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Investigations for Machining of AL/SiC MMC with various percentages of SiC Reinforcements During EDM

Hardeep Singh, Mukesh Verma

Abstract: EDM is a capable of machining of geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries .Advance Particulate Reinforced Al/SiC Metal Matrix Composites (PRALSICMMC) is gradually becoming very important materials in manufacturing industries e.g. aerospace, automotive and automobile industries due to their superior properties such as light weight, high strength to weight ratio, high hardness, high temperature and thermal shock resistance, superior wear and corrosive resistance, high specific modulus, high fatigue strength etc. In this study aluminum (Al-6061)/SiC Silicon carbide reinforced particulate metal-matrix composites (MMCs) are fabricated by stir casting technique. The MMCs plates are prepared with varying the reinforced particles of SiC by weight fraction of 10% and 20%. The average reinforced particles of SiC is 400 mesh. The stirring process is carried out at 200 rev/min rotating speed by graphite impeller for 15 min. The series of machining tests are performed on EDM. Prepared specimens of Al/SiC MMCs are used as work piece (anode), Brass electrodes are used as tool (cathode) and kerosene is used as the dielectric fluid. The parameters are investigated , Tool wear Rate(TWR) and Metal Removal Rate(MRR) for each experiment by varying the, Current(5 amp,10 amp,15amp) Voltage(20 Volts, 40 Volts, and 60 Volts).and the Pulse on time Ton (5 µ sec, 10 µ sec, and 15 µ sec), Taguchi's L9 orthogonal array is chosen to design the experiments and trials are conducted to study the effect of various parameters. Investigations of results are done graphically. The Material Removal Rate (MRR) and tool wear rate (TWR) of the work piece increases with an increase in the current . The MRR decreases by (8-!0%) with increase in the percent weight of silicon carbide. While the TWR Increases by (5-8%) with increase in volume percentage of SiC.

I. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive.

1.1 Principle of EDM

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig 1.1. Both tool and work piece are submerged in a dielectric fluid .Kerosene/EDM oil/deionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases.

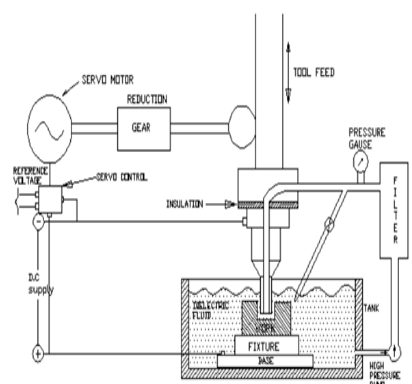

Figure 1.1 Set up of Electric discharge machining

In fig.1.1 is shown the electric setup of the Electric discharge machining. The tool is mead cathode and work piece is anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark in interval of from 10 of micro seconds. And positive ions and electrons are accelerated, producing a discharge channel that becomes conductive. It is just at this point when the

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spark jumps causing collisions between ions and electrons and creating a channel of plasma. A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as a result of which a very high temperature is reached and at such high pressure and temperature that some metal is melted and eroded.

1.2 Problem formulation: From the study of literature survey it has been found that composites have emerged as new class of materials in the recent times. In the past a lot of work has been done on the non conventional machining of composites ,prominent among them are as under:

- MMC of typeAl356/SiCp reinforced with 5%, 10%, and 15% SiC.
- MMC of Al7075 reinforced with Al_2O3 .
- Aluminum composite reinforced with Flyash particulates.
- Machining characteristics of Al2O3/6061Al composite using rotary electrode.
- LM25 Aluminum reinforced with Sic
- A356 al reinforced with SiC.
- Machining characteristics of SiC/6025 Al composite .
- Machining of Al–4Cu–6Si alloy–10 wt. % SiCP composites
- Aluminum matrix composite reinforced with 7 % SiC and 3.5 % graphite.

Though a good number of researches on machining of composite materials have been made, limited amount of literature have been available on the non conventional machining and varying the percentage of reinforcements of SiC in AL6061.So in present study the work has been stressed on the AL6061 reinforced with SiC and the percentage of the SiC ,the reinforcement has been varied at two levels i.e. 10% and 20%.and the machining of the MMC has been done on EDM.

