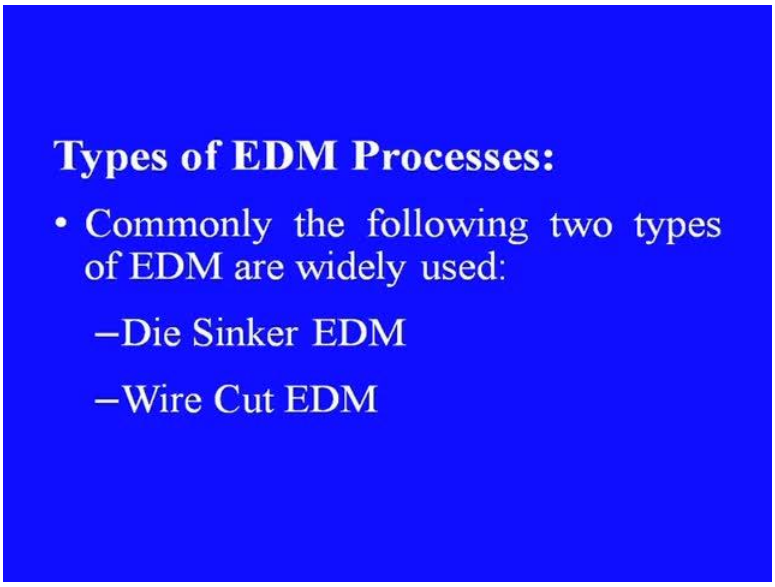
Advanced Manufacturing Process
Prof. Dr Apurbba Kumar Sharma
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 3
Advanced Machining Processes
Lecture - 9
Die-sinker EDM and Wire Cut Electric Discharge Machining (WEDM)

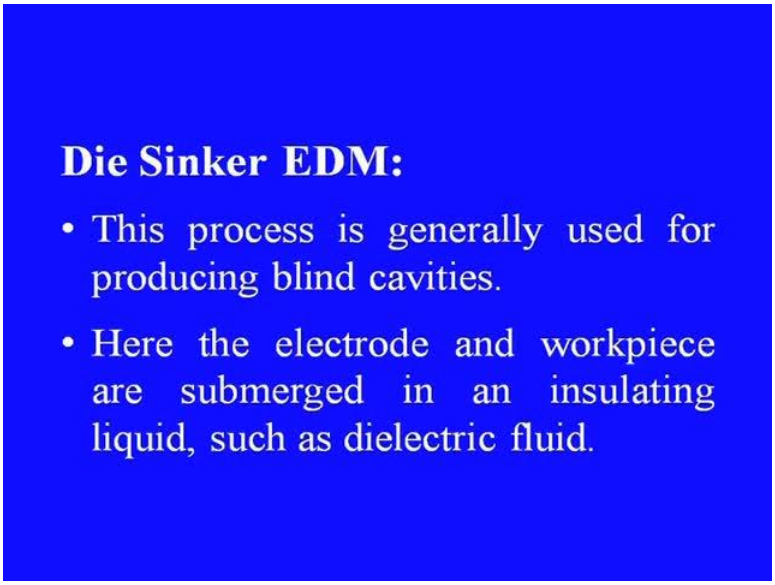
Welcome to this session on electric discharge machining particularly wire cut electric discharge machining under the course advance manufacturing processes. In the last session, we have discussed about the basics of electric discharge machining process, its principle, features, the mechanism of material removal, advantages, limitations and few applications. In this particular session, we will study about the die sinker and wire EDM process, also known as WEDM, the process parameters, applications of this process, advantages and limitations of WEDM process, also we will see some hybrid EDM processes and their variance.

(Refer Slide Time: 01:32)



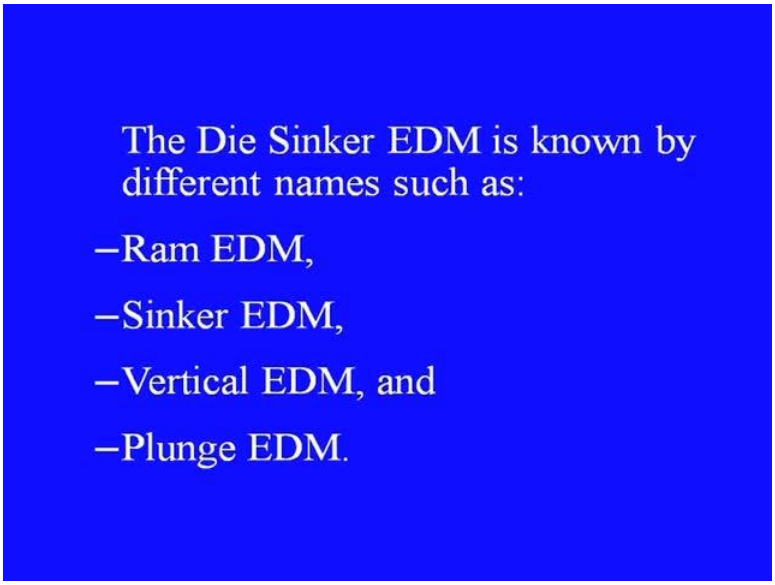
Let us move ahead, in the very beginning let us see the different types of EDM. Commonly there are two types of EDM processes, one is die sinker EDM and the other one is known as wire cut EDM also in short known as WEDM. Let us look into the die sinker EDM.

(Refer Slide Time: 01:55)



This process is generally used for producing blind cavities; here the electrode and a work piece are submerged in an insulating liquid, known as dielectric fluid. So, principally this is similar to that of common EDM process.

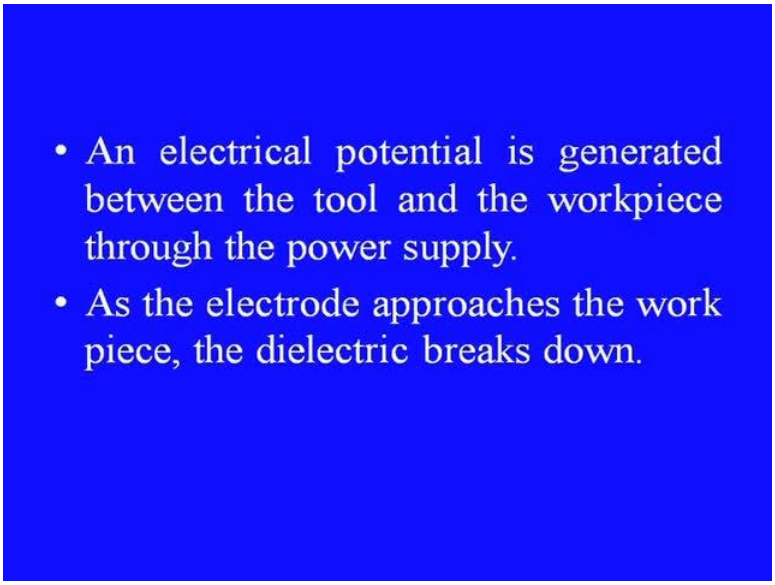
(Refer Slide Time: 02:21)



The die sinker EDM is also known by different names such as ram EDM, sinker EDM, vertical EDM and plunge EDM. The insulating liquid used in die sinker EDM completely submerges the electrode and the work piece. Some special oils, special

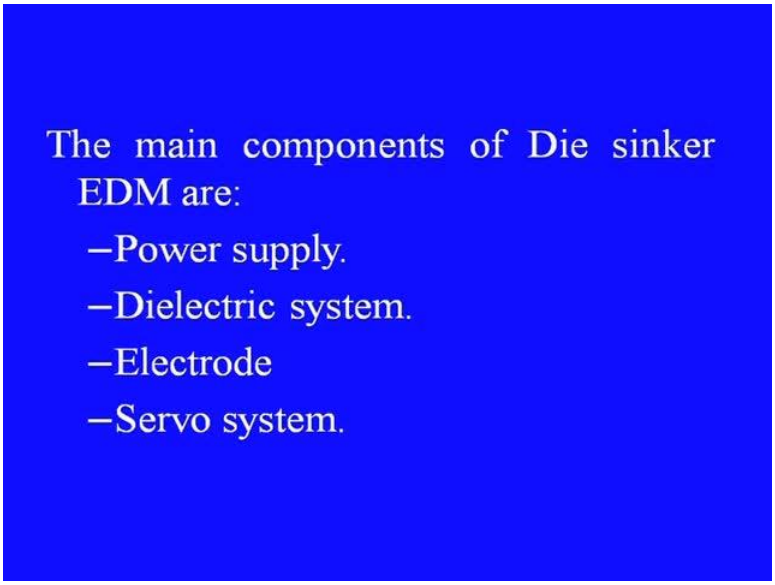
dielectric fluids and de ionized water can be used as the dielectric. The electrode and work piece are connected to a suitable power supply.

