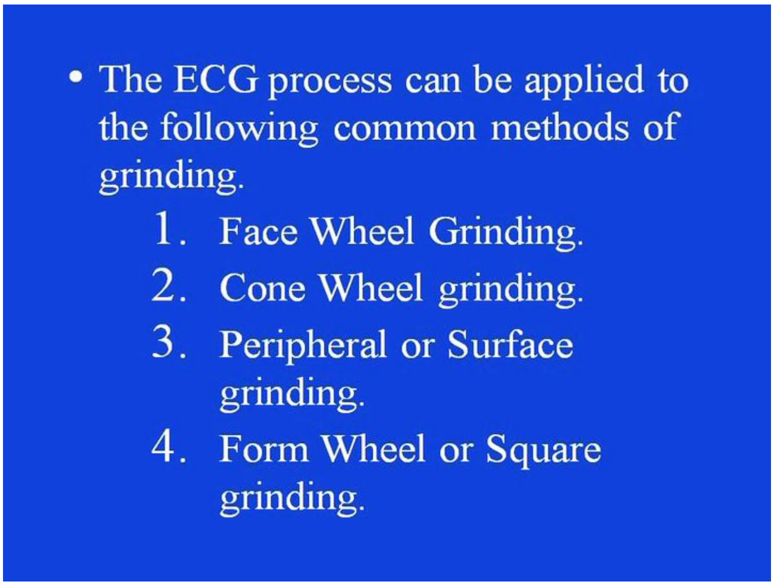

The ECG process can be applied to the following common methods of grinding number 1; face wheel grinding, number 2; cone wheel grinding, number 3; peripheral or surface grinding, number 4; form wheel or square grinding. Now, let us move on to another process which is also considered of the variant of this basic electro chemical process. This is nothing but electro chemical honing process the principle is almost similar as we know in the basic honing process there will be internal generally internal surfaces will be missing.

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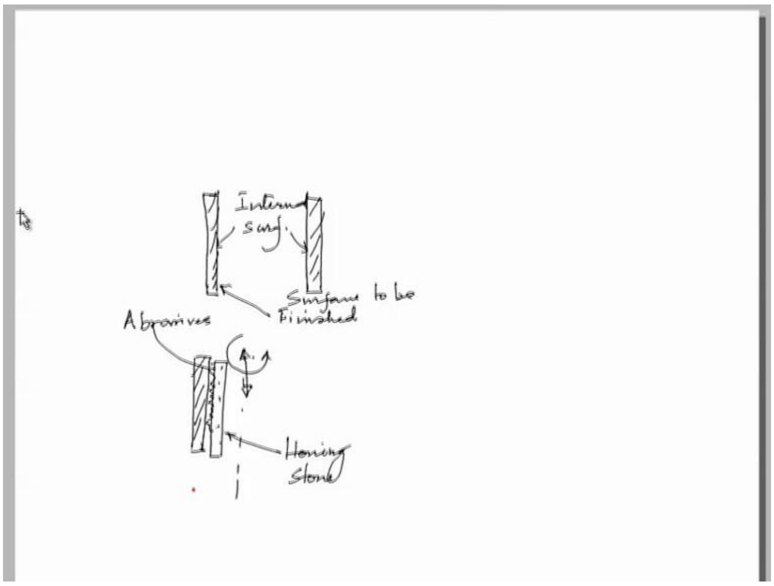

So, if this is the work piece cylindrical work piece and these are the internal surfaces to be honed internal surfaces. Then what is being done is there will be one hone which will be used for finishing this hone will have some small or tiny abrasives embedded into this abrasives. This abrasive will be responsible for touching the work piece material. So, this is, if this is the work piece surface this hone the abrasives embedded on this hone will touch this surface and they will remove tiny chips from the work piece surfaces making this internal surface highly finished.

This is the surface to be finished and after this is. So, this is called honing stone honing stone this honing stone moves in two different directions. 1 is there will be rotary motion of this honing stone and there will be 1 reciprocating motion about this axis. Therefore, the resulting movement of the honing store or that parts of this abrasives that will move with respect to the surface to be finished will be something like this. This is called also called cross hatch pattern.

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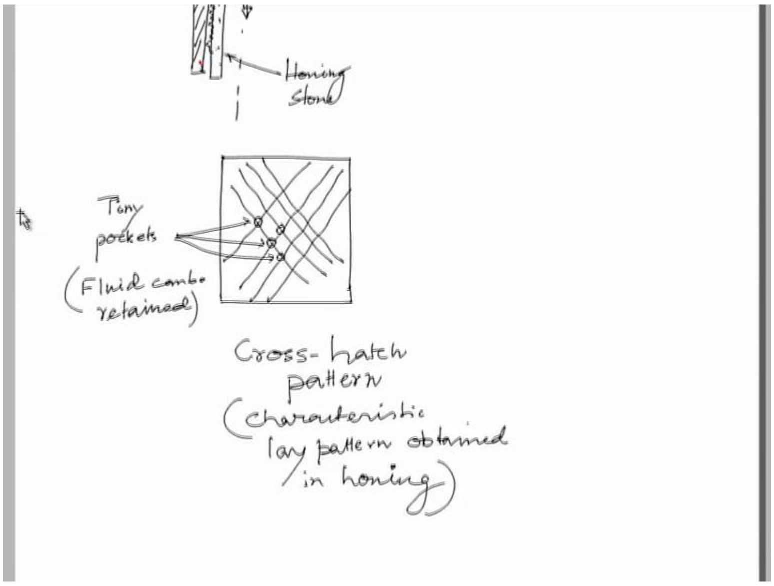

This is considered to be a characteristic lay pattern obtained in honing this is found to be very very useful as these cross sections these cross sections here they serve as tiny pockets tiny pockets where fluids can be retained in some applications. For some applications thus this particular process is considered to be very very useful for creating some functional surfaces. Now, in this hybrid matter that we are currently talking about. In addition to this basic honing process this work piece and this honing stone will be connected to the anode and the cathode respectively and there by the basic ECM cell will be constructed, which will be responsible for removing some material with the basic electro chemical action that we have already discussed.