II. EXPERIMENTAL WORK

For this experiment the whole work can be done by Electric Discharge Machine, model ELECTRONICA-ELECTRAPULS PS 50ZNC (die-sinking type) with servo-head (constant gap) and positive polarity for electrode was used to conduct the experiments. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94˚C) was used as dielectric fluid. Experiments were conducted with positive polarity of electrode. The pulsed discharge current was applied in various steps in positive mode. The EDM consists of following major part as shown in the chapter .

1. Dielectric reservoir, pump and circulation system.
2. Power generator and control unit.
3. Working tank with work holding device.
4. X-y table accommodating the working table.
5. The tool holder.
6. The servo system to feed the tool.

2.1 Calculations for M.R.R , and T.W.R

The material MRR is expressed as the ratio of the difference of weight of the workpiece before and after machining to the machining time and density of the material.

$$MRR = \frac{Wjb - Wja}{t}$$

Wjb = Weight of workpiece before machining.
Wja = Weight of workpiece after machining.

t = Machining time = 1.00 hr.

2.2. Evaluation of tool wear rate

TWR is expressed as the ratio of the difference of weight of the tool before and after machining to the machining time. That can be explain this equations

$$TWR = \frac{Wtb - Wta}{t}$$

Whereas

Wtb = Weight of the tool before machining.
Wta = Weight of the tool after machining.
t = Machining time (In this experiment the machining time is one hour).

Table 1.1 Machining parameters and their levels

Machining parameter	Symbol	Unit	Level		
			Level 1	Level 2	Level 3
Discharge current	(Ip)	Amp	5	10	15
Voltage	(V)	Volts	20	40	60
Spark on time	(Ton)	µsec	5	10	15

2.3 Conduct of Experiment

AL6061/SiC 10% & 20% plates are taken as workpieces And the PS 50ZNC (die-sinking type) of

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EDM machine is used. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94˚C) was used as dielectric fluid. Three factors are tackled with a total number of 09 experiments performed on die sinking EDM on eah specimen plates of 10% and 20% The calculation of material removal rate and tool wear rate by using electronic balance weight machine. This machine capacity is 300 gram and accuracy is 0.001 gram.

Table 1.2 Design matrix and Observation table

AL6061/ SiC -10%

Run	Ip (A)	Volt (V)	Ton (µs)	Wt of Workpiece (mg)		Wt. of Tool(mg)	
				Wjb	Wja	Wtb	Wta
1	15.00	40.00	5.00	58.9761	58.7877	7.658	7.6469
2	5.00	20.00	5.00	59.438	59.4112	7.6893	7.6873
3	15.00	20.00	15.00	58.7877	58.5933	7.6469	7.6338
4	5.00	40.00	10.00	59.4112	59.3749	7.6873	7.6843
5	15.00	60.00	10.00	58.5933	58.4127	7.6338	7.6217
6	10.00	40.00	15.00	59.3103	59.2125	7.6803	7.6736
7	10.00	20.00	10.00	59.1357	58.9761	7.6736	7.6672
8	10.00	60.00	5.00	58.9761	58.7877	7.6672	7.658
9	5.00	60.00	15.00	59.3749	59.3103	7.6843	7.6803

Table 1.3 Design matrix and Observation table
AL6061/ SiC -20%

Run	Ip (A)	Volt (V)	Ton (µs)	Wt of Workpiece (mg)		Wt. of Tool(mg)	
				Wjb	Wja	Wtb	Wta
1	15.00	40.00	5.00	59.4420	59.4160	7.6899	7.6878
2	5.00	20.00	5.00	59.4160	59.3808	7.6878	7.6847
3	15.00	20.00	15.00	59.3808	59.3182	7.6847	7.6806
4	5.00	40.00	10.00	59.3182	59.2233	7.6806	7.6737
5	15.00	60.00	10.00	59.2233	59.1488	7.6737	7.6672
6	10.00	40.00	15.00	59.1488	58.9940	7.6672	7.6577
7	10.00	20.00	10.00	58.9940	58.8112	7.6577	7.6462
8	10.00	60.00	5.00	58.8112	58.6226	7.6462	7.6327
9	5.00	60.00	15.00	58.6226	58.4474	7.6327	7.6203

Experiments were conducted according to Taguchi method by using the machining set up. The control parameters like diameter of Voltage (V) , discharge current (Ip) and pulse duration (Ton) conductivity were varied to conduct 18 different experiments and the weights of the work piece and Tool for calculation of MRR and TWR .