(Refer Slide Time: 02:58)



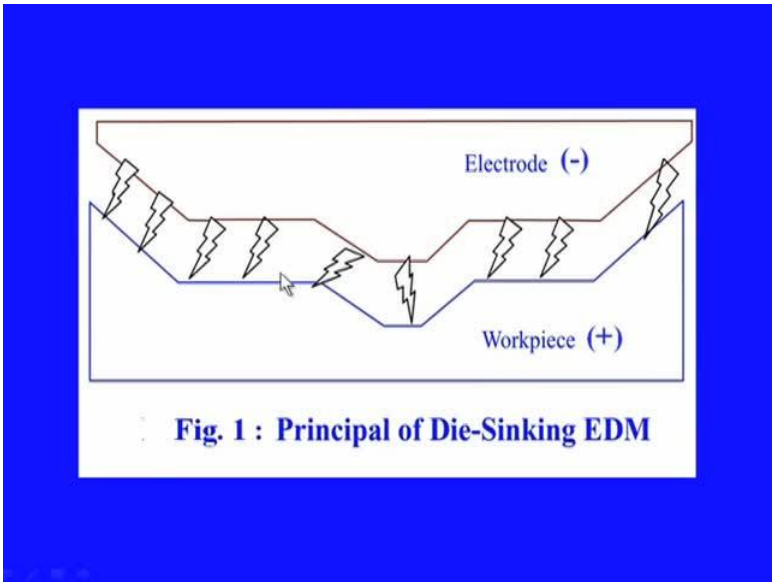
An electrical potential is generated between the tool and the work piece through the power supply. As the electrode approaches the work piece, the dielectric breaks down. Due to this, a plasma channel starts forming and the sparks jump from the electrode to the work piece leading to the material removal from the work piece. The principle of die sinking EDM is shown in the following figure, along with the schematic in the next. Therefore, we have seen almost the principle of working in the die sinking and the normal EDM are equivalent.

(Refer Slide Time: 03:48)



The main component in die sinking EDM are power supply, dielectric system, electrode, the servo system. So, this is the schematic which explains the principal of sparking.

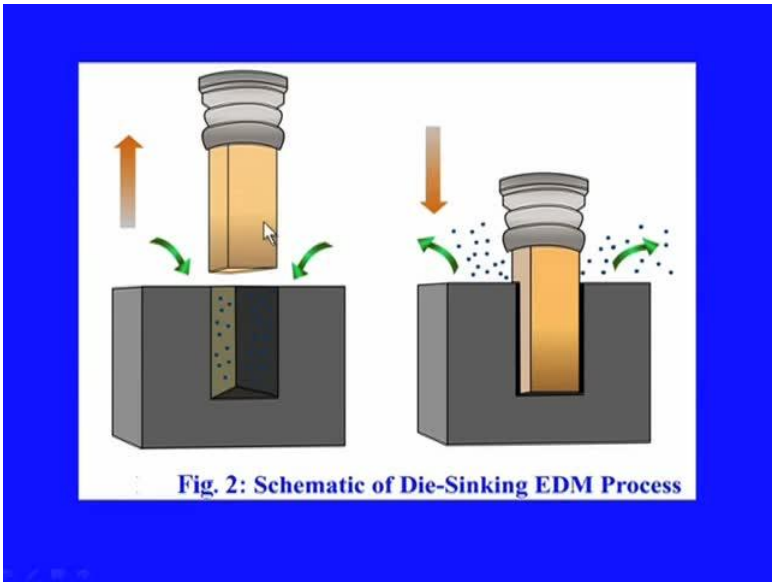
(Refer Slide Time: 04:02)



So, this is this is the electrode and this is the work piece which is usually connected to the positive terminal of the power supply. Here the shape of the tool is shown different and this same shape will be replicated on the work piece as well. The sparking will take place through different zones or the distances through different points, which are closer to the work piece. This sparking, that is the plasma formation zone will create the

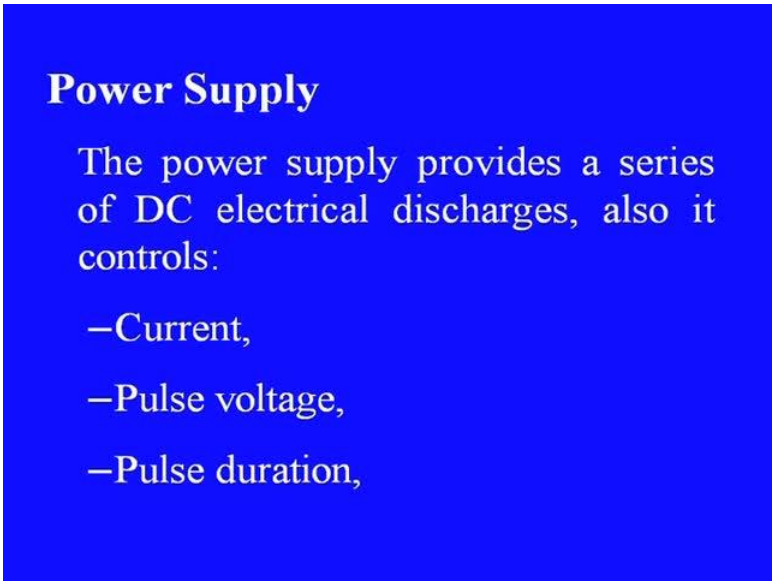
bubbles and high pressure, which will collapse subsequently and erode the work piece, on wherever the sparking is taking place, the erosion of the work piece will also take place. Of course, as we have seen in the case of EDM, small erosion will take place on the electrode as well.

(Refer Slide Time: 05:09)



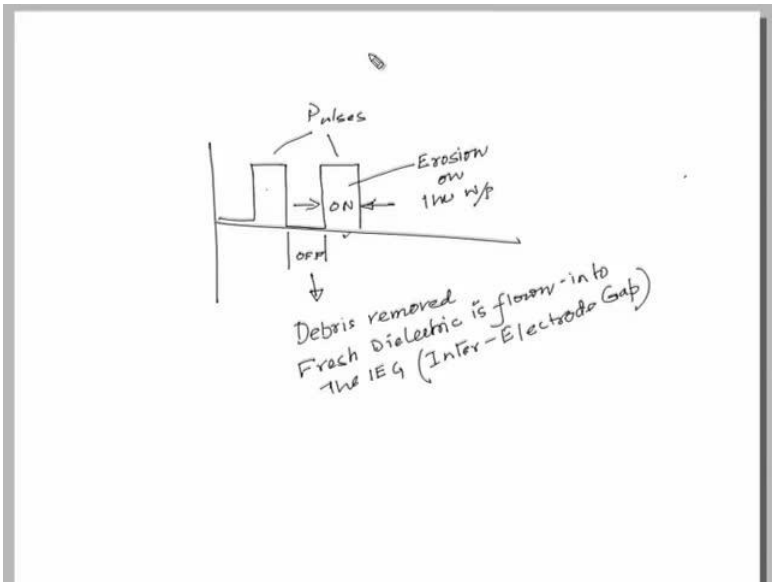
This is we we can say, this is the tool or the electrode and this is the work piece and this is how the dielectric fluid moves into the cavity and the debris are coming out from the cavity. As a result of the machining here and the flowing fluid here, as we remove the tool the dielectric enters inside inside this and as we enter the tool inside this, the sparking does take place and the debris are created, which are subsequently taken away by the flowing dielectric fluid. The power supply in this arrangement provides a series of dc electrical discharges and it also controls current for pulse voltage and the pulse duration.

(Refer Slide Time: 05:59)



As I have already told the pulse supply the pulse power supply is very important in the case of EDM.

