Int. J. Chem. Sci.: 14(4), 2016, 3157-3166
ISSN 0972-768X
www.sadgurupublications.com

INFLUENCE OF SILICON CARBIDE PARTICLE ADDITION IN THE ALUMINIUM (Al6061) COMPOSITE ON EDM PROCESS PARAMETERS

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ABSTRACT

In this study, a new approach of investigation has been traced, by subsequently mixing the Al6061 (base material) with SiC particulate. The percentage (by Volume) chosen was 5%, 10% and 15% SiC, respectively. The casted specimen with appropriate proportion was analyzed by cutting the specimen as per the prescribed standard. Through the electric discharge machining the holes (10 mm diameter and 2 mm depth) were produced on the specimens by varying the different flushing rates 0.5, 0.6, 0.7, 0.8, 0.9 and 1 kg/cm^2, respectively. To validate the process of mixing ratio of SiC particulate on the based material Al6061, the surface roughness (SR) and Material removal rate (MRR) values were investigated through L27 orthogonal array.

Key words: Al6061, SiC, Electric discharge machining.

INTRODUCTION

Nowadays aluminum alloys are very familiar for the outstanding mechanical properties like high strength-to-weight ratio, good resistance to creep and fatigue, excellent corrosion resistance and biocompatibility. That is the reason, why most of the researchers have chosen, variety of aluminum alloys to tap the influential advantage of that. The usage have been applied in many areas like aerospace applications, automotive applications, biomedical applications, marine applications, chemical processing applications, oil and gas extraction, power generation and other major industries[1-4]. Over the past few years, the electro-discharge machining (EDM) process occupies a major role in most of the manufacturing sectors. All the electrical conductive materials can easily be shaped with help

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of this process with better precision and accuracy. As well, these processes have the capability to cut the multipart and difficult shapes. In this study, EDM was achieved by allowing the chain of discrete discharges between the tool and electrically conducted work piece, both of them was separated by the dielectric fluid medium. Material discharge was allowed by maintaining the suitable gap between the work piece and tool by causing the erosion through spark[5-8].

EXPERIMENTAL

Materials and methods

In this experiment, the metal matrix composite consists the base material of pure aluminum (Al6061) and SiC with different proportions. The SiC was received from the NR, Chemicals Mumbai. With the fine size of 30 μm particle, used as received condition. Samples of Al6061 composites were made with 5%, 10% and 15% SiC particles, respectively. An EDM machine (Electronica PSR 35) was used for the present experiment. The test specimens were finely machined by grinding process to make both ends similar. The copper electrode was used as electrode during the entire machining process. Commercially available kerosene was forcibly circulated as the dielectric fluid. During the entire machining investigation, three different type of machining parameters were opted, namely pulse current (0.5, 1 and 1.5 A), time of pulse (400, 600 and 800 μs) and flushing pressure (0.5, 0.6 and 0.8 kgf/cm^2) were chosen and fixed. For the above investigation, the 45V gap voltage was maintained throughout the entire study and pulse off time kept as constant at 150 μs. The size of the hole is 10 mm diameter, 2 mm depth was chosen in the present work. The surface roughness value (Ra) was found out on the machined surface by using surface test equipment. Surface roughness value was obtained by averaging the five measurements at different positions of the work piece. SEM images were taken for all samples, with 5%, 10% and 15% SiC particles, respectively. In addition to that the relative effect between C (Current), P (pulse on time), and F (Flushing Pressure) were studied for all the proportions against MRR.

Machining parameters and the response variables

Three different machining parameters were noted down and their corresponding values were set as shown in Table 1. The response variables were written as MRR (Material Removal Rate), TWR (Tool Wear Rate), T (angle), ROC (Hole diameter) and SR (Surface Roughness).

Table 1: Machining parameters and their corresponding levels

Machining parameter	Symbol	Level 1	Level 2	Level 3
Current (Amps)	C	6	12	18
Pulse – ON Time (μs)	P	300	600	900
Flushing pressure (MPa)	F	0.0207	0.0414	0.0621

Response variables evaluation

MRR is defined as the ratio between the work piece, before machining and after machining within the machining time,

$$MRR = (Wj_b - Wj_a)/t \quad \ldots(1)$$

In this equation, Wj_b and Wj_a are the weights of the work piece before and after machining, t be the time.

