ELECTRO CHEMICAL MACHINING

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ABSTRACT:-

The metal and alloys which are difficult to machine by machining process for this purpose electro machining process is used. It has got vide applications in various processes. Its is based on Michall Faradays classical laws of electrolysis requiring basically two electrodes, an electrolyte, a gap and a source of D.C power of sufficient capacity. In the actual process, the cathode is tool-shaped, more or lens like the mirror image of the finished workspace. The work piece is connected to positive supply. The tool or cathode is connected to negative terminal supply. The cathode is advanced towards anode through the electrolyte that completes electric circuit between anode and cathode. The metal is then removed from the workpiece through electrical action and cathode tool shape is reproduced on the workpiece. The metal is detached atom by atom from the anode surface and appears in the electrolyte as positive ions. During electrolysis of water, its molecules gain electrons from cathode so that they separate in to free hydrogen gas and hydroxyl ion. As the anode dissolves, negative charged hydroxyl ions are electrically balanced by positive charged metal ions entering in to the electrolyte. This process is normally used for mass production and used for hard materials. The process is reversed then electroplating where material is added but in this process material is removed instead of addition .The turbine blades are manufactured by this process only.

Key words: - Cathode, ECM, Electrolytes, Mass production

Introduction:-

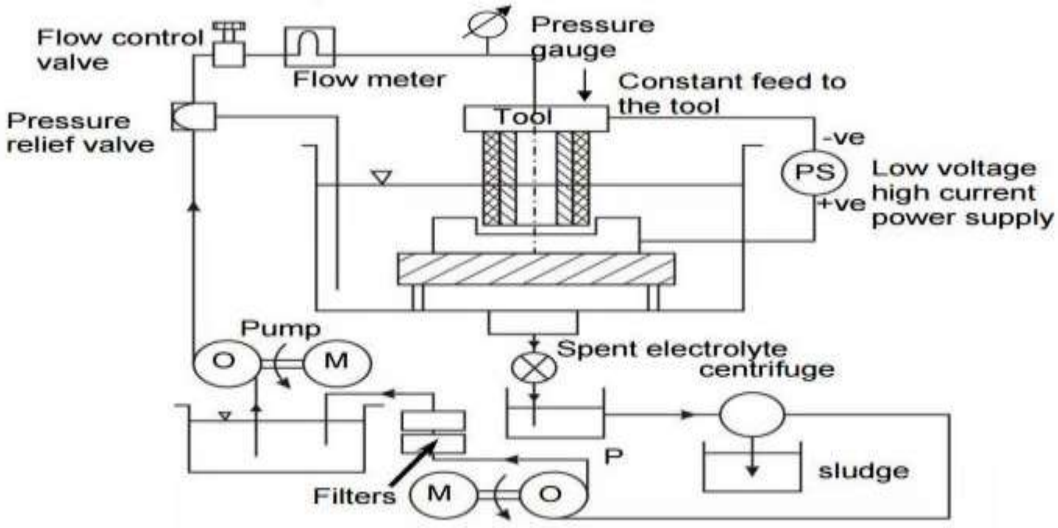
This process is mostly used for production of complicated shapes like turbine blades for example we use in generation of electricity where water falls at a higher speed and runs turbine and water strikes on blade. The blades require a good surface finish. The process is fast and more convenient method of removing by hand. ECM machines are available in both types that are horizontal and vertical type. As per the requirement the machines are made in different sizes. The vertical machine consists of spindle to move, Colum for standing position along with table. The machine is totally advanced where spindle has a servo mechanism that automatically moves the tool and the gap of cathode and work piece is maintained.