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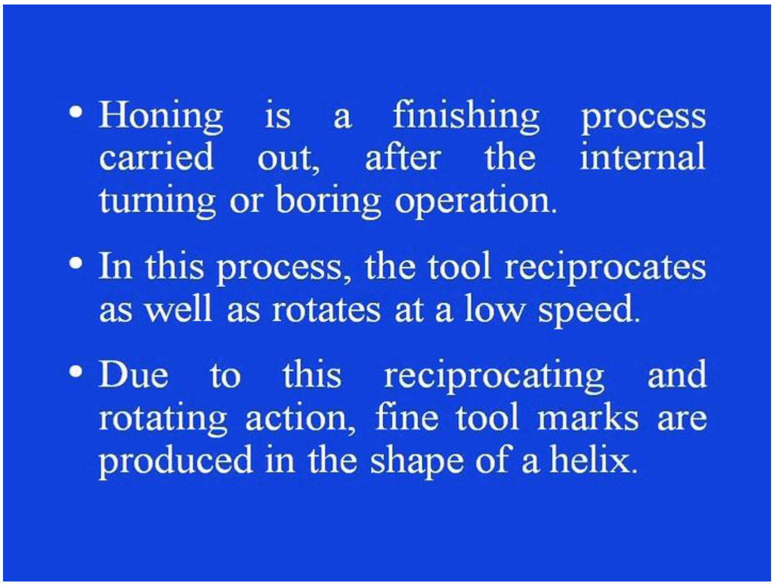

So, honing is a basic finishing process. So, in which the tool reciprocates as well as rotates at a very low speed as we have already explained due to this reciprocating and rotating action fine tool marks are produced in the shape of a helix. That we have already discussed this fine helical marks also known as cross hates tool marks act as the oil carrier and oil retailers this is a very important feature required for hydraulic applications wherein this retained oil helps in self lubrication of the cells. And internal parts honing process uses a continuous circulating oil commonly called the honing oil. This oil helps in heat removal and also carries away the powdered sludge formed by the removal of material from the work piece.

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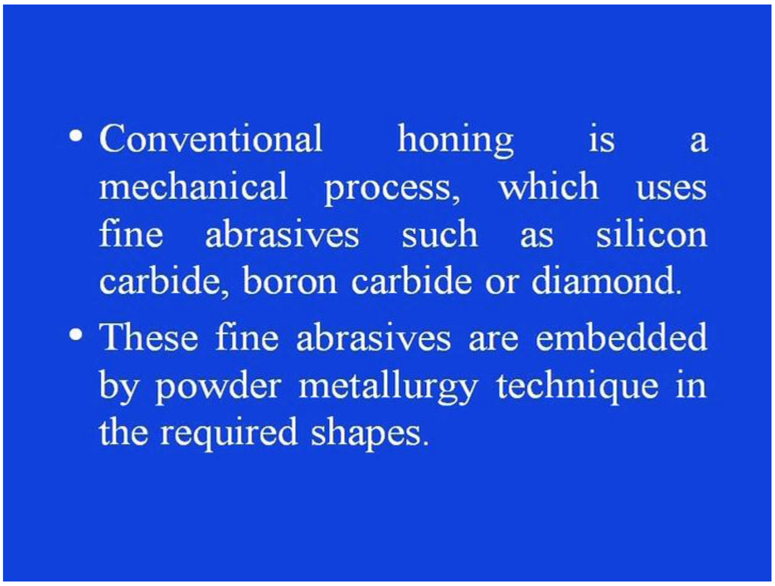

Conventional honing is a mechanical process which uses fine abrasives such as silicon carbide boron carbide or diamond. These fine abrasives are embedded by powder metallurgy technique in the required shapes these are further attached to the honing material. They are often called as honing stones or honing sticks. Just now we have discussed about this honing stones. The electro chemical honing process which is a hybrid process integrating the basic electro chemical machining action and the mechanical honing action in which the material removal takes place by the conventional. Well known sharing action yields added benefits in terms of number 1 improved surface finish number 2 reduced work times and number 3 improved tool life which is found to be up to 3 times the basic process by passing electric current in to the electrolyte solution.

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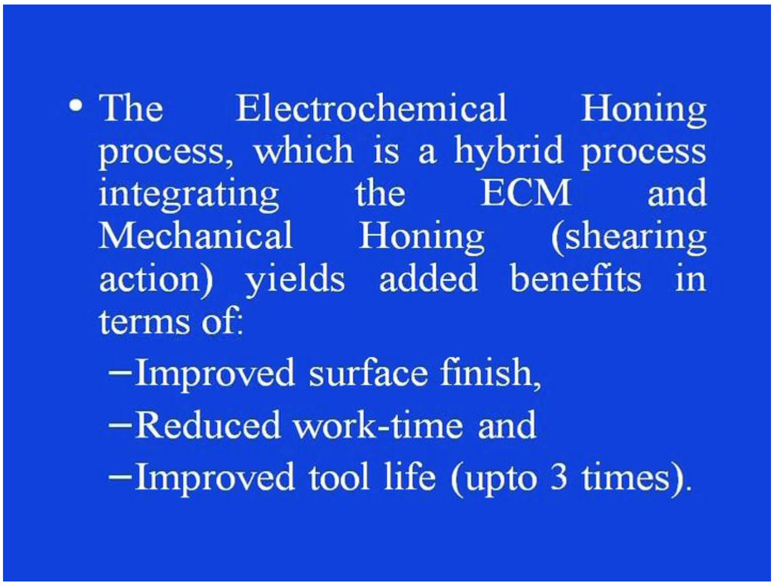

Major material removal takes place by the electrolytic action as we have seen in case of electro chemical grinding in which 90 percent of the material takes place in the form of electrolytic action whereas, only 10 percent is through basic grinding action. So, here also it is similar the basic electrolytic action is the major material removal mechanism in this process as well and the honing stones are abrasive help in removal of the material by very small percentage which is approximately 10 percent in this case as well.

