International Journal of Latest Technology in Engineering & Management (IJLTEM)
ISSN: 2456-1770 //Website: www.ijltem.com
Volume 7, Issue 5 (September - October 2022)

ELECTROCHEMICAL MACHINING TOOLING TECHNIQUE & INSULATION MATERIALS

Abhishek R.[1], Nuthan Babu G R[2], Aditya D[3], Ajay Kumar H[4], Siddappa[5]
Department of Mechanical Engineering
JSS Academy of Technical Education, Bangalore- 560060, India

ABSTRACT: *Electrochemical Machining is a non-traditional machining process which is used to machine difficult-to-machine materials such as super alloys, Ti-alloys, stainless steel etc. The basic working principle is based on Faraday law of electrolysis due to which the material removal takes place atom by atom by the process of electrolysis. It is normally used for mass production and is used for working extremely hard materials or materials that are difficult to machine using conventional methods. Its use is limited to electrically conductive materials. ECM can cut small or odd-shaped angles, intricate contours or cavities in hard and exotic metals, such as titanium aluminides, Inconel, Waspaloy, and high nickel, cobalt, and rhenium alloys. Both external and internal geometries can be machined.*

KEYWORDS: *Electro Chemical Machining, Tools, Insulation*

INTRODUCTION

There is no possibility for tool wear in ECM. The ECM cutting tool is guided along the desired path close to the work but without touching the piece. Unlike EDM, however, no sparks are created. High metal removal rates are possible with ECM, with no thermal or mechanical stresses being transferred to the part, and mirror surface finishes can be achieved.

A cathode (tool) is advanced into an anode (work piece). The pressurized electrolyte is injected at a set temperature to the area being cut. The feed rate is the same as the rate of "liquefaction" of the material. The gap between the tool and the work piece varies within 80–800 micrometers (0.003–0.030 in.) As electrons cross the gap, material from the work piece is dissolved, as the tool forms the desired shape in the work piece. The electrolytic fluid carries away the metal hydroxide formed in the process.

As far back as 1929, an experimental ECM process was developed by W. Gussef, although it was 1959 before a commercial process was established by the Anocut Engineering Company. B.R. and J.I. Lazarenko are also credited with proposing the use of electrolysis for metal removal. Much research was done in the 1960s and 1970s, particularly in the gas turbine industry. The rise of EDM in the same period slowed ECM research in the west, although work continued behind the Iron Curtain. The original problems of poor dimensional accuracy and environmentally polluting waste have largely been overcome, although the process remains a niche technique.

Equipment

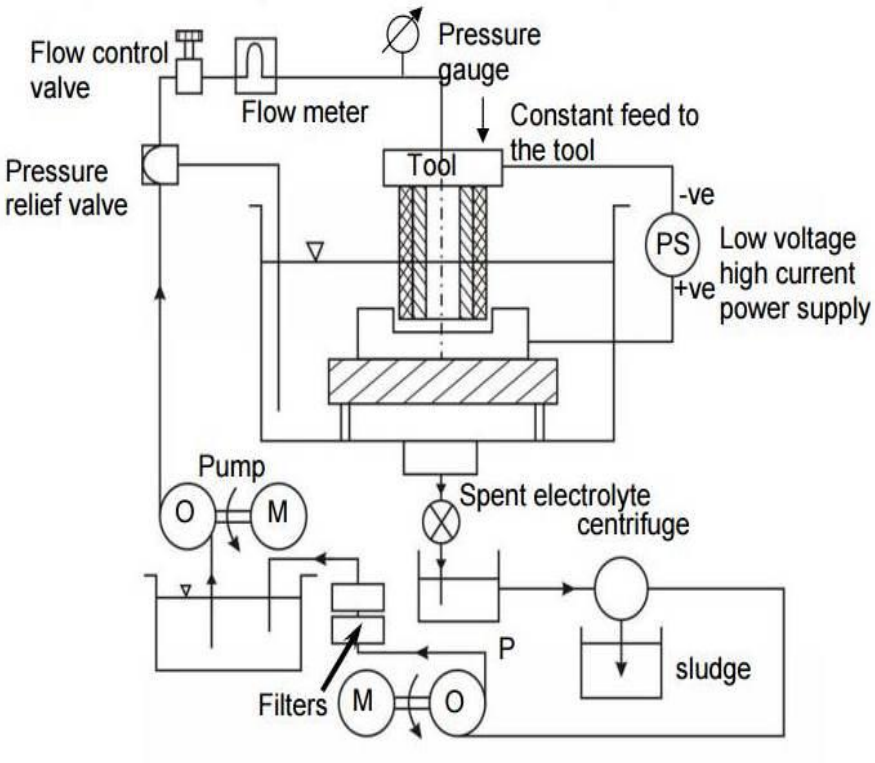


Fig 1. Electrochemical Machining

Tools used in ECM

Tool is made by an anti-corrosive material because it has to withstand in corrosive environment of the electrolyte a for long period of time. It should also have high thermal conductivity. The stiffness of the tool must always be high. The material used to make the tools must highly machinable as very complex shapes are machined using the ECM. It should also have high electrical conductivity for easy flow of electricity from the tool to the work piece. The rigidity of the tool construction and the material is a major factor that affects MRR as the high pressure flow of electrolyte can cause the deflection of tool leading to change in the shapes of the cut as compared to the desired shapes. The tool material must be cheap and easily available. The most commonly used material to prepare the tools for ECM are aluminum, copper, brass, bronze, carbon, copper-manganese, copper-tungsten, titanium, cupro-nickel.

