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Experimental Investigation on Micro ECM Of Aluminium Metal Matrix Composite

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Abstract: All engineering materials can be one or combination of processes in such a way that the material's potential is fully exploited. This paper examines about the process parameters like electrolyte concentration, pulse on/off ratio, machining voltage, voltage frequency, tool vibration frequency on over cut and MRR (Material Removal Rate). Electrochemical machining is a method of removal of a metal by an electrochemical process. It is typically used for the mass manufacturing and is used for extremely working the hard materials or the materials that are difficult to machine using the conventional methods. In this project, we have chosen a composite (Al-6063) reinforced with MWCNT with various composition and found the optimization of parameters on machining rate, overcut, electrolytic concentration, machining voltage, voltage frequency, tool vibration frequency and pulse on/off ratio of a composite be achieved by using a method with EMM (Electrochemical Micro Machining). But before getting into the EMM, we had casted the composite using stir casting, then surface finishing and then we had sliced each composite for the EMM test. This project also attempts in establishing the comprehensive mathematical model for correlating the interactive and higher-order influences of various machining parameters. The MRR (Material Removal Rate) and radial overcut of the composite is achieved by using a method utilizing relevant experimental data as obtained through experimentation. Additionally, Scanning Electron Microscope (SEM) images are taken for the further understanding of micro-hole profile.
Keywords: composite, electrochemical micromachining, machining rate, overcut

I. INTRODUCTION

Electrochemical machining (ECM) is a non-conventional manufacturing process which relies on duplicating the shape of the tool electrode into the workpiece via the anodic dissolution of the workpiece. I ECM, both the tool electrode and the workpiece are submerged in an electrically conductive electrolyte, usually an aqueous salt solution such as sodium chloride (NaCl) or sodium nitrate ($NaNO_3$). A constant potential is applied between the two electrodes ensuring the workpiece becomes the anode (positive electrode). The applied potential causes a DC current to flow between the electrodes, dissolving the anode material in the process. The reaction at the cathode is usually generates hydrogen gas.

ECM is chemical reaction occurred at electrode-electrolytic interface. Fine machined surface with no heat affected zones and cracks can be obtained for almost all metallic materials. Because there is no tool wear with ECM, which is a key problem for micro machining with EDM, it is thought that ECM is more suitable for industrial-scale machining of complex shaped micro holes. Recently, ECM machining of 3D shaped micro holes by controlling tool electrode movement or applied current with side uniformly insulated electrode or disc electrode was proposed. Machining efficiency may be restricted with these methods since only the bottom surface of the tool electrode is used for machining, and complex movement or applied current control of the tool electrode is also needed.

A. *Composition of Composites*

The CNTs reinforced in Aluminium 6063 metal found encouraging use in many applications. J.P. SAVINA et.al., developed MWCNT-Al6063 with various compositions.

P.B. Senthil Kumar, et. al., focused on fabrication of CNTs reinforced with Al-6063, by stircasting method. The microstructure and mechanical properties were experimentally tested for various weight percentages of CNTs. They concluded that, the addition of MWCNTs in Al6063, increases its impact resistance and thereby decreasing the cracks along with voids in the crystal lattice as observed in XRD analysis. We had focused on fabricating three different composites with different compositionstaking Al-6063 each as 500g. Al-6063 are reinforced with CNTs under various compositionslike 2% & 4% of CNTs. Each Al-6063 0f weight 500g is separated using cutting machine and MWCNTs wereweighed and separated for fabrication before the casting process.

TABLE I
COMPOSITION OF COMPOSITES

Samples	MWCNTs	Al-6063
1	0%	100%
2	2%	98%
3	4%	96%

II. EXPERIMENTAL SETUP

Electro Chemical Micro Machining (ECM) is one of the advanced machining processes where material removal takes place through electrolysis phenomena. It is best suited for materials which are difficult to be machined by mechanical machining process. The process is started in the presence of an electrolyte flow that is circulated with the help of special pump filling the gap between anode (workpiece) and cathode (tool). Electrolyte flow is adjusted by flow control valve. The machining is achieved by sinking of tool forming its replica. During the operation sophisticated control panel takes care of any damage to the machine by over load and short circuit protections. After desired time interval hooter gives an indication of completion of the time / process. The small machining area with given power supply can be machined within 30 minutes to one hour.