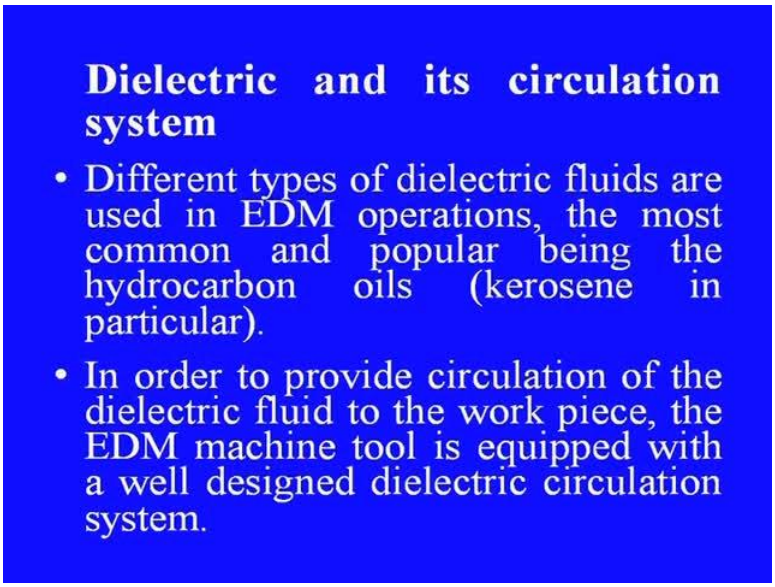
(Refer Slide Time: 06:13)



So, this is pulses are like this, like this. So, these pulses, these are known as pulses and this is the off time and this is the on time, of this pulse. During this time, the erosion will take place, erosion on the work piece as well as to some extent on the tool will take place. During this off time, the debris will be removed, debris removed and fresh dielectric is flown in into the IEG, that is known as inter electrode gap. By design we

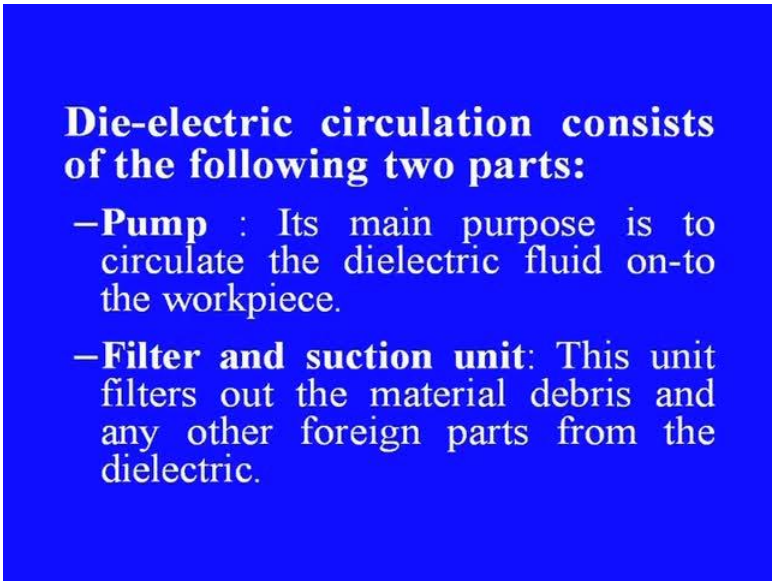
change this this time t on and t off, this this time can be can be changed by design of the circuit and by adjusting different parameters in the control in the control circuit. This depends on the requirement of the machining process. The power supply provides a series of d c electric discharges, it controls the current pulse, voltage, the pulse duration, duty cycle, the electrode, polarity and as well as the pulse frequency.

(Refer Slide Time: 08:32)



The dielectric and its circulation system also an important subsystem of this entire machining setup, different types of dielectric fluids are used in EDM operations. The most common and popular being the hydrocarbon oils, that is kerosene. In order to provide circulation of the dielectric fluid to the work piece, the EDM machine tool is equipped with a well designed dielectric circulation system. The dielectric circulation system consists of the following two parts, two major parts.

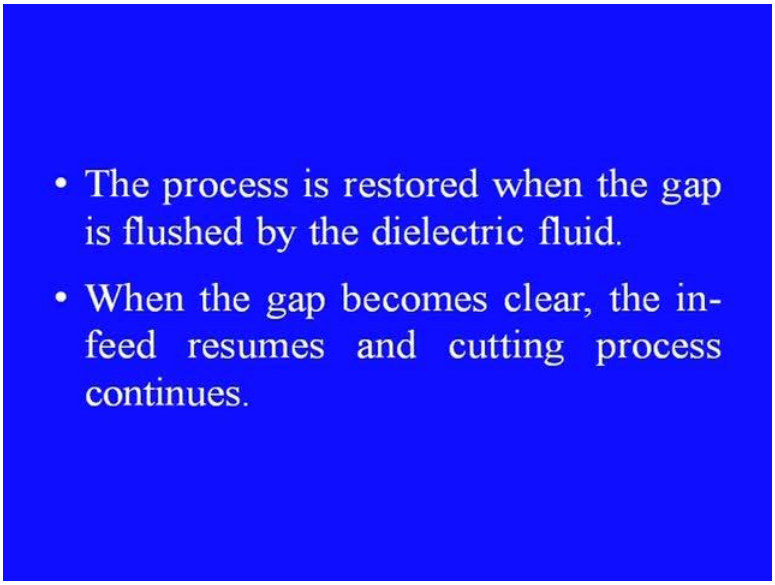
(Refer Slide Time: 09:13)



Number one is pump, its main purpose is to circulate the dielectric fluid on to the work piece and number two is filter and the suction unit. As I have already told, that there should be some filtering system to remove the debris present in the dielectric fluid. This unit filters out the the material debris and any other foreign particles that may come in contact or present in the dielectric fluid. Next is the servo system. The servo system is commanded by signals from gap voltage sensor system in the power supply.

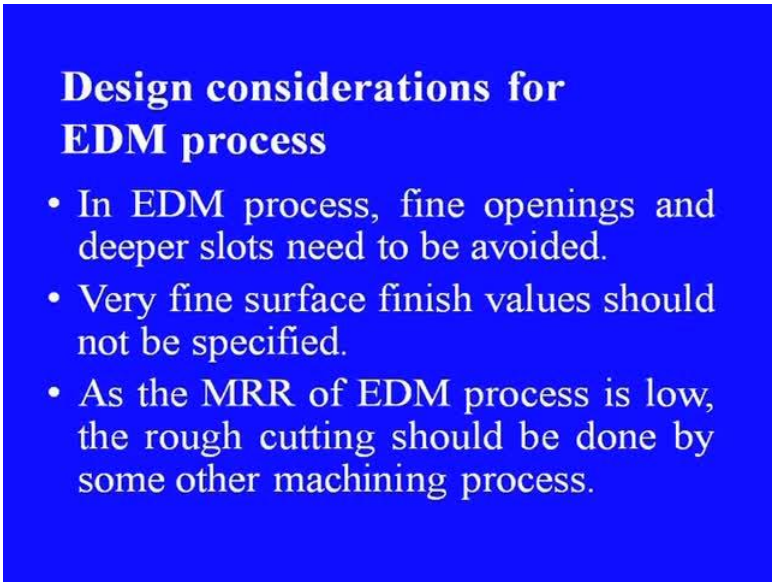
It controls the in feed of the electrode, to precisely match the required rate of material removal. At times stepo motor can be used instead of a servo motor. Once the gap voltage sensor system determines, breezing of the some pieces of electric conducting materials between the electrode and the work piece, immediately the servo system reacts and reverses the direction. That means it retracts the tool, so that the short circuiting of the gap does not take place. As I have already indicated if the short circuiting does take place, then there would not be any sparking, and therefore we will not be getting the desired erosion effect in the working zone.

(Refer Slide Time: 10:52)



The process is restored when the gap is flushed by the dielectric fluid. When the gap becomes clear the in feed resumes and the cutting process continues. Let us look into the electrodes, the electrodes for EDM process are usually made of brass, copper, graphite, and copper tungsten alloys. In EDM process fine openings and deeper slots need to be avoided.

