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IMPACT OF INSULATED ELECTRODES IN ECM – A REVIEW

J. Prasanna
Department of Mechanical Engineering
Anna University
Chennai, India
prasanna@annauniv.edu

Vijay Pranav. S
Department of Mechanical Engineering
Anna University
Chennai, India
vijaynovice12@gmail.com

ABSTRACT

Electrochemical Machining (ECM) is a distinctive method of machining hard materials whose application are most commonly found in the fields of aerospace and automobile. This process which does not have any contact between the tool and work piece has its working based on anodic dissolution and governed on the phenomena of Faraday's law of electrolysis. The machining action happens when a potential voltage is applied between the tool and the work piece and when a suitable electrolyte is allowed to flow in between the gap. The precision of the operation depends on the parameters considered. Selecting the suitable parameters to obtain an accurate result is a big task. Because of this, ECM is considered as one of the complex and nonlinear processes. One of the major complexity that lies in ECM is 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. Having this in mind, this paper deals with an exhaustive review study on the insulation of the electrodes and the methods of providing insulation. Also this paper covers the work carried out on the effect of insulation over Material Removal Rate (MRR) and Overcut.

Keywords—*Insulation, Overcut, Material Removal Rate(MRR), Stray erosion.*

I. INTRODUCTION

Coated electrodes are usually used to achieve improved performance, higher MRR, better surface finish and increased wear resistance. Selection of insulating material and the coating method plays an important role in producing good results. It is not that ECM was the first process where insulation was tried out. Even Electric Discharge Machining (EDM) can produce good results with coated electrodes. But the thing is that tool wear is very high and is not economically suitable for mass production in industries. Hence the role of EDM has been shifted upon to ECM process where normally there is no contact between the tool and work piece and with insulated tool there is a chance of getting even

better performance results. [2] One of the worrying factors one should be concerned while machining in ECM is the stray erosion that occurs around the machining area. Also in operation like die sinking and drilling, Overcut comes into play, where the ultimate is to have a reduced Overcut, or else the purpose of precision machining with ECM fails instantly. Overcut and stray erosion is caused because of the action of the electrolyte when allowed to flow between the tool and the work piece. This phenomena is known as side electrolyzing. [6] Since the gap between the tool and the work piece is very minimum, the control of the gap in accordance to the material dissolved turns out to be a complex task.

This results in the fluctuation of current density acting on the machining area resulting in unpredictable material removal rates. Hence a study on the insulation coating sounds important in identifying the best and the least expensive method of producing insulated electrodes to have a reduced overcut and reducing the action of stray erosion.

II. COATING ON TOOLS

Higher production demands, higher precision and cost have a serious emphasis on the development of coated tools for ECM process. Coating can be classified into two types. One is metallic coating and the other is insulation coating. Metallic coatings are most commonly done by electro deposition and are usually carried out to enhance the properties of the tool and thus improving the machining performance and surface finish. The task lies in identifying the best metal to be coated. Because, the metal chosen should have all the required properties to support the machining process. One of the most required property is being electrochemically stable. Insulation coatings are usually done by coating the tool/electrode by using a suitable epoxy resin or a polymer coating is done either by dip coating or electro spinning method.

Surface coatings convert the base surface into a new material of certain desirable properties (In this case providing a perfect insulation on the sides of the electrode). Sometimes insulation also helps in improving the aesthetics of the tool. The selection of coating process depends on many conditions such as cost, safety, environmental effect, process suitability etc.

III. INFLUENCE OF INSULATION ON OVERCUT AND MRR

Bhattacharyya et al. (2003) carried out the experimental work by insulating the platinum electrode with Silicon Nitride by using Chemical Vapour Deposition (CVD). Insulated electrode with lower electrolyte concentration, higher voltage produced less Overcut with moderate MRR on Copper plate. Subburam et al. (2014) investigated the machining of micro holes on an Aluminium composite by using a plain hollow brass electrode. The experiment results showed that when an insulation less electrode is subjected to machining, it produces larger Overcut, subsequently resulting in les machining accuracy. Thanigaivelan et al. (2010) carried out their experimentation by using a stainless steel electrode coated with a bonding liquid which produced an accurate hole with a reduced overcut.

Also the levels to obtain the minimum overcut have been found out by using S/N ratio. Dahai Mi et al.(2015) proposed a method for controlling the conductive area ratio along the tool electrode for machining complex internal features. The conductive area of the tool was controlled by providing partial insulations and thus obtaining the required accuracy. The effectiveness of the proposed method was justified by comparing both the simulated and experimental results. The impact of the insulation over the electrode has been proved by the obtained results going in agreement with each other. 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, hardner and a coupling agent, the excessive electrolytic erosion can be suppressed effectively. Yuan – Jen Chang et al. (2015) studied the effect of atmospheric dual laser deposited dielectric coating on electrodes. A dielectric medium/coating on the electrode was the simplest way to reduce the stray current. Work was carried out with a dual laser – assisted deposition for TiO_2/ TiN film deposition on Tungsten electrodes. The results showed that the Overcut was reduced by 60% and the depth was improved by 15%. Swain et al. (2012) made an exclusive study on the coated micro tools in the context of ECM. Nickel coating was done on Tungsten electrode in order to improve its electrochemical stability.

Their work compared the results between coated and uncoated tool which concluded that coated micro tools had high MRR and was electrochemically stable. helical electrode insulation layer for Electrochemical Micro Drilling (ECMD). This work was done by using sol-gel method and dip coating to insulate the electrode. Also, ceramic and epoxy double layer films were used to avoid the action of side current machining

IV. CONCLUSION

By making an extensive study on all the works carried over on the influence of insulation of electrodes for ECM it can be considered that there are only a few viable processes which can be carried out to produce considerable results. Processes such as spray coating, electro spinning, dip coating, electro deposition, etc. are the most commonly used methods to insulate the electrode. Regarding the materials, materials such as epoxy resin with a suitable hardner, polymers, bonding liquids, shellac resins, Silicon Carbide, Silicon Nitride etc. are predominantly used for effective insulation. Hence this comprehensive review can be concluded by stating that, any method which is simple in action, safe for use and economically feasible can serve the purpose. Hence producing appreciable results and meeting the accuracy demands of the operation.

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