Fig: 1 ECM Setup

Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning. CNC Mills are classified according to the number of axes that they possess. Axes are labeled as x and y for horizontal movement, and z for vertical movement, as shown in this view of a manual mill table. A standard manual light-duty mill (such as a Bridgeport™) is typically assumed to have four axes: Table x.

A. Experimental Based on Heat Treated Tool

Here we use cyanoacrylate coated heat treated tool as a reference experiment. By using LI5Orthogonal array the Electrolyte Concentration, Machine Voltage, Duty Cycle, Frequency is arranged for a set up experimental readings. They are ranges from 10-21 as Electrolyte Concentration, 7-11 as Machine Voltage, 50-80 as Duty Cycle to make a table with these different 5 levels to perform the coordinative 15 set off experiments.

TABLE III
INPUT AND OUTPUT RESPONCES

S. No	Machining voltage v	Duty cycle (%)	Electrolyte concentration	Machining tine in minu	Machining time sec	MR	OC
1	10	65	20	15.57	934.2	0.9342	192
2	10	75	24	18.57	1114.2	1.1142	142.35
3	10	85	28	24.54	1472.4	1.4724	178.35
4	11	65	24	24.38	1462.8	1.4628	128.34
5	11	75	28	28.34	1700.4	1.7004	187.25
6	11	85	20	29.31	1758.6	1.7586	132.15
7	12	65	28	32.23	1933.8	1.9338	119.57
8	12	75	20	27.43	1645.8	1,6458	142.25
9	12	85	24	33.31	1998.6	1.9986	131.2

III. GRAPH ANALYSATION

A. Influences of Voltage on MRR & OC

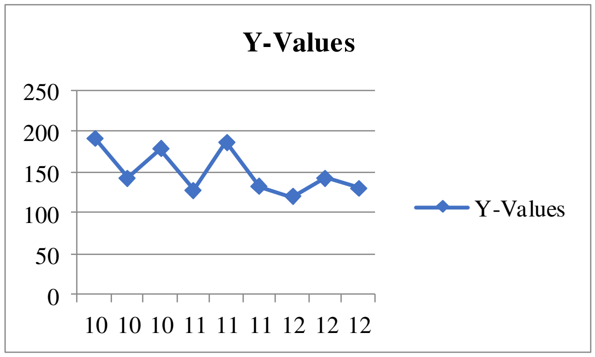

Fig: 2 Investigation of voltage

From this graph, we analyze that at 9.5 V MRR for heated electrode is 1.1 g/min and MRR for non-heated electrode is 1.15 g/min. Overcut at 9.5 V for heated electrode is 250 and heated electrode is 1.6 g/min

B. Influences of Concentration on MRR & OC

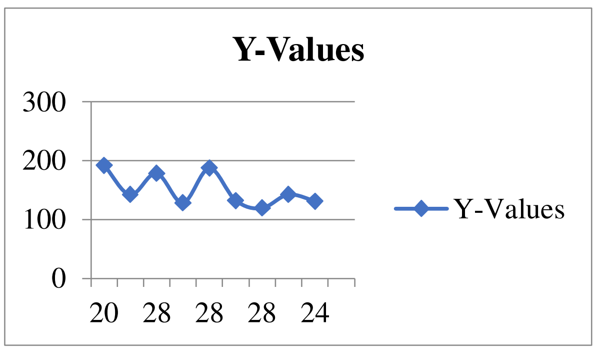

Fig: 3 Investigation of concentration

From this graph, we analyze that at 5 g/lit MRR for heated electrode is 0.4 g/min and MRR for non-heated electrode is 0.7 g/min. Overcut at 5 g/lit for heated electrode is 250 and. In 20 g/lit heated electrode is 2.5 g/min