TWR is defined as the ratio between the weight of the tool before machining and after machining to the consecutive machining time, i.e.:

$$TWR = (Wt_b - Wt_a)/t \quad \ldots(2)$$

In this equation, Wt_b and Wt_a are the weights of the tool, before and after machining, t be the time.

T can be calculated from the expression:

$$\upsilon = \tan\text{-}1((D_{jt} - D_{jb})/2h) \quad \ldots(3)$$

Where D_{jt} and D_{jb} indicate the diameters of the drilled hole at the top and bottom of the work piece, and h resembled the height of the work piece.

ROC is defined as half the difference of diameter of the hole produced to the tool diameter, i.e.:

$$ROC = (D_{jt} - D_t)/2 \quad \ldots(4)$$

Where D_t is the diameter of the tool.

Design of experiments

The 27 set of experiments have been conducted over the three factor-three level. In this work, an L27 orthogonal array was selected. Further study was conducted on the same material and more factors were added. To reduce the number of experiments at the later stage, L27 setups were utilized. The main factor columns were assigned to Current (C), Pulse (P) and Flushing pressure (F), respectively are shown in Table 2 experimental layout.

Table 2: Experimental layout

Experiment No	Machine settings			
	Current (Amps)	Pulse – ON Time (μs)	Flushing pressure (MPa)	Material removal rate (mm^3/min)
1	6	300	0.0207	0.045
2	6	300	0.0414	0.055
3	6	300	0.0621	0.060
4	6	600	0.0207	0.092
5	6	600	0.0414	0.010
6	6	600	0.0621	0.095
7	6	900	0.0207	0.110
8	6	900	0.0414	0.100
9	6	900	0.0621	0.122
10	12	300	0.0207	0.155
11	12	300	0.0414	0.175
12	12	300	0.0621	0.185
13	12	600	0.0207	0.221
14	12	600	0.0414	0.225
15	12	600	0.0621	0.227
16	12	900	0.0207	0.234
17	12	900	0.0414	0.242

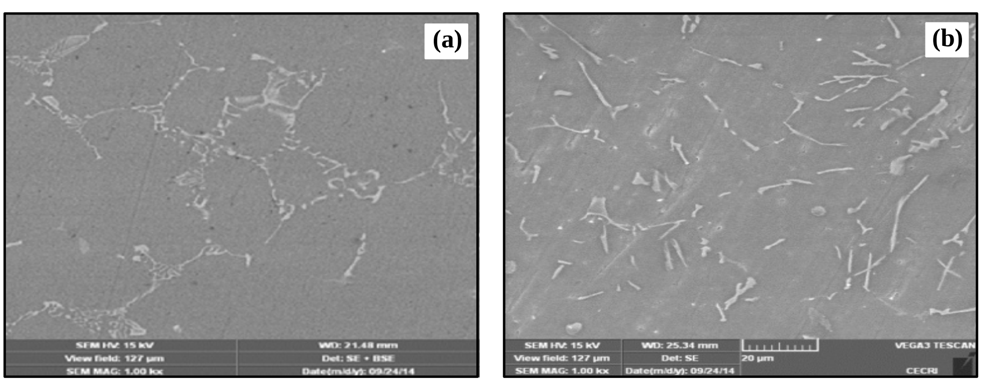
Cont…

Experiment No	Machine settings			
	Current (Amps)	Pulse – ON Time (μs)	Flushing pressure (MPa)	Material removal rate (mm^3/min)
18	12	900	0.0621	0.244
19	18	300	0.0207	0.312
20	18	300	0.0414	0.311
21	18	300	0.0621	0.300
22	18	600	0.0207	0.288
23	18	600	0.0414	0.300
24	18	600	0.0621	0.302
25	18	900	0.0207	0.354
26	18	900	0.0414	0.345
27	18	900	0.0621	0.355

RESULTS AND DISCUSSION

SEM Analysis

The sample was thoroughly polished and examined by scanning electron microscopy. All the samples were scanned with 500 X and are given as the Fig. 1a, b and c. Based on the virtual verification of the section, the photographs clearly envisage the silicon carbide particulates from the range of 4 to 25 μm in length. The average particulate length shows of 20 μm and aligned randomly.