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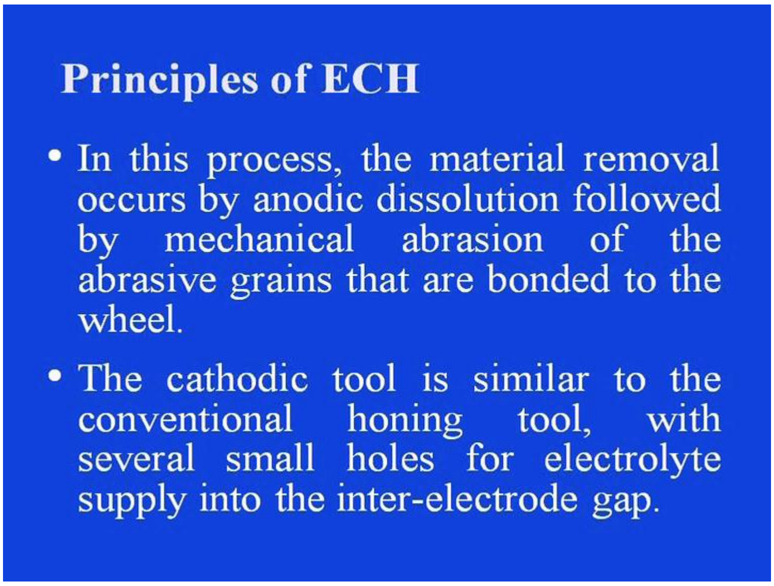

Let us see the principles of electro chemical honing process. In this process as, we have already indicated the material removal occurs by anodic dissolution followed by mechanical abrasion of the abrasive grains. That are bonded to the honing stone the cathodic tool is similar to the conventional honing tool with several small holes for electrolyte supply in to the inter electrode gap. As we have already told if this is the work piece surface and this is the honing stone in which this small small these are the abrasives. So, this will be considered as inter electrode gap this is also known as IEG this is nothing, but, inter electrode gap. This will be this will keep the positively connected work piece and negatively connected tool which is nothing, but the honing stone.

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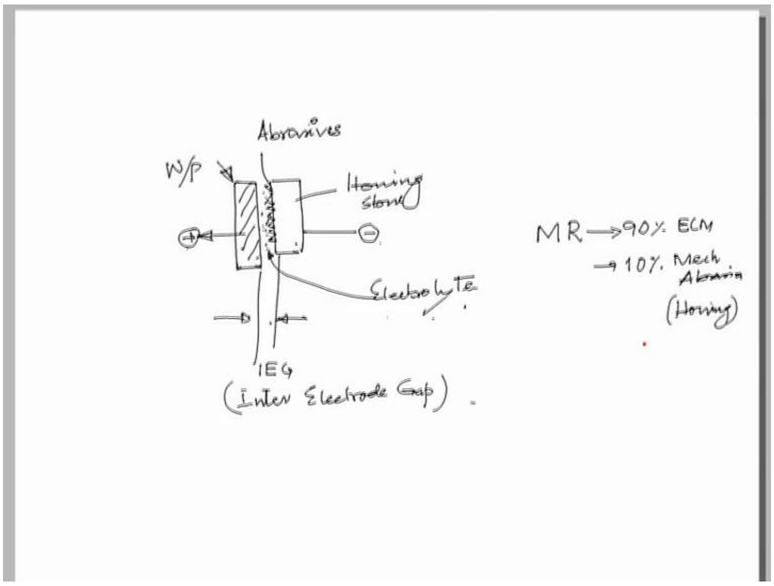

In this case apart by this distance of this IEG and in between there will be the abrasives which will actually make contact with the work piece. So, this is the work piece which is generally conductive in nature. And in this gap there will be the electrolyte kept on flown. So, this will be nothing, but, the electrolyte thus as we can correlate which in the previous basic ECM cell. So, this has got every characteristic of an ECM cell in which work piece is the anode and the tool is the cathode and in between them an electrolyte is being flown keeping a distance between them is the IEG or inter electrode gap.

So, here again the material removal will be 90 percent 90 percent through ECM and only 10 percent will be through mechanical abrasion which is nothing but honing action which is nothing but honing. The electrolyte provides electrons through the ionization process acts as a coolant and flashes away chips that are shared of by mechanical abrasion in short known as MA and metals sludge that results from electro chemical desolation action.

The majority of material is removed by the ECD or electro chemical desolation phase while the abrading stones remove enough metal to generate a round straight and geometrically through cylinder. During machining the mechanical abrasion removes the surface oxides this we have already discussed with respect to the electro chemical grinding process. Wherein also there will be an oxide layer and this oxide layer will be removed continuously by the grinding action of the tiny abrasive present on the wheel.

