Electrochemical Machining

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Abstract: **Electrochemical machining (ECM) is a technique of eradicating metal by an electrochemical procedure. It utilizes an electrolyte and electrical current to ionize and eradicate metal atoms. Electrochemical Machining is a relatively ancient machining system which basis were laid way backside in the 19th century. The process has enhanced extremely everlastingly since, thus becoming an extremely defined practice with gigantic limitless application possibilities across engineering. In this research paper our emphasis would be on understanding the operating principles of electrochemical machining and to know its economical impact. We will also discuss the advantages and disadvantages of ECM and its applications.**

I. **Introduction:** The electrochemical machining (ECM), as a industrial technique, invented from the procedure of electrolytic polishing offered by now in 1911 by famous Russian chemist E.Shpitalsky. In 1928, the industrial ECM scheme known at this time was basically enhanced by the Russian engineers, due to requisite rigorous flushing of electrolyte fluid through interelectrode space and the EDM electrode moving (feeding) with velocity equal to velocity of anode dissolution. It permissible to boost current density and to decrease working interelectrode gaps and, in view of that, to lift up target technological indicators of the ECM (accuracy, quality of the surface and productivity). for the first time ,in 1959 the Anocut Engineering Company, USA presented into production the traditional model of the ECM by means of the uninterrupted current at the production run tools. In the era of1960-1970s serial use of the ECM in aerospace branch (industry), in tool manufacture (forging dies) was began in the USSR and in the Western Europe. Electrochemical skills developed during this period and such well-known companies as Philips, Hitachi, Amchem, etc made the equipment. Novel traditions of microsecond electrochemical processing are confined by tens of patents and make a basis of fundamental electrochemical technology and tools (machines of the "ET" series), developed and produced by a group of Ufa engineers and scientists and manufactured successively by ECM.

II. **Operating principle:** **Electrochemical machining** is a procedure of a choosy dissolution of the anodically linked work piece material submerged in an electrolyte collectively with an anodically connected device.

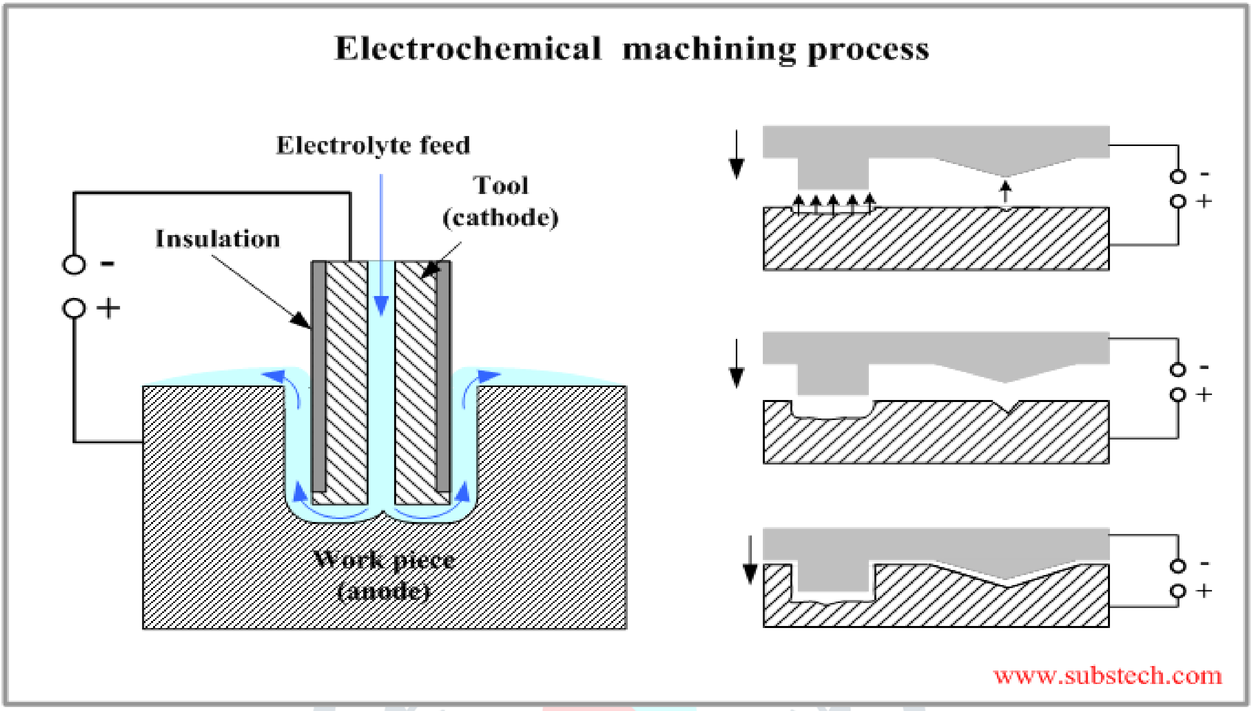
Predominantly electrochemical machining is alike Electro polishing where the work piece surface unevenness diminishes due to the changing of the atoms into ions and their removal from the surface as a result of a passage of an electric current. Electrochemical machining is in obvious differing to electroplating where the metallic ions wandering through the electrolyte solution set down on the surface of the cathodically connected work piece.