C. Influences of Duty Cycle on MRR & OC

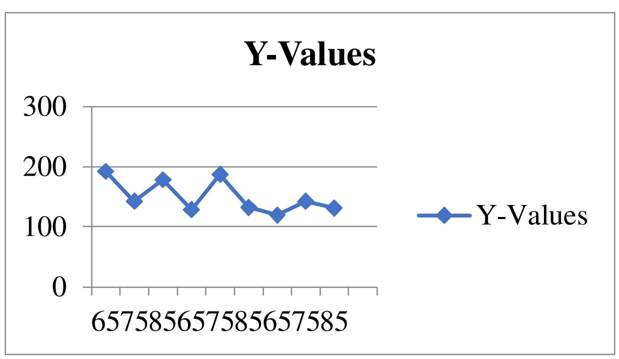

Fig: 4 Investigation of duty cycle

From this graph, we analyze that for 90% duty cycle MRR for heated electrode is 1.1 g/min. Overcut at 90% duty cycle for heated electrode is 250 and for non-heated electrode is 280. In 70 % duty cycle MRR and for heated electrode is 1.4 g/min.

TABLE IIIII
MACRO BEHAVIOURS RESULTS

Sample description	Rockwell hardness (HRB)	Tensile strength (N/mm^2)
$AL6063+AL_2O_3+SIC$	53.6	114.237
$AL6063+AL_2O_3+SIC$	34.2	112.580

D. *Field Emission Scanning Electron Microscope Images*

Field Emission Scanning Electron Microscopy (FESEM) provides topographical and elemental information at magnifications of 10x to 300,000x, with virtually unlimited depth of field. Compared with convention scanning electron microscopy (SEM), field emission SEM (FESEM) produces clearer, less electrostatically distorted images with spatial resolution down to 1 1/2 nanometers – three to six times better.

E. By Using Non-Heat-Treated Tool -Hole No. 06

Electrolyte concentration = 20 g/lit, Voltage = 9 V, Duty cycle = 85 %, Machining time = 440 seconds

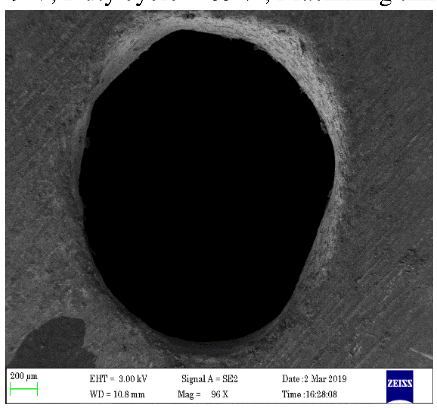

Fig: 5 FESEM Image (Hole No:06)

IV. CONCLUISON

This research has the ability to show various influence on predominant process parameters of EMM on the machining rate and accuracy. The process parameters such as controlled electrolyte flow a controlled micro-tool feed is been controlled in all the sets of experiments. Also, the process parameters like machining voltage, pulse on/off ratio, electrolyte concentration and frequency of pulsed power supply has been varied using L9 orthogonal array. The following conclusions for overcut and MRR are made on the basis of S/N ratio and Analysis of variance (ANOVA). The optimized value for minimum overcut is at electrolyte concentration of 20gm/lit, machining voltage 10V, Duty cycle 65% and maximum MRR is at electrolyte concentration of 30gm/lit, machining voltage 9V, Duty cycle 65%. The percentage contribution of voltage, duty cycle and electrolyte concentration on overcut is found to be 44%, 22.80% and 1.29% respectively and MRR is found to be 51.94%, 13.21% and 11.74% respectively. The result showed that the machining rate for heat treated tool is 2 times better than the non-heat-treated tool. Field emission scanning electron microscope (FESEM) images show much difference in surface structure for heat treated tool and non-heat-treated tool. The findings provide valuable understandings on heat the tool in order to improve the performance of EMM systems.

