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COMPARATIVE STUDY ON THE EFFECT OF DIFFERENT INSULATION MATERIALS ON THE PERFROMANCE CHARACTERISTICS OF ECM

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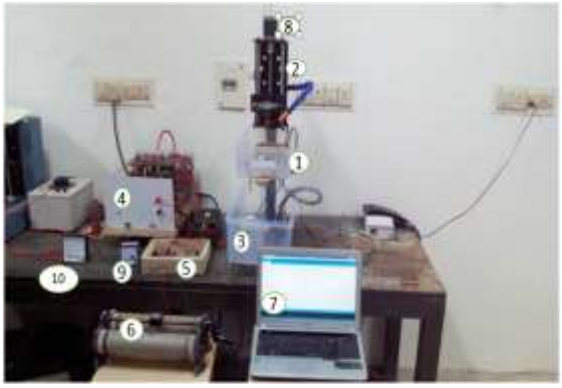
ABSTRACT

Electrochemical Machining (ECM) has been considered as one of the existing discreet modern machining processes for machining hard materials. ECM works on the principle of Faraday's law of electrolysis and the material is removed from the work piece without any contact between the tool and the work piece based on the phenomena known as anodic dissolution. With its vast application in the fields of automobile and aerospace, the efficient use of this process sounds important. One of the determining factors considered for precision machining is, reduced Overcut. Producing large Overcuts makes the process unfit for machining and the aim of achieving precision fails. Stray erosion takes place around the machining area when the electrolyte is passed in between the tool and the work piece because of the effect of stray current on the sides of the tool. Hence, the aim of the work was to investigate the effect of different insulated electrodes over the process responses. Six different factors: voltage, current, feed, electrolyte, electrolyte concentration and electrode were considered. Work piece used was a Titanium alloy (Ti-6Al-4V) with a thickness of 0.5mm. Experiments were carried out with pure electrode in their optimal levels and the responses, Material Removal Rate (MRR) and Overcut were determined. Further, the electrodes were insulated with three different materials and experiments were carried out again at the same optimal levels. The results showed that the insulated electrodes produced improved results in both MRR and Overcut when compared to the results obtained with pure electrodes.

Keywords*— Electrochemical Machining, Material Removal Rate, Overcut, Insulation, stray erosion.*

INTRODUCTION

Machining hard materials and parts with complex shapes have been done with ease with the help of the developments in the machining process. One among the process is the ECM. ECM is an imaging process where the shape of the tool is negatively mirror imaged on the work piece when a potential voltage is applied between the tool and the work piece and a suitable electrolyte is allowed to flow through the gap.[10] ECM stands out from other processes by combining electrical, mechanical and chemical energies to produce a part. Since the machining action does not have a contact there is no stress created in the part and the part is free of micro cracks. Good surface finish can be obtained



with this process and since the tool wear is negligible, this process is more suitable for mass production. ECM has a large number of factors to be controlled which makes the process complex and highly non-linear. With these difficulties, producing a part with required surface finish and dimensional tolerance has posed a challenge to this process. ECM has been widely used in industries for only finishing and deburring process because when used for machining it produces large overcuts which are not acceptable for precision machining.

Researches and studies have been carried on this to make use of the process efficiently for machining because of its unique advantages over the other processes. Since the accuracy of the machining is scaled with the overcut values, it is important to determine a suitable way to reduce the overcut. It is supposed that overcut is caused because of the stray current acting on the side walls of the electrode when the electrolyte flows through the gap. This effect is known as side electrolyzing [7].

This effect is commonly seen where pure electrodes are used as tool. In order to avoid this, the electrodes are coated with suitable insulating materials and hence reducing the action of the electrolyte when it flows over the tool. The coating material should be carefully chosen in such a way that it does not affect the machining process, should not absorb water, should be chemically inert, should not alter the pH level of the electrolyte, should be safe to handle, should be easily available, should be less expensive and should be easily coated over the tool

EXPERIMENTAL SETUP

The experiments were carried out on a custom-made equipment which has its own power supply and electrolyte pumping unit. The fabricated power supply is a variable D.C voltage with 0-30V and 70 A. The gap between the tool and work piece was controlled by a stepper motor drive. The parameter mentioned is with respect to motor speed. The tool size used was a standard rod of 6mm in diameter. Ti-6Al-4V of 0.5 mm thickness was used as the work piece and a through hole was drilled using this setup. Figure 1 shows the experimental setup on which the experiments were carried out.

Fig. 1 Experimental Setup

1	Machining tank
2	Tool feed
3	Electrolyte tank
4	Power supply unit
5	Gap Control unit
6	Varying resistance
7	Feed control
8	Stepper motor
9	Voltmeter

10	Ammeter

EXPERIMENTAL DATASET

The optimal levels for the experimentation were taken from the experimental work carried out by Prasanna et al. [9] to analyze the influence of insulated electrodes over pure electrodes. Authors conducted the experiment based on Taguchi's L18 Orthogonal Array. The machining parameters considered were voltage, current, feed, electrolyte, electrolyte concentration and electrodes and the responses considered were MRR and Overcut. Two different optimal levels were obtained for both MRR and Overcut. Table I and Table II shows

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Concentratio (g/L)
NaCl	30	7	120	200

the optimal levels for the corresponding responses.