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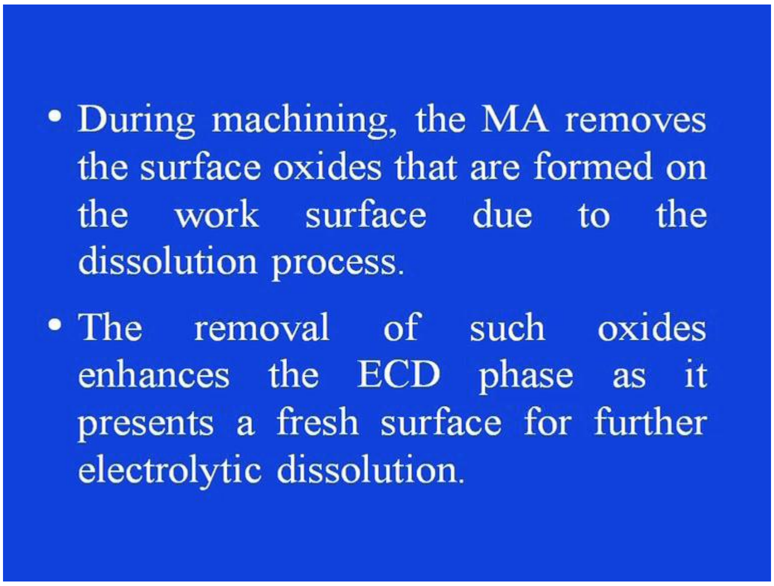

So, here also the same oxide will be removed by the tiny abrasives embedded on the honing stone. The removal of such oxides enhances the ECD phase as it presents a fresh surface for further electrolytic dissolution. As we have told if this oxide layer forms then the performance of the electrolytic dissolution comes down. Because of because most of the oxides are non conductive in nature and this stops the electrolytic tends to rather tends to stop the electrolytic action which. However, will be removed by this abrasive action of this honing stone.

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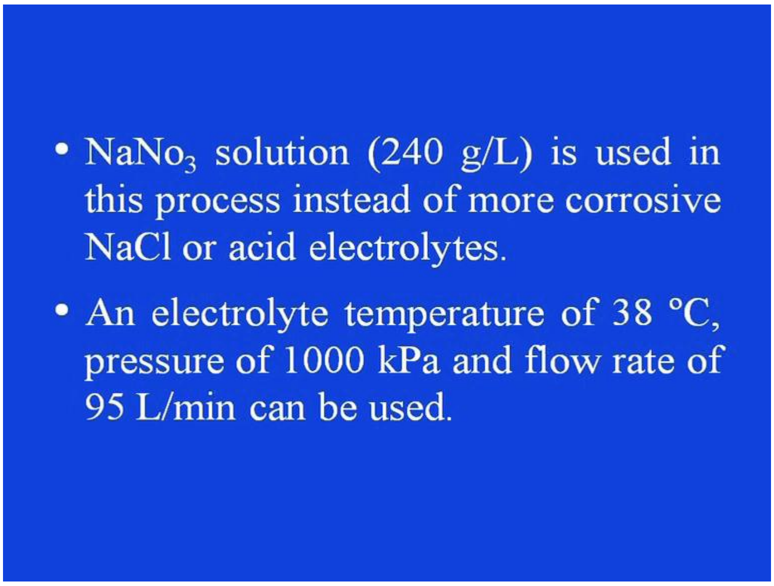

Sodium nitrate solution with a conservation of 240 gram per litter is used in this process instead of more corrosive sodium chloride or acid electrolytes. An electrolyte temperature of 38 degree Celsius and pressure of 100 kilo Pascal and a flow rate of 95 litters per minute can be used for this process. Electro chemical honing employs direct current at a gap voltage of 6 to 30 volts which ensures a current density of 400 and 65 empires per square centimetre which is considered to quite high. Improper electrolyte distribution in the machining machining gap may lead to geometrical errors in produced bow.

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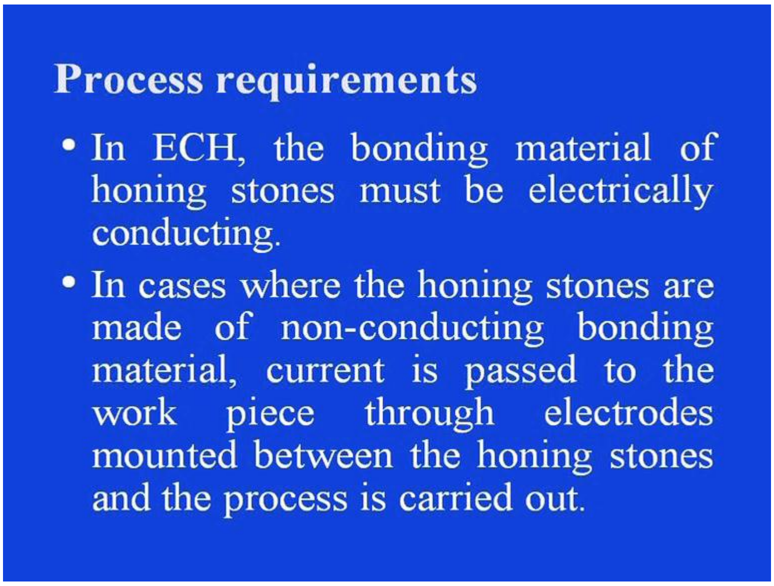

Now, let us see what are the process requirements in electro chemical honing. In this process the bonding material of honing stones must be electrically conducting. This we have discussed with reference to electro chemical grinding process as well in which the grinding wheel consist of metallic materials; that means, the basic binder face consist of the metallic materials which are naturally electrically conductive. On to this conductive materials non conductive abrasives like diamond or silicon carbide etcetera are embedded in cases where the honing stones are made of non conducting bonding material.