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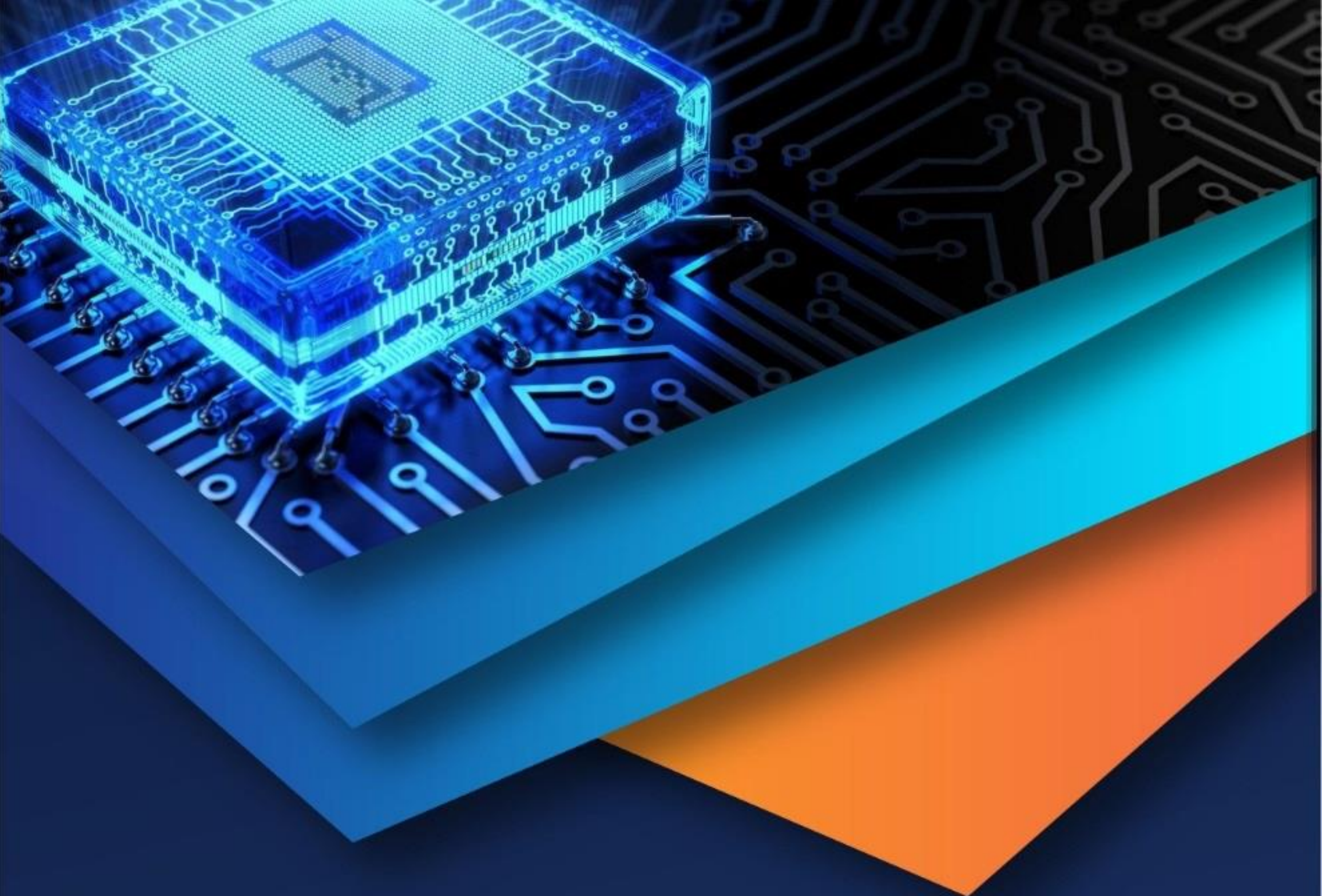

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