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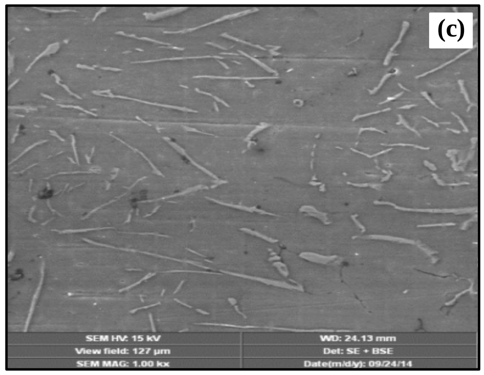

Fig. 1: Micro structure of (a) 5% SiC/Al6061 (20 µm), (b) 10% SiC/Al6061 (20 µm), (c) 15% SiC/Al6061 (20 µm)

Material removal rates

In each case, 10 experiments were conducted on coarse and fine surfaces with different cutting conditions, with the help of the EDM material removal process. The Table 3 shows the maximum, minimum and average calculated material removal rates for both the conditions such as coarse and fine conditions. It was proved that the MRR increases with a raise of power to the electrode. Whereas the cutting speed not increases from the fine to coarse cutting conditions, the MRR decreases[9-11]. Apart from that, the electrode wear rate was also found out and listed in the Table 3.

Table 3: Material removal rates of EDM on SiC/Al6061 samples

Machining condition	Average MRR (mm^3/min)	Minimum MRR (mm^3/min)	Maximum MRR (mm^3/min)	Standard deviation of MRR
Coarse	10.30	5.23	13.82	3.25
Fine	2.20	0.52	2.32	0.31

Surface roughness

The surface quality was validated through the profilometry to evaluate the surface profile. Surface profiles were obtained through EDM for 15%, 10%, 5% SiC mixed drilled specimens are shown in Fig. 2a-c. From the Fig. 2(a), the specimen exhibited irregular shape, variable (non uniform) peaks and valleys. It was also found that the surface profile was more random in manner than periodic, and indicated higher degree of roughness value. Fig. 2(b) was found with smaller peak-to-valley curves than the Fig. 2(a). Variance is very small as compared to the Fig. 2(a). Fig. 2(c) shows a very good and moderate surface finish. From the above results, it was evident that the proportions of the SiC in to the base material increase the surface roughness value considerably[12].