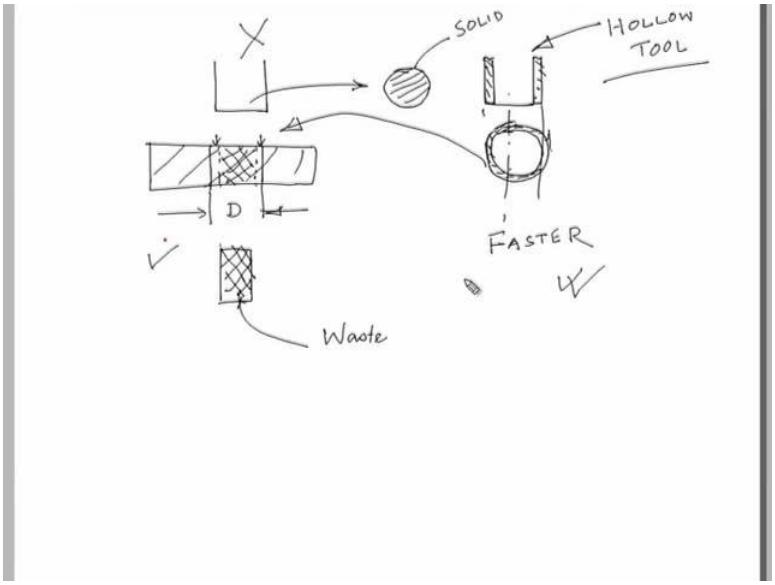
(Refer Slide Time: 11:31)



Design considerations for the EDM process. In EDM process fine openings and deeper slots need to be avoided, very fine surface finish values should not be specified. As we

have already discussed, EDM is a coarse metal removal process basically and is not recommended for fine finishing of surfaces. As the MRR or material removal rate of the EDM process is low, the rough cutting should be done by some other machining process. This will save the machining time and add to the economy of the process. In cases where bigger holes are to be manufactured in hard materials, hollow tools can be prepared, which can save the material and the obtained cylindrical pieces can be used for other applications. This can be explained like this.

(Refer Slide Time: 12:33)



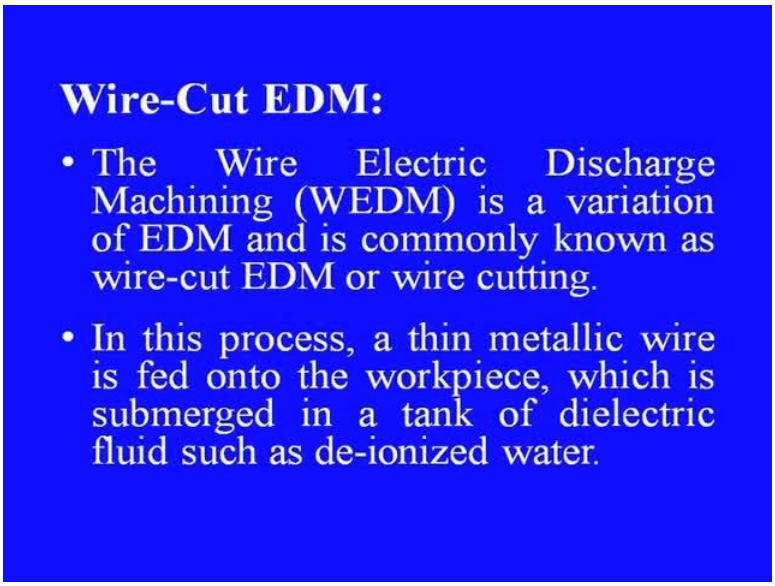
Say for example, in an work piece, a big size hole is to be is to be through hole is to be produced, this is the hole diameter. Now, for this instead of using instead of using a solid tool like this, whose cross section is solid like this, so we can use a tool having hollow cross section something like this. So, this will have the cross section like this and therefore, this is not suggested in this case. Therefore, what will happen? The sparking will take place on this through this cross section and a cutting will take place correspondingly on this zone and this piece.

This in between piece will come out as the waste like this. So, this will be the waste piece produced in in this process, if we use this kind of cross section for machining of this hole. Then the sparking will take place only through this, only through this leaving behind this material in between in between as uncut material. This will be obtained as an

extra piece or the waste piece, which can be further used for some other material removal processes.

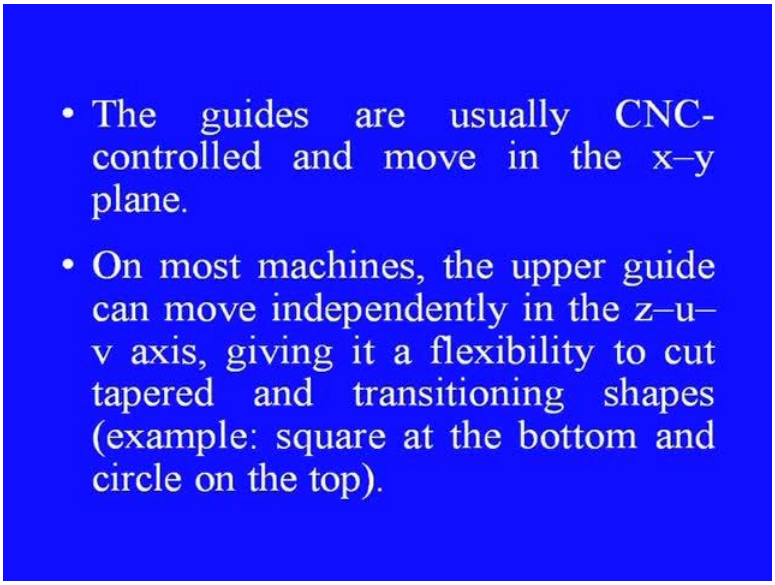
This process, why this process is suggested, is that at times this process is even faster than the process used with the solid tool, this is a solid tool and this is a hollow tool. At times this is considered to be faster and therefore recommended for some such applications like this. Now, let us move into another category of EDM that is wire EDM. This process is mainly used for cutting applications, making slots and fine features on hard blocks. It uses a continuous pool of wire and water is used as the dielectric fluid it is also known as wire cut EDM.

(Refer Slide Time: 15:59)



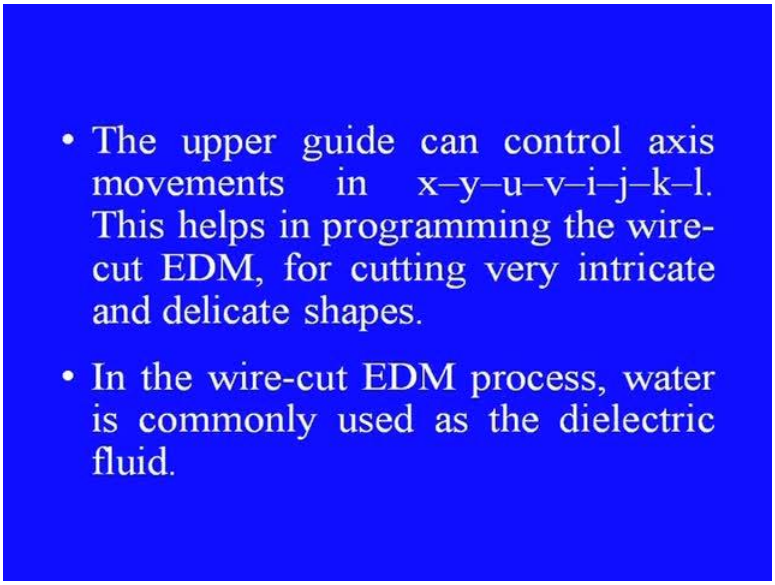
The wire electric discharge machining shortly known as WEDM, is a variation of basically the EDM process and is commonly known as wire cutting. In this process a thin metallic wire is fed into the work piece, which is submerged in a tank of dielectric fluid such as such as de-ionized water. This process can also cut plates as thick as 300 millimeters. Therefore, this is considered to be very useful process. It is also used in making punches, tools and dies from hard metals that are difficult to machine with other metals. The wire, which is constantly fed from a spool is held between the upper and lower diamond guides.

(Refer Slide Time: 17:01)



The guides are usually CNC controlled and move in the x y plane. On most machines, the upper guide can move independently in the z u and v axis, giving a flexibility to where cut tapered and transitioning shapes.

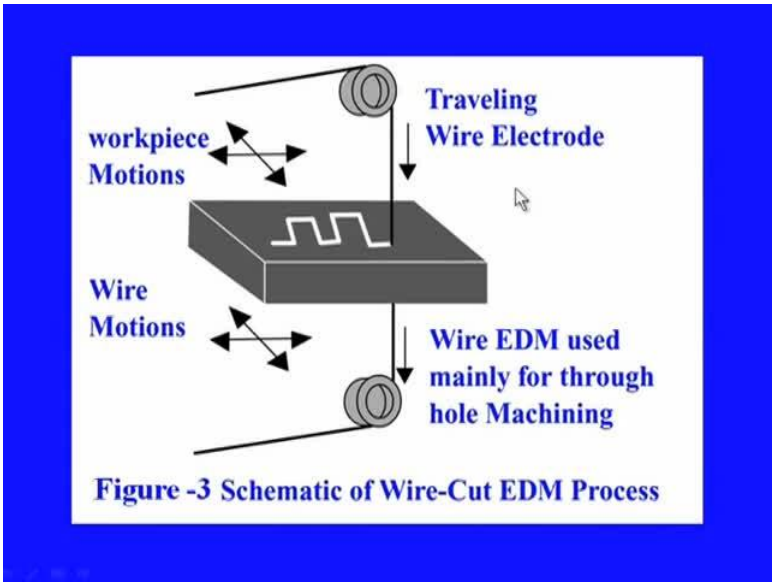
(Refer Slide Time: 17:34)



For example, square at the bottom and circle on the top. The upper guide can control axis movement in x, y, u, v, i, j, k and l. This helps in programming the wire cut EDM for cutting very intricate and delicate shapes in the wire cut EDM process water is commonly used as a dielectric fluid. Filters and de ionizing units are used for controlling

the resistivity and other electrical properties. Wires made of brass are generally preferred, water helps in flushing away the debris from the cutting zone. The flushing also helps to determine the feed rates to be given for different thickness of the materials. Let us see the schematic of this process as in the screen.

