Optimization of Process Parameters on Surface Roughness for Micro Electrochemical Machining of Aluminium Matrix Composite

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ABSTRACT

On the basis of machinability, cost and availability the application of materials such as alloys, composites were found. This paper presents of the influence on surface roughness of Aluminium (Al) 6082 alloy, silicon carbide (SiC) and boron glass powder composites machined on a micro electrochemical machining based on parameters (applied voltage, current, electrolyte concentration, pulse on time, pulse off time and duty cycle). The Al metal matrix composite (AMC) for different compositions were fabricated by stir casting technique. After machining the AMM in electrochemical machining, the average roughness (Ra) of machined surfaces is measured by using Surface Roughness Tester (SRG 4500). To achieve the minimum surface roughness (SR), the optimum values obtained for applied voltage, current, electrolyte concentration, pulse on time, pulse off time and duty cycle. This AMCs can be used for making trusses, frames and containers which are used to store chemicals, milk and other corrosive liquids, it can replace stainless steel which is used in the salty environment to avoid corrosion.

Keywords *- Aluminium 6082 alloy, boron glass powder, metal matrix composite, silicon carbide, surface roughness.*

I. INTRODUCTION

Electrochemical Machining technique is an alternative method to machine conventionally very difficult AMCs, in these metals can be machined without contact, independent of material hardness and thermal or mechanical impact [1]. ECM removes material by anodic dissolution it does not produce any stress (residual). As dissolution of the workpiece material occurs the tool electrode is moved at a controlled rate, to remove material is required. It's carried out by passing an electric current through an electrolyte in the gap of tool and workpiece. However, there are many parameters which influence the SR, those parameters represents the machining phenomenon between the tool and work piece [2]. The relationships between the applied voltage and the parameters (% of gap) with two different electrolytes, $NaNO_3$ solution and NaCl solution were determined [3]. The influence parameters such as applied voltage, current, electrolytic concentration, pulse on time, pulse off time, duty cycle and machining time on the material removal rate were discussed in [4]. Have investigated the effect of cutting parameters on surface finish and machinability of graphite reinforced Al-8011 matrix composite. Results indicated that higher cutting speed with lower depth of cut and lower feed rates gives good surface finish when compare to lower speed [5]. Presented the influence on surface roughness of Co28Cr6Mo medical alloy machined on a CNC lathe based on cutting parameters rotational speed, feed rate, depth of cut and nose radius [6].

The weight percentage of six different compositions of AMCs shows in table. 1. After were fabricated by using stir casting technique, the objective of the present paper focused on the measurement of SR calculations using surface roughness tester (SRG-4500) for six different composites and calculations through non-linear regression analysis (NRA) using Minitab for six different composites.

Table 1. Weight percentage of AMCs

Composition No	**SiC** (% of weight)	**Boron Glass Powder** (% of weight)	**Al 6082 alloy** (% of weight)
1	1	1	98
2	1	3	96
3	3	3	94
4	3	5	92
5	5	5	90
6	5	7	88

II. MATERIALS AND METHODS

The experiments were employed to study the effects of process parameters on surface roughness of the materials when machining AMCs work piece. In this study, experiments were planned on the basis of proposed by Box and Hunter [7]. The machining parameters and their levels shows in table 2. Consider six parameters Voltage A (9-17 volts), Current B (0.6-1 amps), Electrolyte concentration E (0.23-0.50 mole/lit), Pulse ON time D (10-17.5 ms), Pulse OFF time F (2.5-10 ms) and Machining time C, in which machining time is an output parameter this value is measured during the machining a hole. The electrolyte used in this experiment was NaCl.

Table 2. Machining parameters and their levels

Set No	Holes No	Constant parameters	Variable parameters	
SET-I		**Voltage**-15 (volts) **Current**-1 (amps) **Electrolyte concentration**-0.23 (mole/lit)	**Pulse ON time** (ms)	**Pulse OFF time** (ms)
	1		10	10
	2		12.5	7.5
	3		15	5
	4		17.5	2.5
SET-II		**Voltage**-15 (volts) **Pulse ON & OFF time**-17.5 & 2.5 (ms) **Electrolyte concentration**-0.23 (mole/lit)	**Current** (amps)	
	5		0.6	
	6		0.7	
	7		0.8	
	8		0.9	
SET-III		**Voltage**-15 (volts) **Current**-1(amps) **Pulse ON & OFF time**-17.5 & 2.5 (ms)	**Electrolyte Concentration** (mole/lit)	
	9		0.23	
	10		0.32	
	11		0.41	
	12		0.50	
SET-IV		**Current**-1(amps) **Electrolyte concentration**-0.23 mole/lit **Pulse ON & OFF time**-17.5 & 2.5 ms	**Voltage** (volts)	
	13		9	
	14		11	
	15		13	
	16		15	

Mathematical model:

To minimization of SR the mathematical model were developed by NRA for SR with their indices. The parameters concerned for this model were A, B, C, D, E and F [8].

$$SR = Constant \times A^{a} \times B^{b} \times C^{c} \times D^{d} \times E^{e} \times F^{f}$$

Where a, b, c, d, e and f are the indices of Voltage, Current**,** Machining time, Pulse ON time, Electrolyte concentration and Pulse OFF time. The mathematical model of logarithmic was initially done by linear regression, after linear regression models were developed, it transformed to an NRA. The formulated models for SR using Minitab are shown in a following table 3.