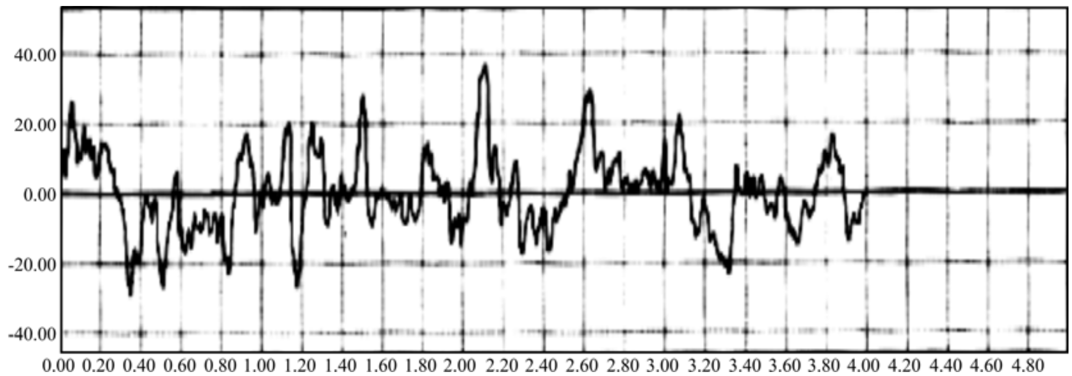

Fig. 2a: Surface profiles of machined through EDM for 15% SiC

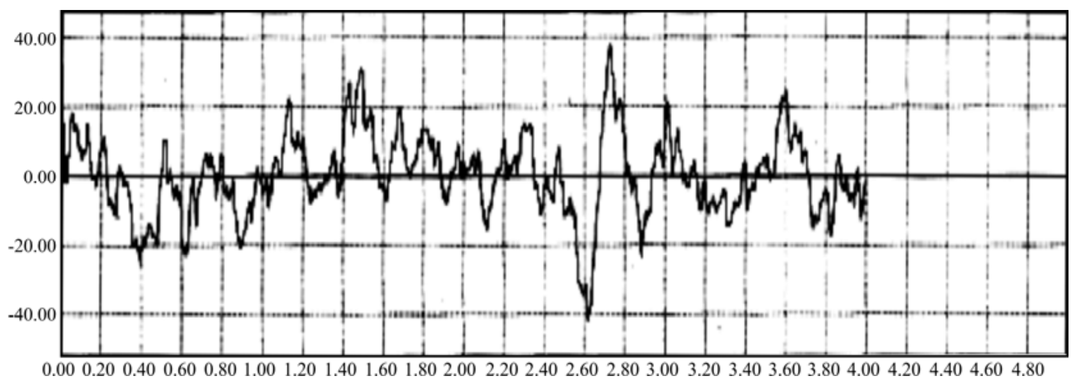

Fig. 2b: Surface profiles of machined through EDM for 10% SiC

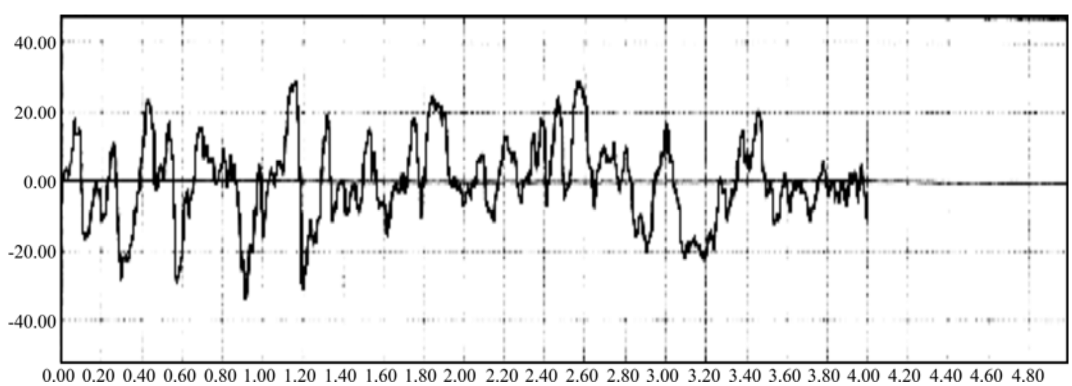

Fig. 2c: Surface profiles of machined through EDM for 5% SiC

Nomenclature

A	:	Ampere
υ	:	Angle
C	:	Current
D_{jb}	:	Diameters of the machined hole at the bottom of the work piece
D_{jt}	:	Diameters of the machined hole at the top of the work piece
D_t	:	Diameter of the tool
F	:	Flushing pressure
h	:	Height of the work piece
MRR	:	Material removal rate
μs	:	Micro seconds
P	:	Pulse on time
ROC	:	Hole diameter
SR	:	Surface roughness
t	:	Time
TWR	:	Tool wear rate
T	:	Angle
V	:	Voltage
$W_{jb,}$	:	Weights of the work piece (before machining)
W_{ja}	:	Weights of the work piece (after machining)
W_{tb}	:	Weights of the tool (before machining)
W_{ta}	:	Weights of the tool (after machining)

CONCLUSION

The experimental investigation carried out on 5%. 10%, 15% SiC/Al6061 Aluminium MMC material. Based on the results, the following important points were drafted:

(i) The machining process through the EDM is purely depending upon the electrical conductivity of the work piece.