(Refer Slide Time: 18:34)



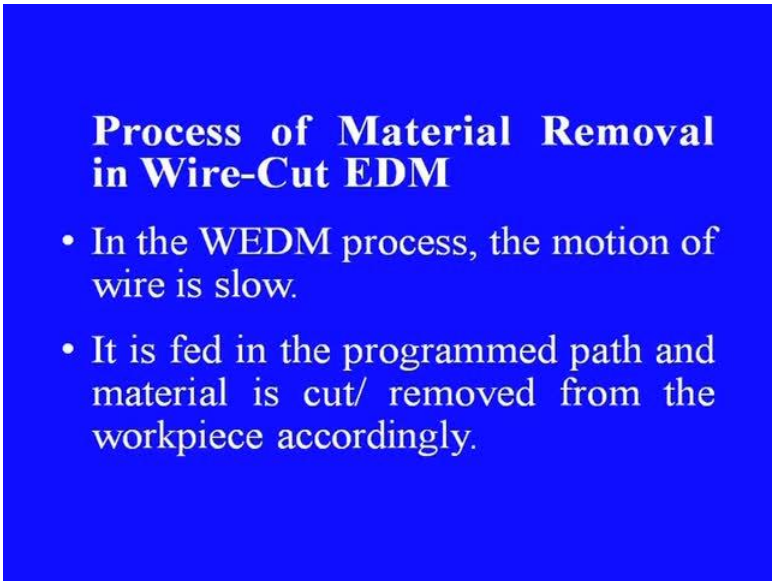
This is the wire we are talking about, this is nothing but a wire of material brass or something like that. This forms actually the tool, which is also connected to one end of the power supply and this is the work piece, which will be eventually connected to the other end of the power supply. That means, this wire and this work piece forms the pair of electrodes in this case. Now, this wire will be constantly fed through a (( )), it will be continuously moving from the one (( )) to the another and there is separate mechanisms for this.

This tips always are fresh portion of the wire to come in contact to the working zone, otherwise if it is kept at the same position, the wire will also erode very fast and continuity of this, wire will get vanished, it will be broken in between. Therefore the fresh piece of the wire will come always in this cutting zone providing a better sparking condition in the working zone. This work piece is connected to the table, work table which can be controlled in x, y, z directions like this, as shown in this figure. Generally x and y will be controlled here and basically any profile with the help of this movement of this x y, can be cut on this work piece as shown here.

This motions of this work table and hence the work piece can be controlled or programmed through CNC machining device. The WEDM process requires lesser cutting forces in material removal. It is generally used when lower residual stresses in the work piece are desired. If the energy or power for pulse is relatively low, as in the finishing operations, then very little changes in the mechanical properties of the material are expected, due to these low residual stresses. The materials which are not stress relieved earlier can get distorted in the WEDM process.

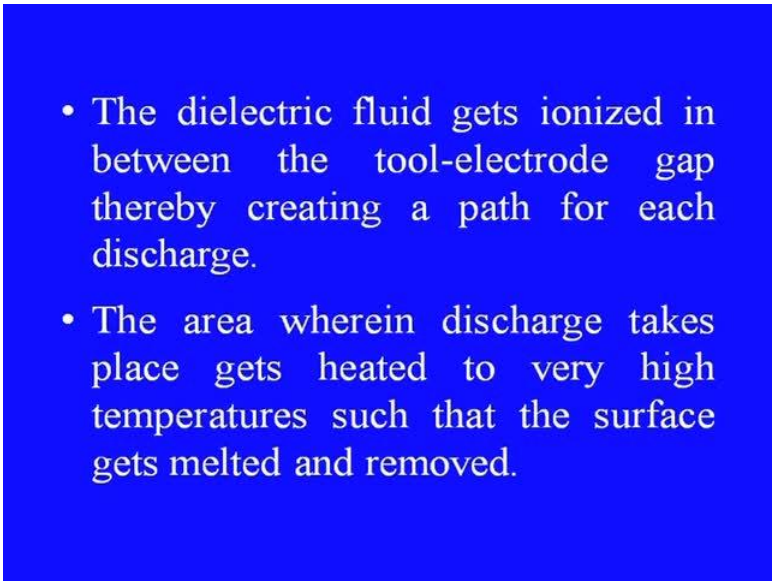
The selection of process parameters is very crucial in this process. The work piece undergoes significant thermal cycles. These thermal cycles can be considered very severe from designing point of view. The thermal cycles can form recast layers, as we have already discussed while discussing the basics of EDM process and induced residual tensile stresses on the work piece surface, which are at times, almost of the times undesired. Now, let us see the process of material removal in wire cut EDM process.

(Refer Slide Time: 22:18)



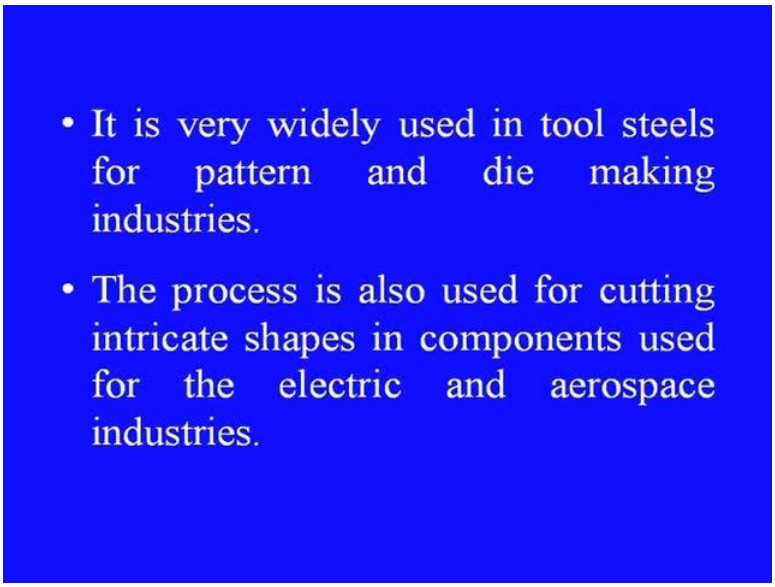
In the wire EDM process the motion of the wire is very slow. It is fed from the programmed part and material is cut or removed from the work piece accordingly. Electrically conductive materials are cut by WEDM process by the electro thermal mechanisms. Material removal takes place by a series of discrete discharges between the wire electrode and the work piece, in the presence of a dielectric fluid, which we have already discussed as in the case of normal EDM.

(Refer Slide Time: 23:01)



The dielectric fluid gets ionized in between the tool electrode gap thereby creating a path for each discharge, also called the plasma column. The area wherein discharges take place heated to very high temperature such that the surface gets melted and removed. The cut particles or the debris get flushed away by the continuously flowing dielectric fluid. The WEDM is a non conventional process working on the basics of EDM principle.