Table 3. SR mathematical model for six different composition

Composition No	MRR Mathematical model
1	$SR = 0.3837 \times A^{0.09} \times B^{-0.06} \times C^{-0.19} \times D^{0.21} \times E^{0.28} \times F^{0.21}$
2	$SR = 0.2996 \times A^{0.25} \times B^{-0.07} \times C^{-0.19} \times D^{0.20} \times E^{0.17} \times F^{0.21}$
3	$SR = 3.1596 \times A^{-0.03} \times B^{-0.08} \times C^{-0.31} \times D^{0.05} \times E^{0.23} \times F^{0.18}$
4	$SR = 0.0415 \times A^{0.26} \times B^{-0.21} \times C^{0.30} \times D^{0.67} \times E^{0.47} \times F^{0.27}$
5	$SR = 0.1558 \times A^{-0.06} \times B^{-0.23} \times C^{-0.28} \times D^{0.91} \times E^{0.37} \times F^{0.78}$
6	$SR = 0.5450 \times A^{-0.10} \times B^{-0.32} \times C^{-0.25} \times D^{0.31} \times E^{-0.006} \times F^{0.45}$

From the mathematical model, the SR was negatively influenced by voltage, current, machining time and electrolyte concentration whereas positively influenced by pulse on time and Pulse off time.

III. RESULTS AND DISCUSSION

Experimental SR values for six different composition was calculated from SRG-4500 is shown in table 4.

Table 4. Experimental SR values for six different composition

Holes No	SR (μm) values for different Composition No						Average
	1	2	3	4	5	6	
1	0.368	0.549	0.964	1.201	1.148	0.890	0.853
2	0.397	0.592	1.040	1.296	1.238	0.960	0.921
3	0.339	0.506	0.889	1.108	1.058	0.821	0.787
4	0.278	0.415	0.728	0.908	0.867	0.673	0.645
5	0.390	0.581	1.020	1.271	1.215	0.942	0.903
6	0.361	0.538	0.945	1.178	1.125	0.873	0.837
7	0.283	0.422	0.741	0.924	0.883	0.685	0.656
8	0.267	0.398	0.699	0.871	0.833	0.646	0.619
9	0.405	0.603	1.060	1.321	1.262	0.979	0.938
10	0.537	0.800	1.405	1.752	1.673	1.298	1.244
11	0.280	0.417	0.732	0.913	0.872	0.676	0.648
12	0.537	0.800	1.405	1.752	1.673	1.298	1.244
13	0.319	0.475	0.835	1.041	0.994	0.771	0.739
14	0.306	0.456	0.800	0.997	0.953	0.739	0.708
15	0.275	0.410	0.720	0.898	0.858	0.665	0.638
16	0.526	0.784	1.377	1.717	1.640	1.272	1.219

It was experimental that SR was significantly affected by current and electrolyte concentration. MRR increased by increasing current, pulse ON time and pule OFF time because speed of chemical reaction and mobility of ions was more from the AMC to the solution.

Theoretical SR values for six different composition was calculated from mathematical model is shown in table 5.

Table 5. Theoretical SR values for six different composition

Holes No	SR (μm) values for different Composition No						Average
	1	2	3	4	5	6	
1	0.378	0.561	0.987	1.232	1.156	0.900	0.869
2	0.370	0.558	0.975	1.209	1.215	0.933	0.877
3	0.360	0.532	0.939	1.176	1.076	0.841	0.821
4	0.339	0.487	0.872	1.102	0.905	0.651	0.726
5	0.348	0.532	0.923	1.191	1.019	0.864	0.813
6	0.347	0.506	0.892	1.120	1.126	0.855	0.808
7	0.346	0.506	0.916	1.071	1.176	0.845	0.810
8	0.345	0.514	0.880	1.037	1.062	0.674	0.752
9	0.346	0.537	0.907	1.048	1.169	0.892	0.817
10	0.368	0.549	0.954	1.522	1.395	0.948	0.956
11	0.416	0.639	1.116	1.272	1.091	1.029	0.927
12	0.469	0.684	1.211	1.452	1.530	1.086	1.072
13	0.297	0.438	0.766	0.904	0.859	0.658	0.654

14	0.314	0.475	0.839	1.091	1.106	0.841	0.778
15	0.336	0.504	0.882	1.220	1.045	0.882	0.812
16	0.351	0.526	0.948	1.102	1.015	1.032	0.829

IV. CONCLUSION

In the present work, mathematical models were developed and minimum SR 0.619 µm was found on hole no 13 (9 volts, 0.9 amps, 17.5 ms [ON time], 0.23 mole/lit and 2.5 ms [OFF time]) in first composition. In ECM the SR significantly influenced by the various predominant parameters considered in the present study. Achieved the combination of parameter for minimum SR to effective utilization of ECM for Al 6082, SiC and boron glass powder composites.

V. REFERENCES

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