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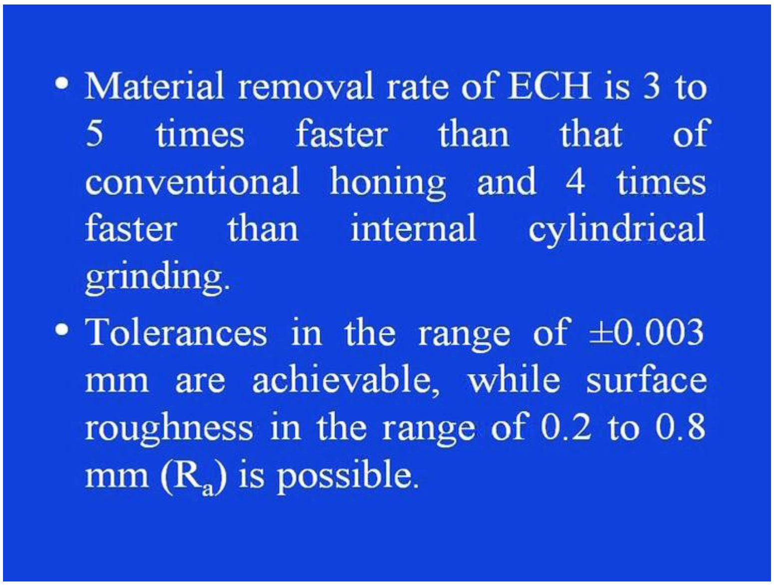

Current is passed to the work piece through electrodes mounted between the honing stones and the process is carried out. A small gap of around hundred microns is maintained between the work and the electrodes the supply of electrolyte is made through series of holes different electrolytes depending on the work material can be used. Material removal rate of 3 to 5 times faster than that of conventional honing and 4 times faster than internal cylindrical grinding can be obtained in this process.

Tolerances in the range of plus minus 0.003 mille meter are easily achievable while surface roughness in the range of 0.2 to 0.8 milimeter of average roughness are easily available for hydrolic applications where the cross hatch pattern is explained earlier for oil retention is desired. Then the electric current is turned off for the last few strokes and the mechanical abrasion mode of honing is accomplished. However, for stress phase free surfaces and geometrically accurate bores the last few seconds of mechanical abrasions should be avoid in favour of pure electro chemical dissolution process. Therefore, the marks or what we call as cross hatch pattern will be absent.

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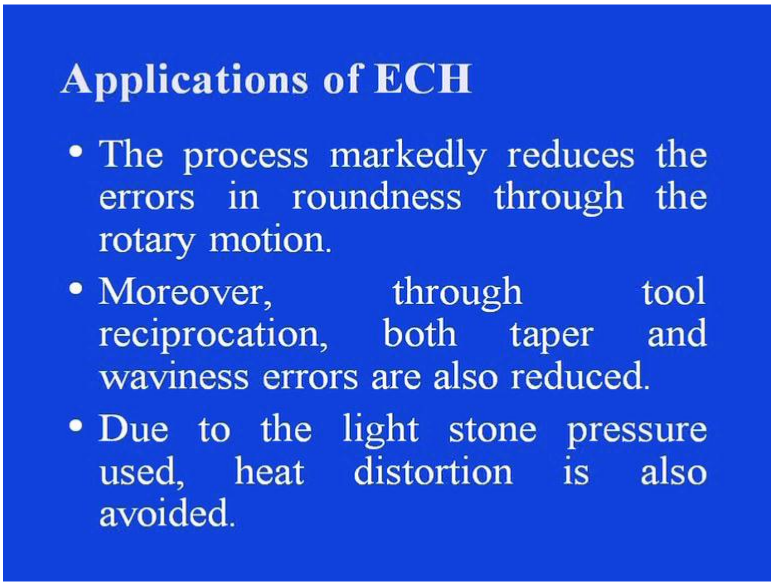

Now, let us see few applications of the electro chemical honing process. The process markedly reduces the errors in the roundness through the rotary motion. Moreover through tool reciprocation both taper and waviness errors are also reduced due to the light stone pressure used heat distortion is also avoided. The electro chemical honing process is commonly used in precision finishing of various mechanical and hydraulic applications oriented compounds like micro finishing of gears micro finishing of pump and valve components.

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The presence of the electro chemical disillusion phase introduces no stress and automatically deburrs the part in this process the electro chemical honing process thus can be used for hard and conductive materials that are susceptible to heat and distortion. The process can be tackle pinion gears of high alloy steels as well as holes in cast tool steel components, own forming in another application that combines honing and electro deposition process. It is used simultaneously abrade the work surface and deposit metal the method is reversal of electro chemical honing in basic principles.

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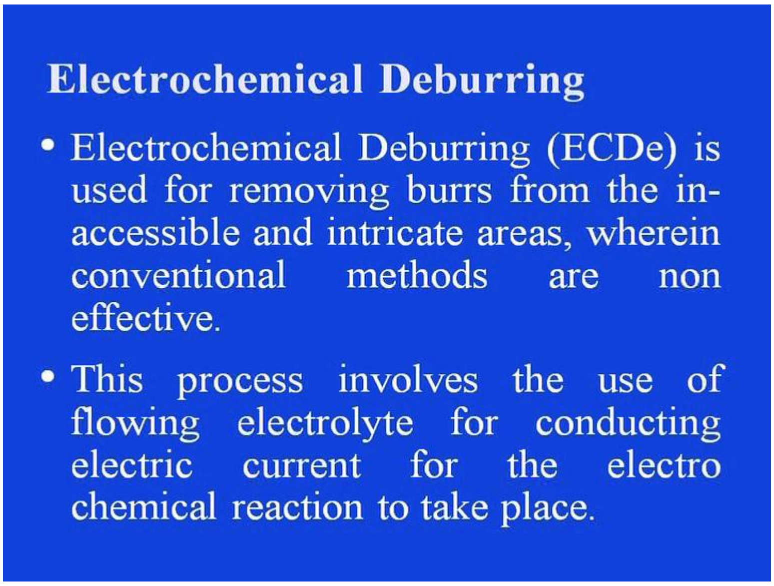

Now, let us move onto other electro chemical machining variant processes and their applications once is process is electro chemical deburring, which is in short known as ECDe. This process is used for removing burrs from the inaccessible and implicated areas wherein conventional methods are non effective. This process involves the use of flowing electrolyte for conducting electric current for the electro chemical reaction to take place.