TABLE I. Optimal levels for MRR [9]

TABLE II. Optimal levels for Overcut [9]

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Concentration (g/L)	Electrode
NaCl	20	1	80	200	Brass

IV.COATING OF TOOL

Based on the literature study made, three distinct insulation materials were selected for coating. Shellac resin, bonding liquid and an epoxy were chosen to provide insulation for both Copper and Brass electrodes.

The coating was done by a simple dip coating method, where the sides of the tools were insulated by dipping the tool in the coating liquid. Once the tools were coated, they were allowed to dry depending upon their curing time. As a result, an even, and a thin non-conductive layer was obtained, thus making the bottom of the tool alone conductive. Figure 2 and 3 shows the coating method and the coated electrodes.

Fig. 2. Coating method

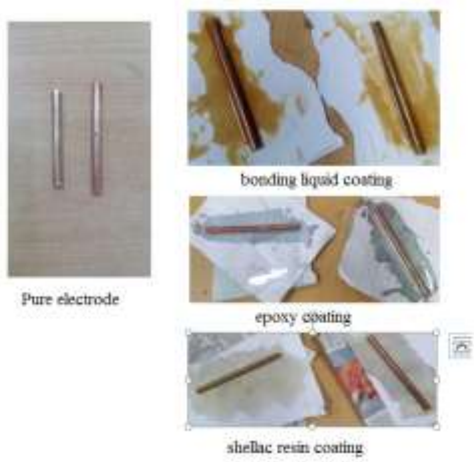


Fig. 3. Insulated electrodes

V EXPERIMENTATION

With the above given optimal levels, experiments were carried out separately for both MRR and Overcut. For each response four set of experiments were carried out. One with a pure electrode and the remaining three with three different insulated electrodes. It has been noted that, for MRR, Copper electrodes have been used and for Overcut, Brass electrodes have been used. Experiments were carried out by machining a through hole on the work piece and the values were recorded accordingly. Figure 4 shows the machined samples obtained during the experimentation.

Fig. 4. Machined Sample

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	Overcut (mm)
NaCl	20	1	80	200	Brass	0.22

Effect of insulation over MRR

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	MRR (mg/min)
NaCl	30	7	120	200	Cu	17.134

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	MRR (mg/min)
NaCl	30	7	120	200	Cu	14.125

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	MRR (mg/min)
NaCl	30	7	120	200	Cu	25.714

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	MRR (mg/min)
NaCl	30	7	120	200	Cu	14.285

Four sets of experiments were carried out at the specified optimal levels to get to know the influence of both pure and insulated electrode over the MRR.

TABLE III. Effect of pure electrode over MRR

TABLE IV. Effect of shellac coated electrode over MRR

TABLE V. Effect of bonding liquid coated electrode over MRR

TABLE VI. Effect of epoxy coated electrode over MRR

TABLE III to VI shows the effect of insulated copper electrodes over the MRR. The weight of the work piece, before and after machining, and time to machine the through hole were noted and MRR was calculated appropriately.

Effect of insulation on Overcut

The same set of procedure was repeated with Brass electrode to determine the effect of insulation on Overcut. Overcut is usually obtained by calculating the difference between the machined hole diameter and the tool diameter. TABLE VII to X shows the effect of insulated Brass electrode on overcut.

TABLE VII. Effect of pure electrode on Overcut

TABLE VIII. Effect of shellac coated electrode on Overcut

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	Overcut (mm)
NaCl	**20**	**1**	**80**	**200**	**Brass**	**1.22**

TABLE IX. Effect of bonding liquid coated electrode on Overcut

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	Overcut (mm)
NaCl	20	1	80	200	Brass	0.37

TABLE X. Effect of epoxy coated electrode on Overcut

Electrolyte	Voltage (V)	Current (A)	Feed (rpm)	Conc. (g/L)	Electrode	Overcut (mm)
NaCl	20	1	80	200	Brass	0.80

CONCLUSION

The results obtained clearly depicts that there is a huge influence of insulated electrodes over the machining responses when compared to pure electrodes. The results justify the fact that stray erosion is reduced as a result of reducing the stray current by insulating the sides of the electrode. Also this results emphasizes on the fact that, use of a simple and a least expensive coating method and material can provide better results. Figure 4 and 5 clearly shows that, when a Copper electrode coated with a bonding liquid produces high MRR and a Brass electrode coated with shellac resin produces reduced overcut. This research work has provided a result with a maximum MRR of 25.714 mg/min and a reduced Overcut of 0.22mm. Figure 4 and 5 graphically shows the impact of insulation over MRR and Overcut. It is clear that, bonding liquid coated Copper electrode produces high MRR and Shellac resin coated Brass electrode produces reduced Overcut while machining titanium alloy.

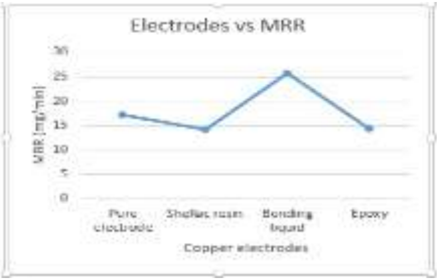


Fig. 5. Copper electrodes MRR

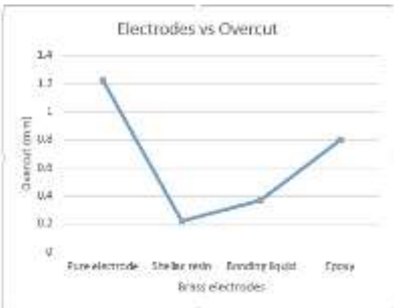


Fig. 6. Brass electrodes vs. Overcut

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