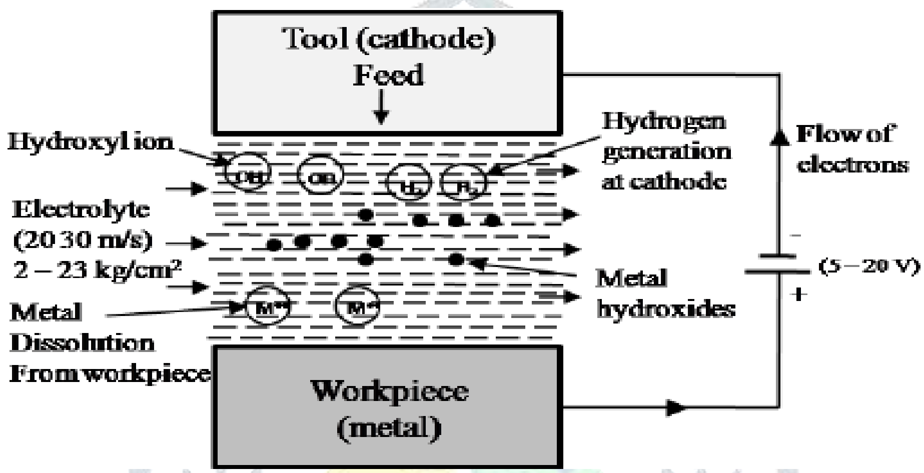
Problem:

There is no proper method for machining therefore advanced technology to be used.

Methodology:-

Metal ions do not remains ions in the solution but combine with the hydroxyl ions to form metal hydroxides .These hydroxides are insoluble in water hence they appear as solid precipitates sluges and no longer effect the electrochemical reaction. This process continues and the cathode tool reproduces its shape on the work piece anode.





The application of direct current through a solution of electrolyte results in redox (reduction and oxidation) reactions, while application of A.C leads to conduction only. The reason being that the electrodes change their polarities very fast hence the electrode reaction occurring in first half of the cycle is reversed in later half of the cycle. Hence only DC is used in this process. The electric current is of the order 50 to 40000Amp at 6 to 30 V DC for a current density of 20 to 300 A/cm2 across a gap of 0.05 to 0.7 mm between the tool and the workpeice. The electrolyte flows through this gap at a velocity of30 to 60m/forced by an inlet pressure of about20 kgf/cm2 Suspended solids are removed from the electrolytes by centrifugal pumps, settling tanks and filters and the filtered electrolyte is recalculated fIn this way machinery takes place due to atomic level dissociation of workpiece.

CHEMICAL EQUATION: -

At Cathode:

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

At Anode:

$$Fe - 2e \rightarrow 2Fe^{2+}$$

$$Fe^{2+} + 2(OH)^- \rightarrow Fe(OH)_2$$

ELECTROLYTES:-

The water is used as base of electrolyte in ECM. Commonly used electrolytes are:-

Sodium chloride(NaCl), Sodium nitrate (NaNo3), Potassium chloride (KCL), Sodium Hydroxide (Na OH), Sodium fluoride(NaF). These solutions on reaction produce an insoluble compound in the form of sludge.

Functions of Electrolyte:-

It carries current between tool and workpiece. It dissipates heat produced in the operation; It removes products of machining and other insoluble products from the cutting region.

Characteristics of Electrolyte:-

1-Good electrical conductivity. 2-Low viscosity. 3-High specific heat. 4-Non corrosion. 5-Non-toxic. 6-Readily available7-Inexpensive. The most commonly used electrolyte is Podium chloride as its electrical conductivity is fairly constant; PH value is zero to thirteen, inexpensive and non-poisons. However a disadvantage is that it is corrosive and produces large amount of sludge.

Tool Material for ECM:-

Material for tool and fixture should be anti-corrosive because they are required to operate in the corrosive environment of electrolyte.

Should have high thermal conductivity. High electrical conductivity. Easy machining of tool material is required because dimensional accuracy and surface finish of the tool directly affects the workpeice accuracy and surface finish. It should be rigid enough to take up the load due to fluid pressure. It should be chemically inert to electrolyte. Copper, Brass, Bronze, Aluminum, Stainless steel and are used. Also those areas on the tool ECM action is not required should be insulated.

Workpeice and Work Holding System:-

Only electrically conductive work materials can be machined by this process. Work holding devices are made of electrically nonconductive materials having good thermal stability and low moisture absorption properties ex-graphite fibers-reinforced plates, plastics, etc.