(Refer Slide Time: 23:44)

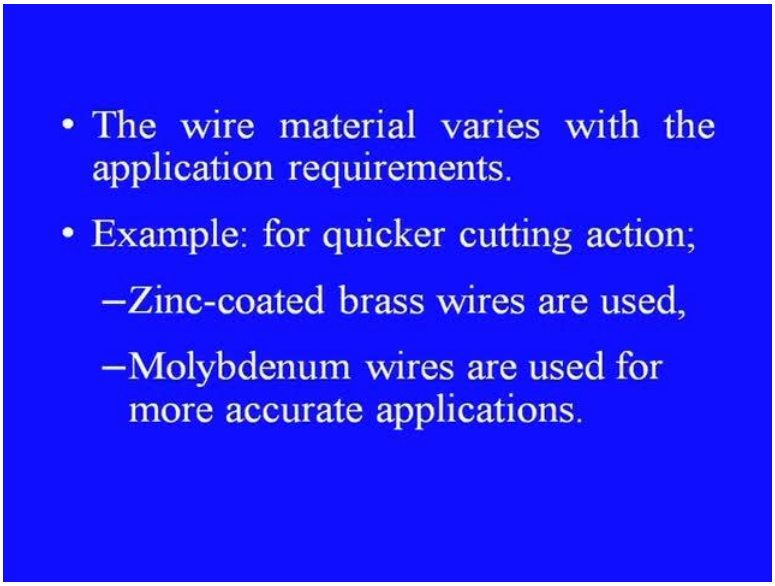


It is very widely used in tool steels for pattern and die making industries. The process is also used for cutting intricate shapes in components used for dielectric and aerospace industries. Let us see the applications common applications of wire cut EDM.

(Refer Slide Time: 24:07)

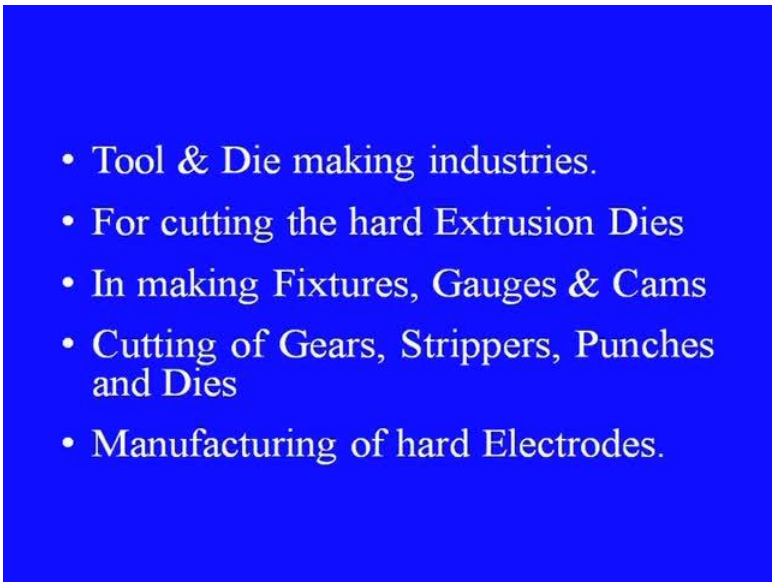
It is used for cutting metals like aluminum, brass, copper, carbides, graphite, steels and titanium. The wire cut materials varies with the application requirements.

(Refer Slide Time: 24:22)



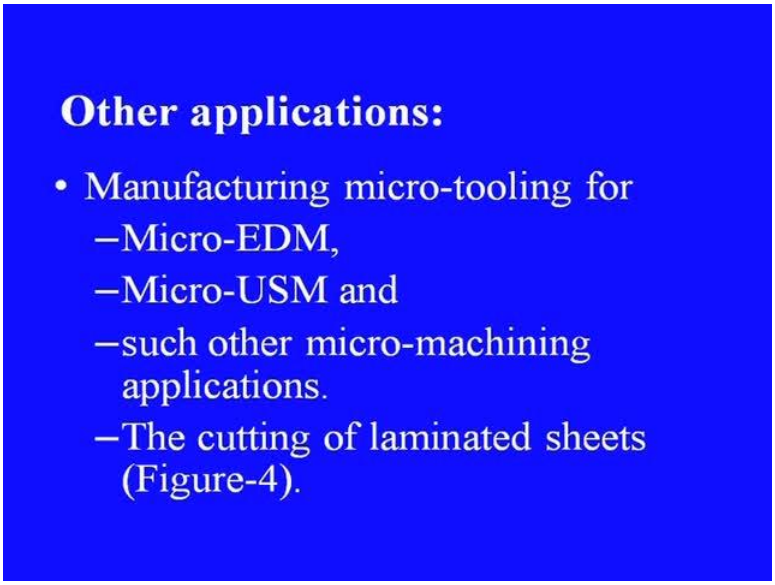
For example, for quicker cutting action zinc coated brass wires are used. Molybdenum wires are used for more accurate applications, the process is used in the following areas aerospace, medical, electronics and semiconductor applications.

(Refer Slide Time: 24:29)



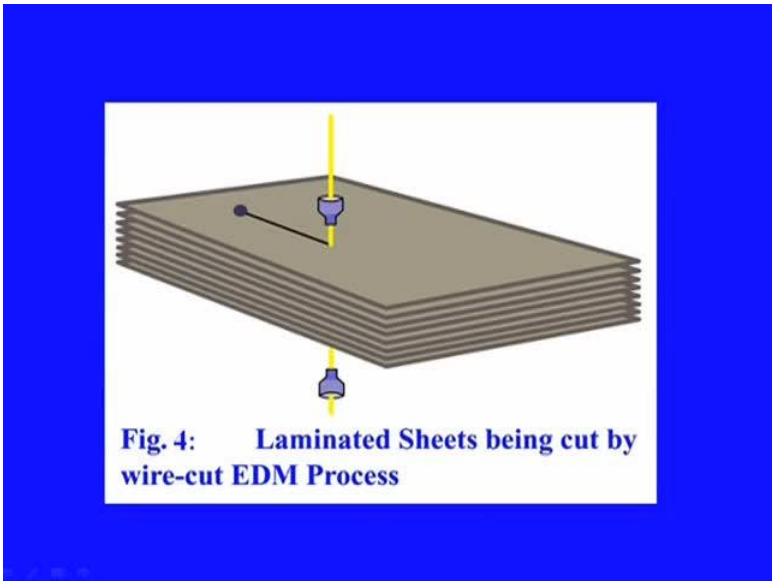
Tool and die making industries, where EDM is highly preferred for cutting hard extrusion dies, where EDM is usually preferred. In making fixtures, gauges and cams cutting of gears, strippers, punches and dies and manufacturing of hard electrodes is where EDM is generally preferred.

(Refer Slide Time: 25:23)



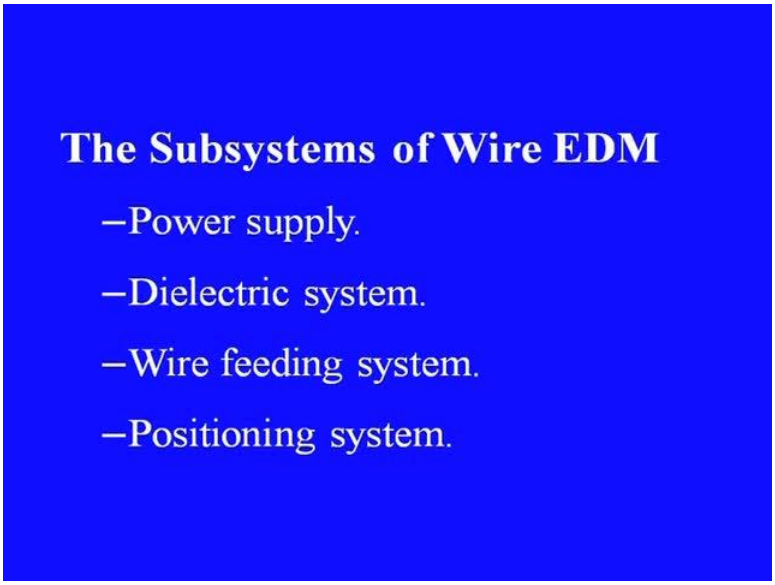
Other applications of this process include, manufacturing of micro tooling for micro EDM, micro USM and such other micro machining applications.