Based on experimentations and the experience the current and time of deburring are set the commonly used electrolytes are sodium nitrate or sodium chloride the deburring machines need to be built from non corrosive materials else the corrosive nature of electrolyte, which we have already discussed as sodium fluoride and sodium nitrate in which sodium chloride is highly corrosive as we know. So, this type of electrolyte will corrode the machine parts them self.

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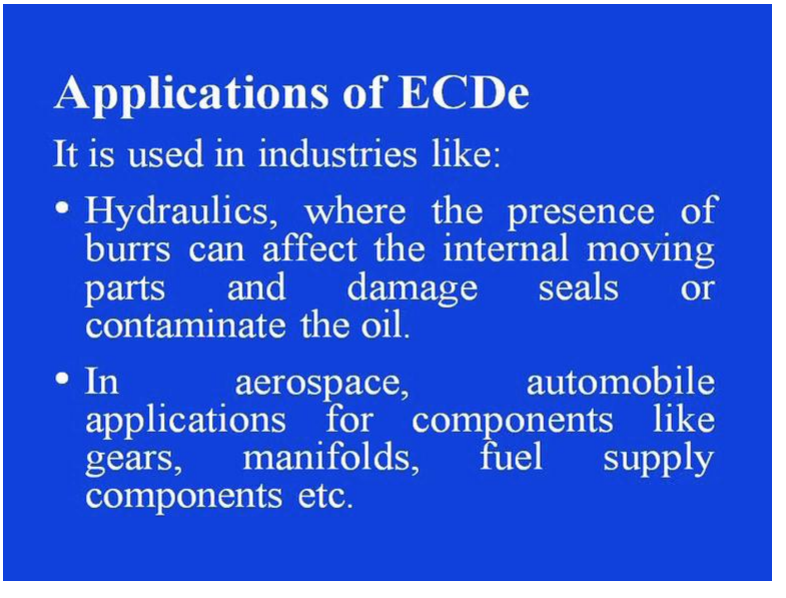

The basic applications of electro chemical deburring processes include hydraulics where the presence of burrs can affect the internal moving parts and damage seals of contaminate. The oil damage the seals there four if the seals are broken then that will contaminate the entire oil in aerospace or automobile applications for components like gears manifolds fuel supply components etcetera this process is used. Other applications involved consumer appliances and biomedical systems the system gives higher reliability lesser operational time uniformity and overall a very economical process the process can also be automated very easily.

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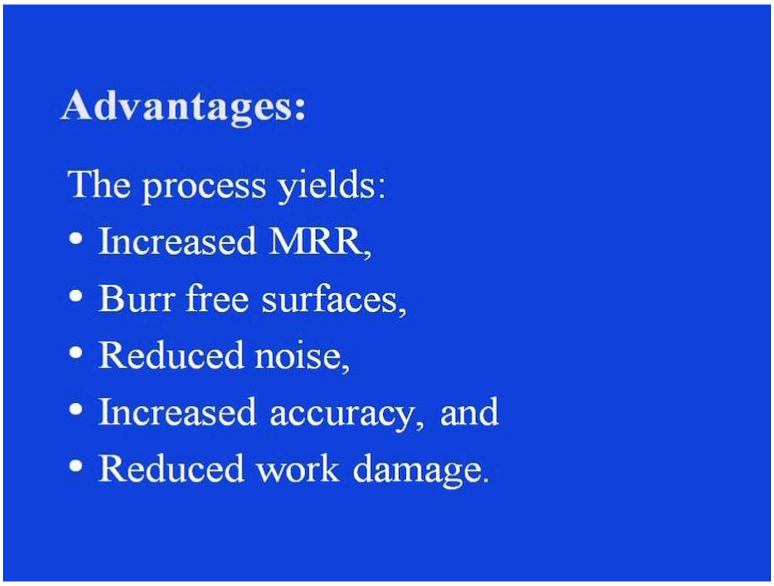

The advantages of this process include increased MRR burr, free surfaces, reduced noise, increased accuracy and reduced work damage. Now, let us look at another variant process which is called saved tube electrolytic machining in short stem process. It is based on the dissolution process when an electric potential difference is imposed between the anodic work piece and a cathode tool.

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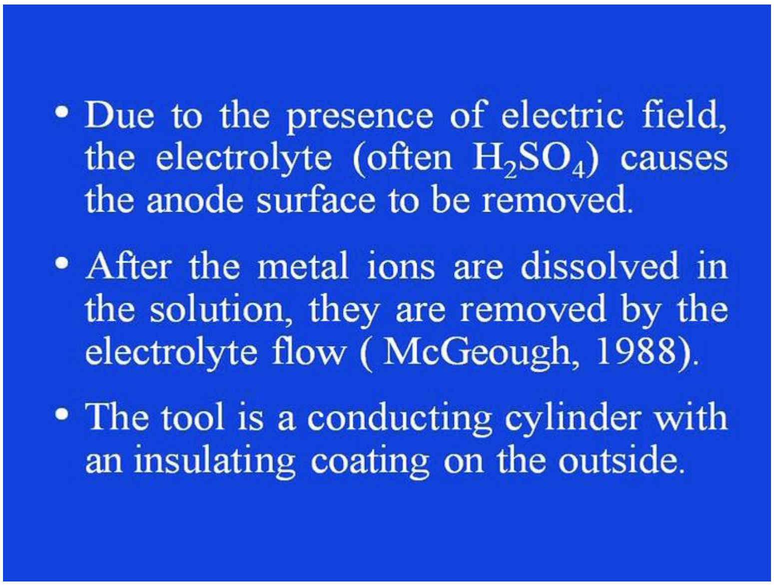

Due to the presence of electric field the electrolyte often sulphuric acid H 2 S O 4 is used causes the anode surface to be removed. After the metal ions are dissolved in the solution they are removed by the electrolyte flow the tool is a conducting cylinder with an insulating coating on the outside. The tool is moved towards the work piece at certain feed rate while a voltage is applied across the machining gap in this field a cylindrically shaped hole is obtained. STEM is a modified variation of the ECM process that uses acid electrolytes. For example, sulphuric acid.