Power sources:-

During ECM, a high value of direct current and a low value of electric potential (V) across IEG is desirable. IEG-Inter electrode gap with the help of a rectifier and transformer a 3 phases A.C is converted to low voltage, high current DC. Silicon controlled rectifier (SCRs) are used for rectification and voltage regulation. Voltage regulation of 1% is adequate for ECM.

Various machinery operations based on electrochemical dissolution of Anode:-

I-Electrochemical Boring (ECB) Ii-Electrochemical Drilling (ECD) Iii-Electrochemical Grinding (ECG) Iv-Electrochemical Honing (ECH) V-Electrochemical Milling (ECM) Vi-Electrochemical Souring (ECS) Vii-Electrochemical Debarring (ECD)

Applications: - 1-Machinery of turbine blades. 2-Cutting of curvilinear slots. 3-Machinery of intricate patterns. 4-Production of integrally bladed nozzle for use in diesel locomotives. 5-Machinery of thin large dia etc. diaphragms 6-Machinery of tungsten carbide. 7-Machiery of gears etc. 8-For sharpening and internal finishing of surgical needles. 9-Machinery of Hard, Brittle and heat resistant material.

Advantages:-

1-The metal removal rate by this process is high for high strength-temperature resistant (HSTR) material compared to conventional machining. 2-Complex shapes can easily be machined. 3-There is no application of force, no direct contact between tool and work and no application of heat so there is no scope of mechanical and thermal residual stresses in the work piece. 4-Very close tolerances can be obtained. 5-Unlike EDM work need not be submerged in electrolyte but it is pumped around the work piece at high speed so there is no tool wear unlike EDM giving it a very long life. 6-Machining is done at low voltage. 7-Since no spark is produced and temperature generated are low so it does not cause metallurgical change in the work piece material.

Disadvantages:-

1-Non conducting materials cannot be machined. 2-Corrosion and rust occur in ECM machine. 3-High initial and working cost. 4-Space and floor requirement are higher than conventional machining techniques. 5-The specific power consumption is nearly 100 times more than in turning. Or milling steel. 6-Tool material and work piece material should be chemically stable with its electrolyte solution.

Metal Removal Rate:-

It is the volume of work piece material removed per unit time. It is expressed in mm3/min.

$$\boldsymbol{MRR = \frac{V_i - V_f}{t} = \frac{(M_i - M_f)}{e \times t}}$$

where

$M_i =$ Initial mass of workpiece in grams, $M_f =$ Final mass of work piece in grams.

e = Density of work piece in gm/cm^3, t = Machinery time in minutes.

a. It is a function of feed rate which dictates the current passed between work and tool.
b. As tool advances towards work gap decreases, hence current increases which in turn increases metal removal rate.
c. High feed rate produces best surface finish but is limited by removal of hydrogen gas and products of machining.
d. MRR is lower with low voltage, low electrolyte concentration and low temp

Radial Overcut:-

It is the difference between the radius of the hole and the external radius of the tool when a hole of constant diameter is produced in the work piece.

$$\boldsymbol{Radial\ Overcut = \frac{D_h - D_{t_e}}{2}}$$

where,

$D_h =$ Diameter of hole, $D_{t_e} =$ External diameter of tool

In case of tapered hole

$$\boldsymbol{Radial\ overcut} = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{D_{h_i}}{2} - R\right)$$

where,

R = External tool radius, D_{h_i} = Dia of hole at i^{th} location, n = no of locations at which dia is measured.

Taper angle θ

$$\tan\left(\frac{\theta}{2}\right) = \frac{R_{top} - R_{bottom}}{L} = \frac{D_{top} - D_{bottom}}{L}$$

D_{top} = Dia of hole at the top, D_{bottom} =Dia of hole at the bottom, L= Depth of hole, Θ=Taper Angle

Output process parameter:-

1. Material Removal Rate
2. Radial Overcut
3. Taper Angle θ

Input process parameter:-

1. Tool feed Rate
2. Voltage
3. Electrolyte concentration
4. Electrolyte flow Rate
5. Inter electrode gap

Result/Conclusion: - By using the above process started with methodology the proper machining have been done and further study to be done for mass production as per the challenging current scenario**.**

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