<u>Reaction taking place in process are as follows:</u>
At the anode the iron atoms change into the iron ions (cations): $\mathbf{Fe=Fe^{2+} +2e^-}$

The electrons vanished by the iron atoms travel to the cathode through the DC power supply. At the cathode the electrons act in response with water molecules forming gaseous Hydrogen and hydroxyl ions (anions) according to the reaction: $\mathbf{H_2O+2e^- =H_2 +2OH^-}$

The cations and the anions respond in the aqueous solution and create insoluble ferrous hydroxide: $\mathbf{Fe^{2+} +2OH^- =Fe(OH)_2}$

The insoluble hydroxide is taken by the flowing electrolyte and then it precipitates at the tank bottom forming the sludge. The standard design of electrochemical process is presented in the figure below.



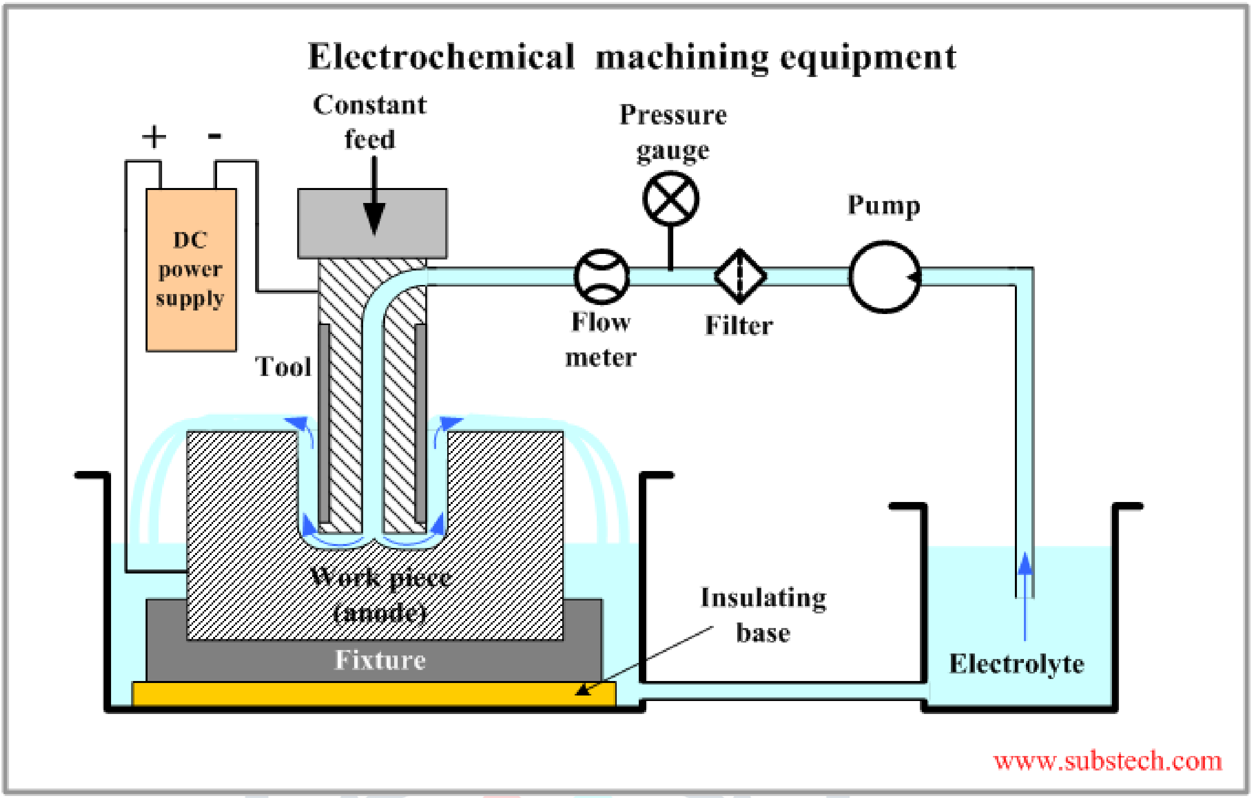
The work piece is board on in a fixture electrically segregate from the tank and other machine component. The work piece is linked to the positive terminal (anode) of the Power Supply. The tool is coupled to the negative terminal (cathode).The electrolyte is constantly streaming through a hole in the tool to the gap between the work piece and the tool surfaces. The tool is travelling in the direction of the work piece at a constant speed of about 0.05”/min .The fissure between the tool and the work piece is kept constant. Stable behavior of the procedure is a consequence of a control of the power supply voltage. The concluding shape of the work piece produced as a outcome of the electrochemical machining process conforms the shape of the tool.