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III. RESULTS & DISCUSSION

The different output responses like Material Removal Rate (MRR) and Tool Wear Rate (TWR) were analyzed. MRR and TWR. The results of different experimental investigations carried out under the present work are in the form of table, graph and response analysis. The average values of the response characteristics were calculated from the experimental data and the response curves were plotted to depict the variation of the process performance characteristics. Analysis of Variance (ANOVA) on the raw data was performed to identify the significant parameters and to quantify their effect on the performance characteristics. The effect of the individual process parameters and first order interactions of the process parameters on the above mentioned response characteristics are also presented.

3.1 ANALYSIS OF MATERIAL REMOVAL RATE

Final Equation in Terms of Coded Factors:

MRR = +1.90+1.21 * A+0.48 * B-0.32 *-0.55 * A * B+0.36 * A * C

Final Equation in Terms of Actual Factors:

MRR =-1.57203+0.31632* Current (I)+0.078881 -5.49524E-00 * Current (I) * Voltage (V)+0.014552 * Current (I) * Time (T)

3.2 Graphical Representation Of M.R.R

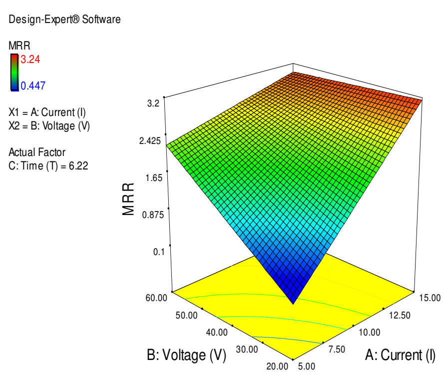

Figure 1.2 Effect Of Simultaneous Variation Of Voltage (B) and Current (A) On MRR.

Figure 1.2 shows the effect of simultaneous variation of Voltage (B) and Current (A) on MRR. For different levels of Voltage, the increase in value of Current leads to increase in MRR value. MRR attains a maximum value of 3.24 when quantity of Current is 15, For lower values of Current, increase in Voltage has higher effect on MRR from 0 to 1.7 but for large values of Current , with increase in Voltage , MRR is very small.

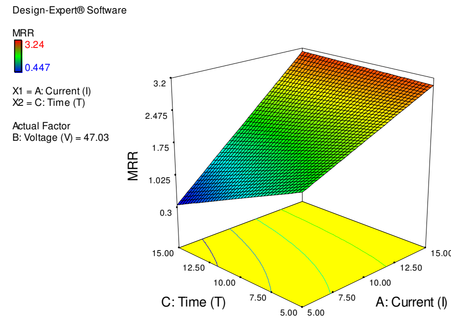

Figure 1.3 Effect Of Simultaneous Variation Of Time (C) and Current (A) On MRR.

Figure1.3 shows the effect of simultaneous variation of Time (C) and Current (A) on MRR. For all levels of Pulse on Time, the increase in value of Current leads to increase in MRR. With the increase in the Pulse on Time, at lower values of Current (5-7.5 amps) there is a decrease in MRR, then it becomes almost constant for current around 10 amps and after 12.5 amps with rise in Pulse on time MRR also goes on increasing and for 15 amps current it attains a maximum value of 3.24 when Pulse on Time is 15 seconds.

* Voltage (V) -0.210 * Time (T)

3.4 Graphical Representation Of T.W.R

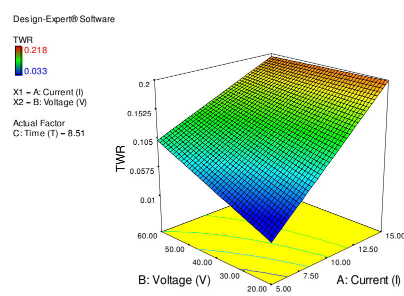

Figure 1.4 Effect Of Simultaneous Variation Of Voltage (B) and Current (A) On TWR

Figure 1.4 shows the effect of simultaneous variation of Voltage (B) and Current (A) on TWR. For different levels of Voltage, the increase in value of Current leads to increase in TWR. TWR attains a maximum value of 0.218 when quantity of Current is 15. For lower values of Current, increase in Voltage has higher effect on TWR from 0 to 0.103 but for large values of Current , with increase in Voltage , increase in TWR is very small.