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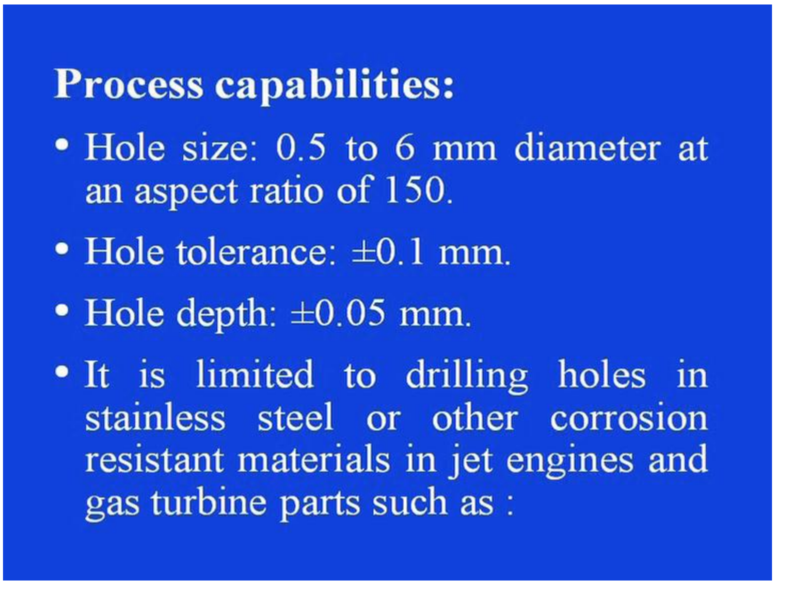

Let us quickly look at the process capabilities of this STEM process hole sizes of 0.5 to 6 mm diameter at an aspect ratio of 150, which is quit high can be produced. Then hole tolerance is obtainable in this process is plus minus 0.1 mm hole depth can be obtained as 0.05 mm. This is the tolerance as well as the whole depth is concerned which is quite a high.

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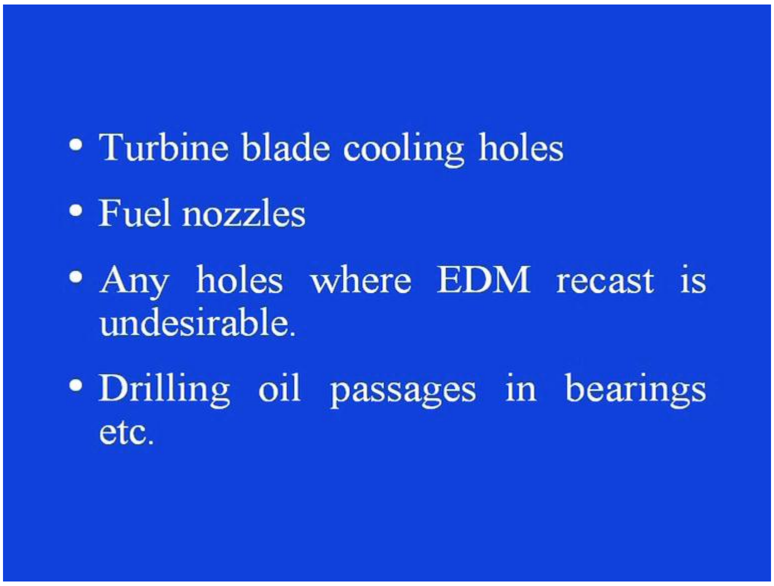

This process is limited to drilling holes in stainless steel or other corrosion resistant materials in jet engines and gas turbine parts such as turbine blade cooling holes fuel nozzles any holes where EDM recast is undesirable this recast layer can be removed by this process drilling oil passages in bearings etcetera.

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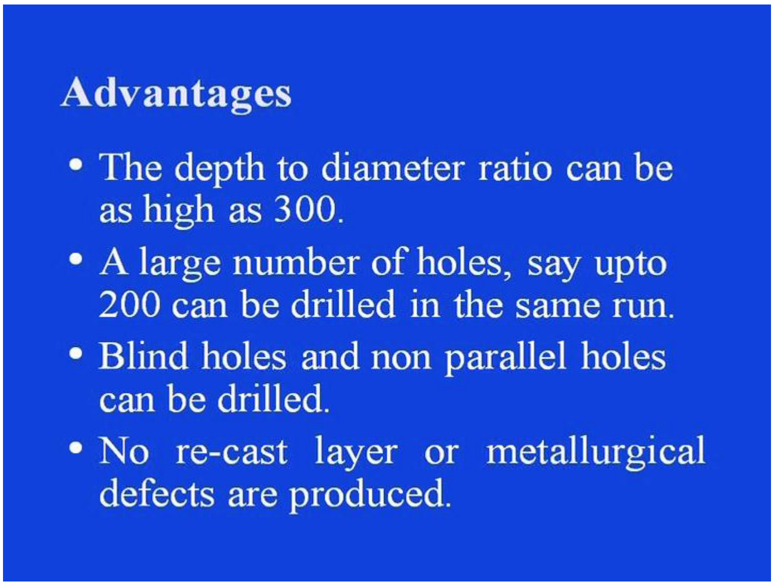

The advantages of this STEM process includes the depth to diameter ratio can be as high as 300. A large number of holes say up to 200 can be drilled in the same run blind holes and non parallel holes can be drilled. No recast layer or metallurgical defects are produced the limitations of this process include the process is used for corrosion resistant metals. This is also a very slow process if a single hole is to be drilled on drilled, then the process could be hazardous. It can produce hazardous waste and therefore, the special work place and environment is required.