Insulation for electrodes in ECM

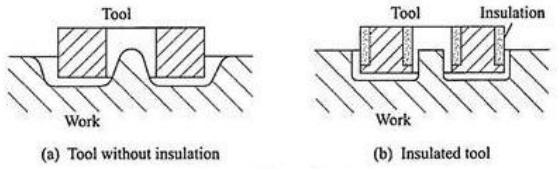
One of the major drawbacks of ECM is the effect of pulsating currents which causes a phenomenon known as the overcut. Since the accuracy of the machining is scaled with the overcut values, it is important to determine a suitable way to reduce the Overcut. Researches and studies have showed that overcut is predominantly caused because of the stray current on the sides of the non-insulated electrode which causes electrolytic erosion and thus producing oversized holes. To reduce this phenomenon, various experiments and research have been conducted. Experiments by Bhattacharya et al. (2003) and Subburam et al. (2014) inferred that when a less coated electrode in used for machining, it produces a greater overcut and hence the accuracy of the cut decreases significantly. While Bhattacharya et al. (2003) used a Platinum electrode coated by Silicon Nitride by using the process known as Chemical Vapour deposition (CVD), Subburam et al. (2014) used a plain brass electrode to drill a hole in an Aluminium composite by ECM in their experiments. To add to these

inferred results, the result of experiment conducted by Thanigaivelan et al. (2010) who used stainless steel electrode coated with a bonding liquid showed a highly accurately drilled hole due to the reduced overcuts due to coating.

Dahai Mi et al. (2015) proposed a method for controlling the conductive area ratio along thetool electrode for machining complex internal features. The conductive area of the tool was controlled by providing partial insulations and thus obtaining the required accuracy. Using a factor known as the S/N ratio, the levels to the minimum overcut has been found. Also, Harmen (2004) has described the role of ECM in mass production for Philips DAP. Experimental investigations over the product showed that all the slots for the product would be readily formed by insulating the side walls of the electrode.Yin Qingfeng et al. (2014) carried their research on lower tool electrode wear in simultaneous EDM and ECM operation. Regarding ECM, the results show that, by insulating the sides of the electrode by using a suitable insulating material which is made up of epoxy resin, dilute agent, hardener and a coupling agent, the excessive electrolytic erosion can be suppressed effectively.

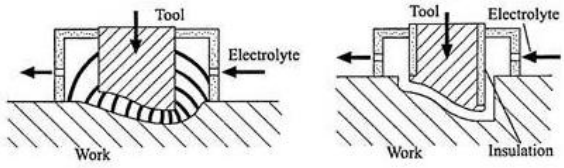
Generally, the simplest method of applying insulation is by spraying or dipping. Teflon, urethane, phenolic, epoxy, powder coating and other materials are commonly used for insulation. Sprayed or dipped coatings of epoxy resins are among the most effective insulating materials. For optimum effectiveness, these coatings should be used with a protective lip on the tool to protect the edge of the insulation from the flow force of the electrolyte.

Die sinking without and with a proper insulation



(a) Tool without insulation (b) Insulated tool

Fig. 6.47 Effect of insulation.



(a) Tool without insulation (b) Insulated tool

Stray machining with uninsulated tool.

Application:

- ECM with insulated electrodes is used to machining disk or turbine rotor blade.
- It can be used for slotting very thin walled collets.
- It can also be used to generate internal profile of internal cam.
- Production of satellite rings and connecting rod, machining of gears and long profile etc.

Advantages:

- It can machine very complicated surface. -Z Pandilov 2018 IOP Conf. Ser.: Mater. Sci. Eng. 329 012014
- A single tool can be used to machining large number of work-piece. Theoretically no tool wear occurs.
- Machining of metal is independent on strength and hardness of tool.

- ECM with coated electrodes gives very high surface finish. -Anup Malik & Alakesh Manna

Disadvantages:

- High initial cost of machine.
- Design and tooling system is complex. - Anup Malik & Alakesh Manna
- Fatigue property of machined surface may reduce.
- Nonconductive material cannot be machined.
- Blind hole cannot be machined form ECM.
- Space and floor area requirement is high compare to conventional machining.

Conclusions

By studying the various factors affecting the MRR and the accuracy of shape that is to be machined, we can conclude that these are the following characteristics required for the tool and the insulation for the desired output.

Tool material

1. High electrical and thermal conductivity
2. Good stiffness
3. Easy machinability - particularly important if complex shaped tools are required
4. High corrosion resistance - to protect itself from the highly corrosive electrolyte solution
5. Rigidity - Rigidity of the tool construction and material is important because the high pressure can cause deflection of the tool
6. Easily available

Insulation:

- Adhesion to the tool: preformed insulation can be held to the tool by shrinkfitting, adhesives or fasteners
- Sealing without pores or leaks that could cause stray machining by current leakage
- Adequate thickness
- Smoothness to avoid disturbing the flow of electrolyte
- Resistance to heat for continuous service at 200°C without breakdown
- Durability to resist wear in guides and fixtures
- Chemical resistance to the electrolyte
- High electrical resistivity
- Uniform application to minimize disturbance of the flow of electrolyte and to preventinterference
- Low water absorption

REFERENCES

[1] "IMPACT OF INSULATED ELECTRODES IN ECM – A REVIEW" by J Prasanna and Vijay Pranav S.

[2] Bhattacharyya. B, Munda. J (2003), 'Experimental investigation on the influenceof electrochemical machining parameters on machining rate and accuracy in micromachining domain' - International Journal of Machine Tools & Manufacture, 43 1301–1310.

[3] Dahai Mi, Wataru Natsu (2015), 'Proposal of ECM method for holes with complexinternal features by controlling conductive area ratio along tool electrode'- Precision Engineering, 42 179–186.

[4] Harmen S.J. Altena (2004), 'EDM and ECM for mass production Philips DAP'- Journalof Materials Processing Technology, 149 18–21.