(ii) Based on the experiment done on the work piece, it is observed that the particulate induction of the SiC in to the base matrix material increases the thermal resistance in such a way that it decreases the electrical resistance capacity of all the three proportions of work piece.

(iii) Material Removal Rate for various compositions was found. It is seen that for higher current and pulse ON-time the MRR was quite high.

(iv) It is evident from this study that for larger current settings, the TWR was quite high.

Flushing pressure played an important role to control the MRR and TWR. For larger value of flushing pressure adversely increases the value of MRR and TWR.

REFERENCES

1. Y. Jiang, W. Zhao and X. Xi, A Study on Pulse Control for Small-Hole Electrical Discharge Machining, J. Mater. Proc. Tech., **212(7)**, 1463-1471 (2012).

2. I. Puertas, C. J. Luis and L. Alvarez, Analysis of the Influence of EDM Parameters on Surface Quality, MRR and EW of WC–Co, J. Mater. Proc. Tech., **153**, 1026-1032 (2004).

3. T. A. K. Hyun-Seok, H. A. Chang-Seung, L. E. E. Ho-Jun, L. E. E. Hyung-Woo, Young-Keun Jeong and K. A. N. G. Myung-Chang, Characteristic Evaluation of Al_2O_3/CNTs Hybrid Materials for Micro-Electrical Discharge Machining, Trans. Nonferrous Met. Soc. China, **21**, s28-s32 (2011).

4. P. M. George, B. K. Raghunath, L. M. Manocha and A. M. Warrier, EDM Machining of Carbon-Carbon Composite-A Taguchi Approach, J. Mater. Proc. Tech., **145(1)**, 66-71 (2004).

5. M. Ramulu, G. Paul and J. Patel, EDM Surface Effects on the Fatigue Strength of a 15 Vol% SiC p/Al Metal Matrix Composite Material, Comp. Struct., **54(1)**, 79-86 (2001).

6. V. Senthilkumar and B. U. Omprakash, Effect of Titanium Carbide Particle Addition in the Aluminium Composite on EDM Process Parameters, J. Manuf. Proc., **13(1)**, 60-66 (2011).

7. K. Kanlayasiri and S. Boonmung, Effects of Wire-EDM Machining Variables on Surface Roughness of Newly Developed DC 53 Die Steel: Design of Experiments and Regression Model, J. Mater. Proc. Tech., **192**, 459-464 (2007).

8. P. N. Singh, K. Raghukandan, M. Rathinasabapathi and B. C. Pai, Electric Discharge Machining of Al-10% SiC p As-Cast Metal Matrix Composites, J. Mater. Proc. Tech., **155**, 1653-1657 (2004).

9. N. E. Arun Kumar, A. Suresh Babu and D. Murali, A Study on Parametric Optimization of Wire Electrical Discharge Machining using Response Surface Methodology, Int. J. Chem. Sci., **14(2)**, 1051-1059 (2016).

10. L. Gu, L. Li, W. Zhao and K. P. Rajurkar, Electrical Discharge Machining of Ti6Al4V with a Bundled Electrode, Int. J. Mac. Tools Manuf., **53(1)**, 100-106 (2012).

11. P. N. Singh, K. Raghukandan and B. C. Pai, Optimization by Grey Relational Analysis of EDM Parameters on Machining Al-10% SiC P Composites, J. Mater. Proc. Tech., **155**, 1658-1661 (2004).

12. Y. Zhang, Y. Liu, R. Ji and B. Cai, Study of the Recast Layer of a Surface Machined by Sinking Electrical Discharge Machining using Water-in-Oil Emulsion as Dielectric, Appl. Surf. Sci., **257(14)**, 5989-5997 (2011).

13. P. Pecas and E. Henriques, Electrical Discharge Machining using Simple and Powder-Mixed Dielectric: The Effect of the Electrode Area in the Surface Roughness and Topography, J. Mater. Proc. Tech., **200(1)**, 250-258 (2008).

Accepted : 04.10.2016