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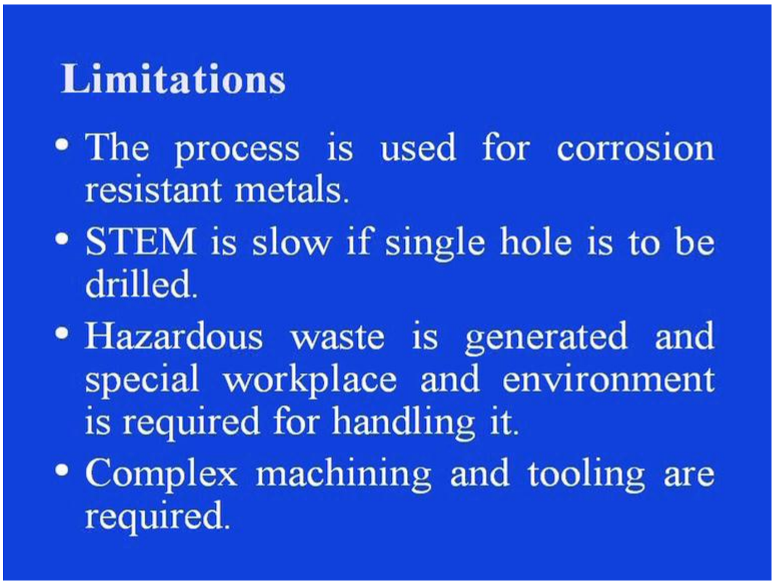

Then the complex machining and tooling are required for this process. Another process in this electro chemical machining variants includes the electro chemical jet drilling process.

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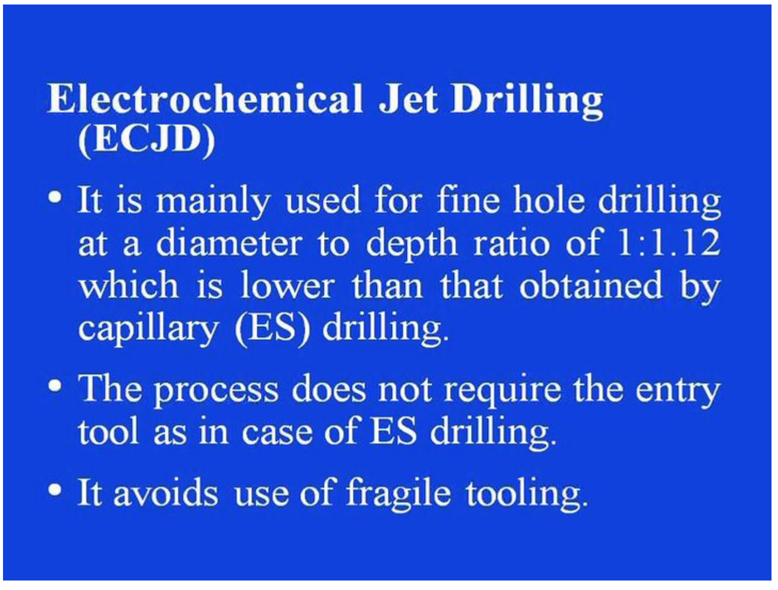

It is mainly used for fine hole drilling at a diameter to depth ratio of 1 is to 1 point 1 2, which is lower than that obtained by capillary or ES drilling. The process does not require the entry tool as in case of ES drilling. It avoids use of fragile tooling the jet of a dilute acid electrolyte causes dissolution and enough room is required for the electrolyte to exit preferably in spray form a typical high voltage of 400 to 800 voltage used in this process. The hole produce depends on electrolyte throwing power.

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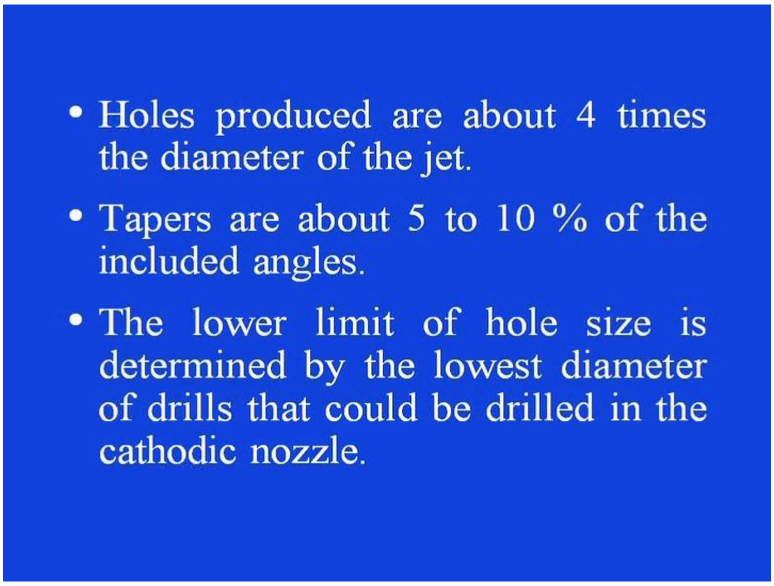

The hole holes produced are about 4 times of the diameter of the jet. Tapers are about 5 to 10 percent of the included angles the lower limit of the hole size is determined by the lowest diameter of drills that could be drilled in the cathodic nozzle. Now, let us summarize what we have discussed in this session in this session we have discussed about the setup and the important features of the electro chemical grinding process as well as electro chemical honing process. Other processes like electro chemical deburring process STEM process etcetera have also been studied in brief unique advantages limitations and applications of all this processes have been discussed. We will hope this session was informative and interesting.

Thank you.