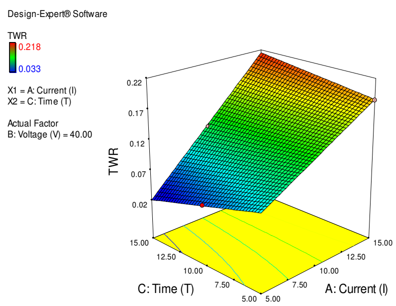

Figure1.5 Effect Of Simultaneous Variation Of Time (C) and Current (A) On TWR

Figure1.5 shows the effect of simultaneous variation of Time (C) and Current (A) on TWR. For all levels of Pulse on Time, the increase in value of Current leads to increase in TWR. With the increase in the Pulse on Time, at lower values of Current (5-7.5 amps) there is a decrease in TWR, then it becomes almost constant for current around 10 amps and after 12.5 amps with rise in Pulse on time TWR also goes on increasing and for 15 amps current it attains a maximum value of 0.218 when Pulse on Time is 15 seconds.

Table 4 Experimental data and responses (AL6061 SiC-20%)

STD	RUN		Ip(Amp)	V(Volt)	Ton(µ sec)	MRR(mg/min)	TWR(mg/min)
8	1	Block 1	15.00	40.00	5.00	3.143	0.225
1	2	Block 1	5.00	20.00	5.00	0.433	0.035
7	3	Block 1	15.00	20.00	15.00	3.047	0.192
2	4	Block 1	5.00	40.00	10.00	0.587	0.052
9	5	Block 1	15.00	60.00	10.00	2.92	0.207
5	6	Block 1	10.00	40.00	15.00	1.242	0.108
4	7	Block 1	10.00	20.00	10.00	1.582	0.115
6	8	Block 1	10.00	60.00	5.00	2.58	0.158
3	9	Block 1	5.00	60.00	15.00	1.043	0.068

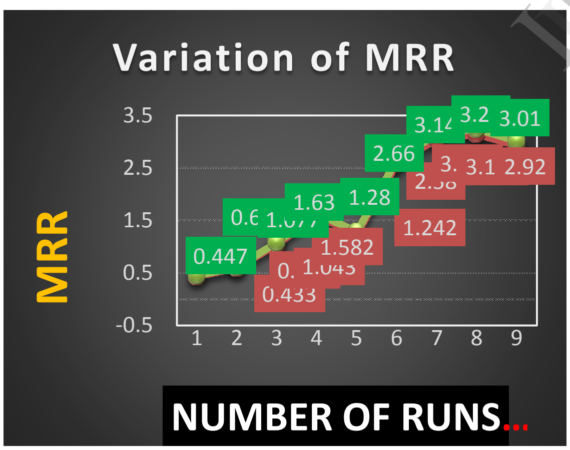

Fig.1.10 Variation of M.R.R

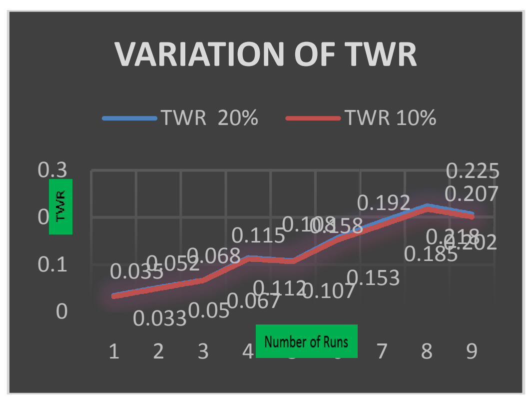

Fig.1.11 Variation of T.W.R

IV. CONCLUSION

Aluminum alloy-silicon carbide composites were developed using stir casting technique. The material removal rate increases with increasing discharge current and increased pulse duration up to an optimal value and thereafter decreases. It has also been shown that the material removal rate decreases with increased SiC contents. In the case of TWR ,the tool wear rate increases, it increases with the percentage of SiC This can be explained by a number of factors. Firstly, the electrical conductivity of the aluminum matrix decreases due to the presence of the reinforcement. Furthermore, because of the low thermal conductivity, and the much higher thermal resistance of the SiC, the aluminum alloy between the SiC particles is preferentially removed. It was observed that the SiC-particles were not melted during the machining process since their full size and sharp corners were still visible in the machining debris as well as in the recast layer. This appears to suggest that the removal of the composite material occurs through the process of melting and vaporizing the matrix material and at some point the entire SiC-particle becomes detached. This shielding" effect of the SiC is followed by a decreased removal rate with increased SiC. The machined surface of a material generated using EDM is composed of many microscopic craters associated with the random spark discharge between the electrodes.

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