(Refer Slide Time: 25:41)



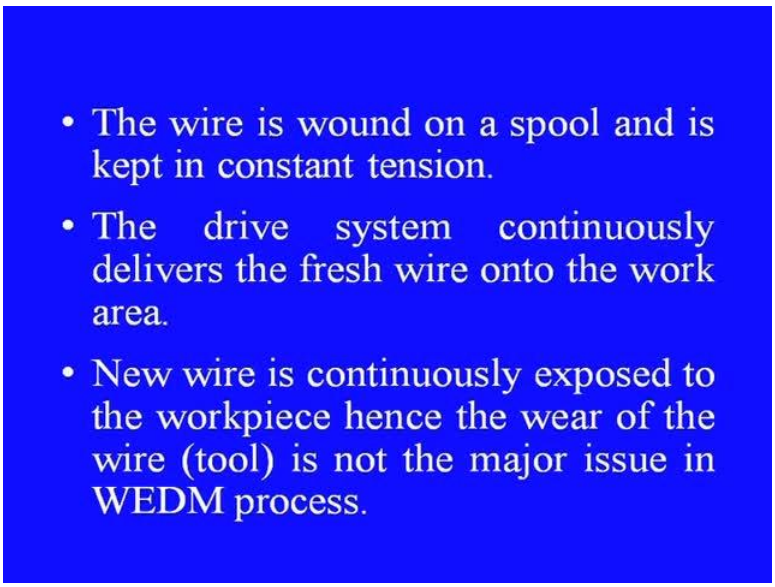
One such application like cutting of laminated sheets is shown in this particular figure in the screen. So, number of plates being placed stacked in this configuration. The wire can be cut or moved through this stack of sheets or laminar making a slit. Thus if a pattern, particular pattern is to be cut on these number of laminates, then the wire cut is a very, very effective or useful process. Now, let us see the subsystems of wire EDM system.

(Refer Slide Time: 26:23)



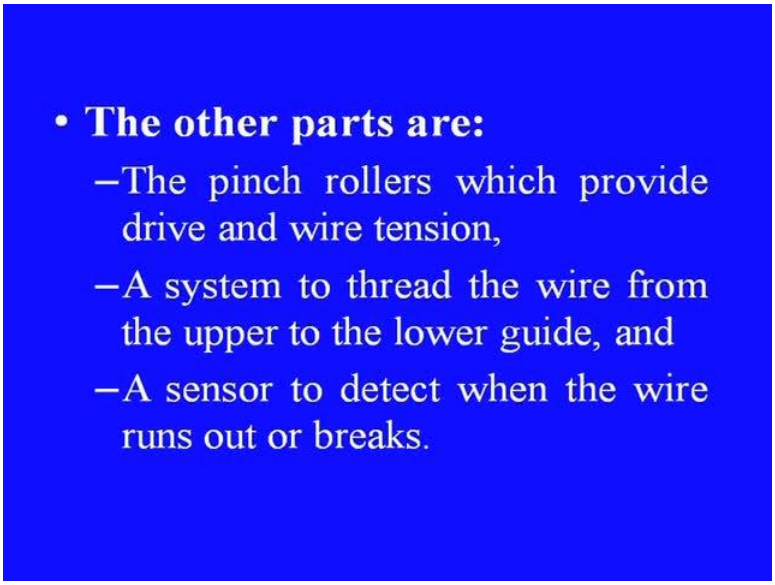
As in the case of EDM, power supply, dielectric system, wire feeding system and positioning systems are used in this wire EDM setup. Here the wire feeding system is a, is an addition to what get in the normal EDM process. The power supply and dielectric system used in the WEDM is very similar to that of the conventional EDM, as I have been already telling. The main difference lies only in the type of dielectric used. In wire cut EDM, a moving wire electrode is used to cut complex outlines and fine details in the required work piece.

(Refer Slide Time: 27:16)



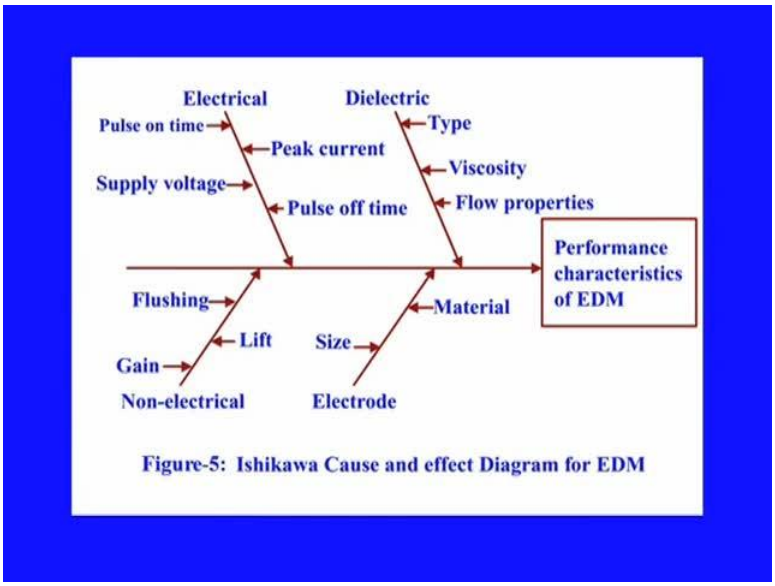
The wire is wound on a spool and is kept in constant tension. The drive system continuously delivers the fresh wire onto the work area. New wire is continuously exposed to the work piece, hence the wire of the wire, which is a tool here is not the major issue in this process. The wire feeding system consists of a large pool of wire and rollers, which direct the wire through the machine. The presence of metal provides power to the wire and guides it further in order to keep the straight throughout the cutting process.

(Refer Slide Time: 28:14)



Other parts in this setup are; the pinch rollers, which provide drive and wire tension, a system to thread the wire from the upper to the lower guide and a sensor to detect, when the wire runs out or breaks. Now, let us look into the process parameters in WEDM process, these parameters are shown in this familiar figure.

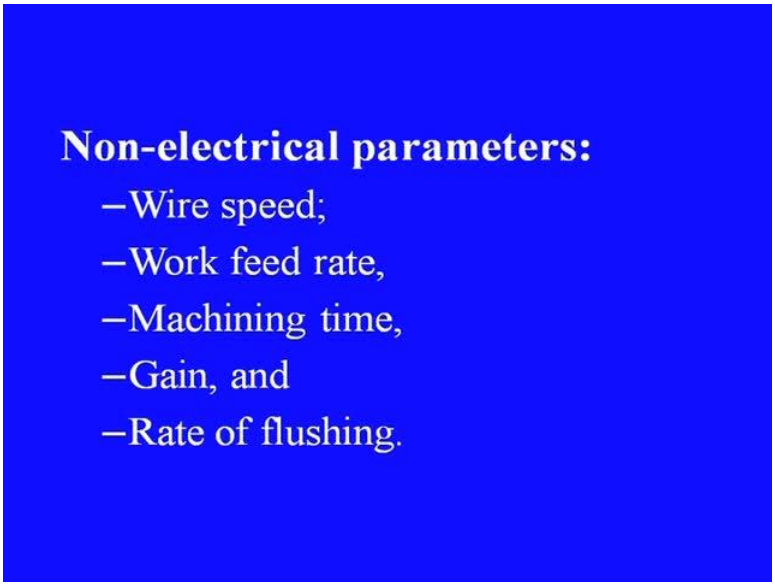
(Refer Slide Time: 28:51)



These process parameters are grouped into four main categories electrical parameters, which are pulse on time, supply voltage, peak current and pulse off time. And dielectric based parameters like type of dielectric, viscosity and then flow properties. Then other

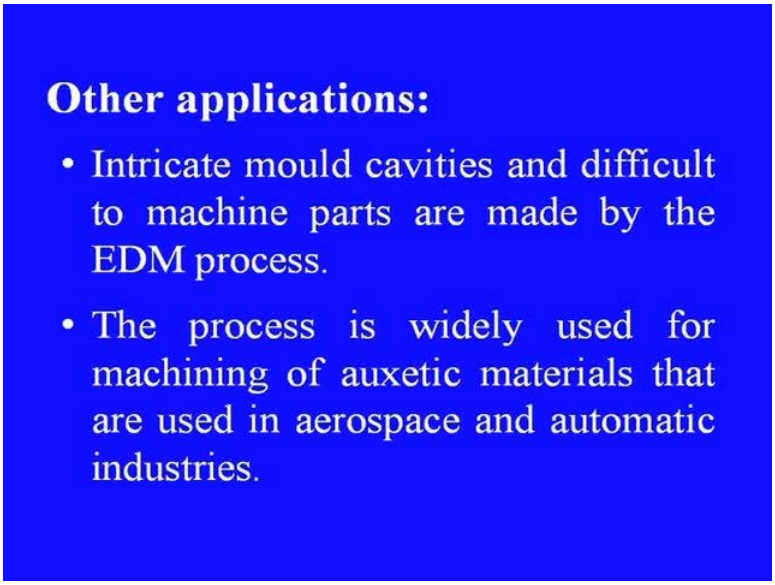
non electrical parameters are like gain, flushing and lift electrode based parameters are the size of the electrode and the material of the electrode, conductivity of the electrode, and so on. Electrical parameters include peak current, pulse on time, pulse off time supply voltage and polarity.