Electrolytes concentration in electrochemical machining:

Sodium chloride (**NaCl**) at the concentration of 20% is used for ferrous alloys. Sodium nitrate (**$NaNO_3$**) is used for ferrous alloys. Hydrochloric acid (**HCl**) is used for Nickel alloys. A mixture of sodium chloride (**NaCl**) and sulfuric acid (**H_2SO_4**) make use for nickel alloys. A mixture of 10% hydrofluoric acid (**HF**), 10% hydrochloric acid (**HCl**), 10% nitric acid (**HNO_3**) applied for Titanium. Sodium hydroxide (**NaOH**) - for tungsten carbide (**WC**).

III. **Main Subsystems:**

a) The power supply.
b) The electrolyte circulation system.
c) The control system.
d) The machine**.**



A. Power supply- The power needed to operate the ECM is observably electrical. There are numerous requirement s to this power. The current density must be high. The gap between the tool and the work piece must be low for high-pitched correctness, thus the voltage must be small to prevent a short circuit. The control system uses some of this electrical power.
B. Electrolyte circulation system- The electrolyte must be injected in the gap at high speed (between 1500 to 3000 m/min).The inlet pressure should be in between 0.15-3 Mpa. The electrolyte system should comprise a fairly strong pump.
C. Control system-Control parameters include: Voltage, Inlet and outlet pressure of electrolyte, Temperature of electrolyte. The current is dependent on the above parameters and the feed rate.
D. Machine - The machine is a main subsystem of the ECM. It consist of the table, the frame, work enclosure (prevents the electrolyte from spilling), the work head (where the tool is mounted).The tools (electrodes) are also part of the machine system.

IV. Advantages:

1. There is no cutting forces therefore clamping is not required except for controlled motion of the work piece.
2. There is no heat affected zone.
3. Very accurate.
4. Relatively fast.
5. The rate of machining does not depend on the hardness of the work piece material.
6. The tool does not wear. Soft materials (e.g., copper) may be used for tool fabrication.
7. No stresses are produced on the work piece surface.
8. No burrs form in the machining operation.
9. High surface quality may be achieved.
10. High accuracy of the machining operation.

V. Disadvantages

1. The saline (or acidic) electrolyte poses the risk of corrosion to instrument, work piece and equipment.
2. Higher cost.
3. Electrolyte may cause corrosion of the equipment.
4. Large production floor is required.
5. Only electrically conductive materials may be machined.
6. Not environmentally friendly process.

VI. Applications:

1. The most common application of ECM is high accuracy replication. Because there is no tool wear, it can be used frequently with a high degree of accurateness.
2. It is also employed to make cavities and holes in various yields.
3. Sinking operations (RAM ECM) are also utilized as an alternative to RAM EDM.
4. It is generally used to thin walled, with no trouble deformable and brittle material for the reason that they would probably develop cracks with conventional machining.
5. ECM technique is widely used in the manufacturing of jet engines.

VII. Economical status:

a) The procedure is economical when a huge figure of complicated duplicate yields needs to be prepared (at least 50 units).
b) Numerous apparatus could be coupled to a cassette to make loads of cavities parallely.
c) Big cavities are further economical on ECM and can be processed in 1/10 the time of EDM.

VIII. Products:

The two mainly conventional inventions of ECM are turbine/compressor blades and rift barrels. Each of those parts demand machining of tremendously unbreakable metals with definite mechanical properties 7 characteristics that would be in actuality complicated to carry out on standard machines.

IX. X. Characteristics achieved by ECM:

1. Stress unbound grooves.
2. Whichever groove geometry can be achieved.
3. Several conductive metal can be machined.
4. Repeatable accuracy of 0.0005".
5. From top to bottom surface finish.
6. Speedy cycle time.

X. XI. Safety consideration:

a) Numerous sensors are employed to have power over short circuit, turbulence, passivation, contact and over current sensors. In situation of contact, immeasurable heat would be generated melting the instrument, vanishing the electrolyte and grounds a fire.
b) The employee must be insulated to avoid electrocution.
c) The instrument and the work piece must be grounded earlier any handling is carried out.
d) Hydrogen gas produced is very combustible, so it should be disposed of appropriately and fire safety measures should be taken.

e) The garbage material is very hazardous and environmentally antisocial (metal sludge) so it must be reprocess or disposed of properly.

f) Electrolyte is extremely under pressure hassled and labor must verify for minor fault in piping earlier than operating.

XI. Conclusion:

ECM is a technological procedure which is employed by chemical processes. It is economical procedure which is very frequently used. It has numerous advantages over EDM .it is very fast and accurate process known till know .the only disadvantage of it is being costly. Safety measure should be taken properly to avoid accidental damages which could have been resulting in the loss of labor & money.

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