(Refer Slide Time: 29:46)



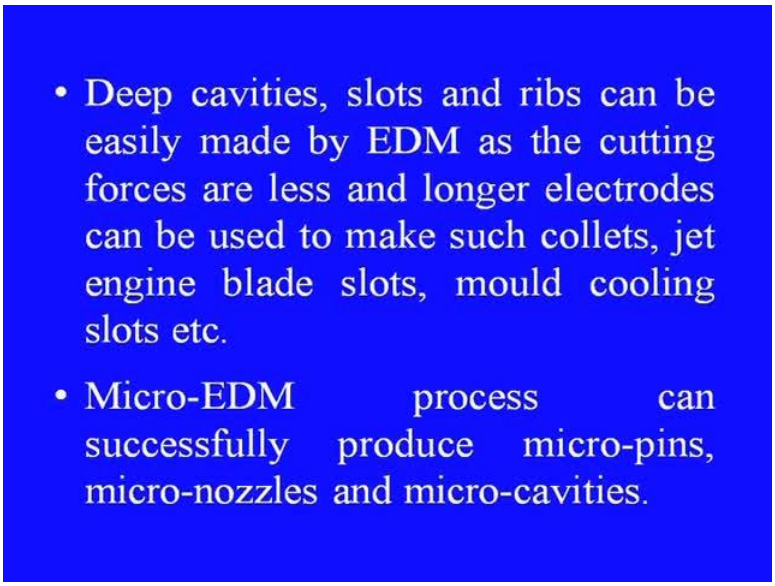
Non electrical parameters include, wire speed, work feed rate, machining time, gain and rate of flushing as well. Whereas, electrode based parameters include, material and size of the wire. The dielectric system based parameters include, type of the dielectric, viscosity of the dielectric and other flow characteristics.

(Refer Slide Time: 30:16)



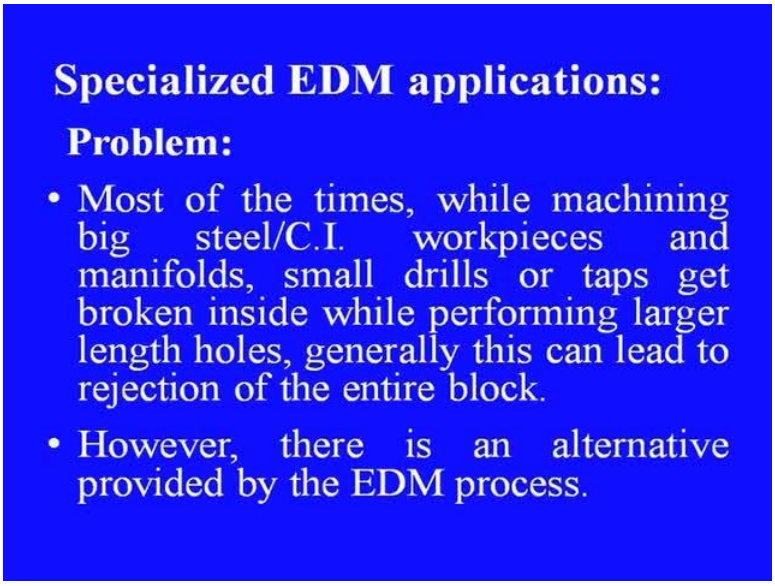
Let us see some other applications of this WEDM process. This process is useful for cutting intricate mold cavities and difficult to machine parts. The process is widely used for machining of exotic materials that are used in aerospace and automatic, automotive industries. EDM being a non contact type machining process is very well suited for making fragile parts, which cannot take the stress of machining. The parts that fit such profiles include washing machine agitators, electronic components, printed parts and difficult to machine features such as honeycomb shapes.

(Refer Slide Time: 31:20)



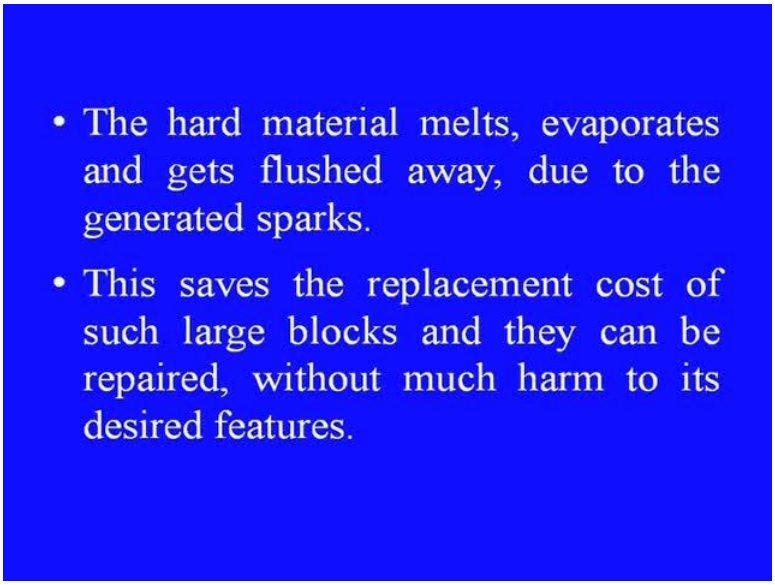
Deep cavities, slots and ribs can be easily made by EDM as the cutting forces are less and longer electrodes can be used to make such collets, jet engine blade slots, mould cooling slots etcetera. Micro EDM process can successfully produce, micro pins micro nozzles and micro cavities. As we know these are some of the applications like producing micro pins for micro machining, micro nozzles and micro cavities are otherwise very difficult to machine using other conventional techniques. But here this process wire EDM can be very, very useful. Now, let us see few specialized applications of this EDM process.

(Refer Slide Time: 32:19)



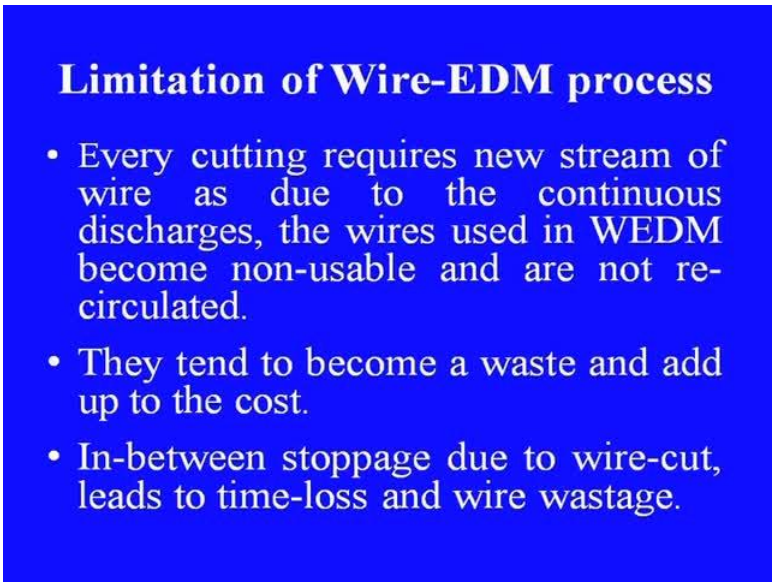
Some problems are like this. Most of the times while machining big steel or cast iron work pieces and manifolds, small drills or taps get broken inside the hole, while performing larger length holes. Generally this can lead to rejection of the entire block, which is a sheer wastage of money. However, there is an alternative provided by the EDM process in such cases. As the EDM is a localized machining process, it can be readily used for removing the broken tapes and drills or tools from the bases. In order to achieve this task, suitable tool little smaller in diameter than the embedded tool size is preferred and the block is machined by EDM on this localized area.

(Refer Slide Time: 33:32)



The hard material melts evaporates and gets flushed away due to the generated sparks. This saves the replacement cost of such large blocks and they can be repaired without much harm to the desired features. Now, let us also look at the limitations of this process wire EDM process.

(Refer Slide Time: 34:01)



Every cutting requires new stream of wire as due to the continuous discharges the wires used in WEDM become non usable and are not re-circulated. They tend to become a waste and add up to the cost in between stoppage due to the wire cut leads to time loss

and wire wastages. Now, let us summarize what we have discussed in this particular session. In this session, we have discussed in details the common types of EDM, the die sinker and the wire EDM processes in particular typical applications of these processes. The process parameters that affect the machine product using these processes and limitations of these processes have also been discussed. We hope this session was informative and interesting.

Thank you.

.