International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.4., 2015
(July-Aug)

RESEARCH ARTICLE

ISSN: 2321-7758

REGRESSION ANALYSIS OF MATERIAL REMOVAL RATE AND RADIAL OVERCUT ON ELECTRIC DISCHARGE MACHINE FOR Al/SiC COMPOSITE MATERIAL

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ABSTRACT

Existing manufacturing industries are fronting challenges from these advanced nascent materials Viz. nanomaterial, ceramics, super alloys, and metal matrix composites, that are hard and Difficult to machine, requiring high accuracy, surface quality excellence which affects and Increases machining cost. To meet these tasks, unconventional machining processes are being used to achieve optimum metal removal rate, better surface finish and greater dimensional Correctness, with a reduced amount of tool wear. Electrical discharge machining (EDM) is one of the most extensively used non-conventional material removal processes. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage in the manufacture of mould, die, automotive, aerospace and surgical components. In addition, EDM does not make direct contact between the electrode and the work piece eliminating mechanical stresses, chatter and vibration problems during machining.

KEYWORD: EDM, MRR , COMPOSITE MATERIAL, LM25, RADIAL OVER CUT

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INTRODUCTION

In recent years, composite materials have gained more and more attention in both Commercial and industrial applications. The term ‘’composite’’ originally arose in engineering when two or more materials were combined in order to rectify some shortcoming of a particularly useful component. In many engineering high strength to weight ratio of materials are important while designing the components. Present work highlights that significantly influence of process parameters on strength of composite material.

COMPOSITE MATERIAL

Recently, the composite materials are brought into greater use in the industries of aircraft, Automobiles and especially solar vehicles, because of their light density and high specific strength. In these applications the fracture strength and fatigue loads are usually unavoidable. For this reason resent designs do not specify static strength alone as a primarydesign criterion but also include fatigue analysis. The demand for improved performanceof structural materials in transportation industries, particularly in aircraft, makes strength analysis is an important consideration

FABRICATION TECHNIQUES FOR METAM MERIX COMPOSITES

A number of composite fabrication techniques have been developed that can be placed into two broad categories. These are: (i) powder metallurgical techniques, (ii) liquid metallurgy. The liquid metallurgy techniques include unidirectional solidifications to produce directionally aligned MMCs, suspension of reinforcement in melts followed by solidification, compo casting, squeeze casting, spray casting, and pressure infiltration. The liquid metallurgy techniques are the least expensive of all, and the multi-step diffusion bonding techniques may be the most expensive

(A) STIR CASTING

This involves incorporation of ceramic particulate into liquid aluminum melt and

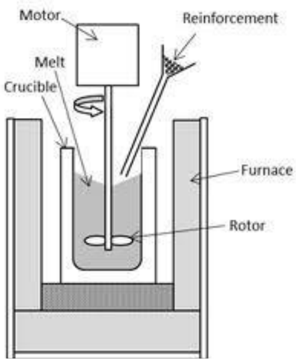

Fig: 1Stir casting process

Allowing the mixture to solidify. Here, the crucial thing is to create good wetting between the particulate reinforcement and the liquid aluminum alloy melt.

III.EDM (Electric Discharge Machining)

(A) WHAT IS EDM?

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machiningprocess, where electrical energy is used to generate electrical spark and material removalmainly 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

(B) DESIGN VARIABLE OF EDM:

Design parameters –

1. Material Removal Rate (MRR): The Material removal rate is express as the ratio of the difference of weight of the work piece to the machining time and density of the material.

2. Radial over Cut (ROC): ROC is express as half the difference of diameter of the hole produced the tool diameter

Machining parameter –

1. Discharge Current: Current is measured in ampere allowed to per cycle. It is directly proportional to MRR.

2 .Pulse on time: The duration of time the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on time.

3 .Pulse off time: The duration of time between the spark. This time allows the molten metal to solidify and to be wash out of the arc gap.

4 .Duty Cycle: It is the ratio of pulse on time to the total cycle time (pulse on time +pulse off time)

(C) EDM SETUP:

Fig: 2Control unit of EDM machine

Fig: 3Tool with tool holder and work piece

4.LITERATURE REVIEW

Dasgupta et al discussed about composites were formed by adding 15 wt% of SiC dispersed in the size range of 20-40 µm to Al-Zn-Mg-Cu alloy (corresponding to 7075 series) by stir casting process. The composite exhibits a uniform distribution of SiC particulates as well as good bonding between the matrix and particulates. Grain boundaries are clearly defined with some precipitates in the grains [1].

B.Mohan et al**[2]** discussed that the of effect of the EDM Current, pulse duration and rotation of electrode on metal removal rate, TWR, and SR, and the EDM of Al-Sic with 20-25 vol. % SiC, the MRR increased with increased in discharge current and specific current is decreased with increasing in pulse duration. Increasing the speed of the rotation electrode resulted in a positive effect with MRR, TWR and better SR than stationary. The electric motor can be used to rotate the electrode(tool) A V belt was used to transmit the power from the motor to the electrode Optimization parameters for EDM drilling were also developed to summarize the effect of machining characteristic such as MRR, TWR and SR

5. OBJECTIVE:

Objectives of present work are as following under:

1.To study the effect of input parameters of CNC EDM machine such as the %WtSiC, Current, pulse on time and Duty cycle on metal removal rate (MRR) & Radial over Cut (ROC).

2.To develop the regression model and validate it with different values which are not used in experiment.

6. EXPERIMENTAL WORK:

we are going to discuss about the experimental work which is consist about formation of the L-9 orthogonal array based on Taguchi design, orthogonal array is reduces the total on of experiment, in this experiment total 9 run. And Experimental set up, selection of work piece and material, tool manufacturing, and taking all the value and calculation of MRR and ROC.

I.MATERIAL SELECTION:

Two materials are used in MMC, one is matrix material and other is reinforcement material.

II.STIRRER MANUFACTURING:

Stirrer is designed according to dimensions of crucible and height of furnace. Material selection for stirrer is very important due to work at high temperature. So, SS 304 is selected for stirrer. Shaper machine is use for making the stirrer.

Table:1Chemical composition of grade 304 stainless steel

Grade	C	Mn	Si	P	Cr	Mo	Ni	N
304	0.08	2.0	0.75	0.045	20.0	-	10.5	0.10

DESIGN OF EXPERIMENT:

Design of experiments (DOE) or experimental design is the design of any information gathering exercises where variation is present, whether under the full control of the experimenter or not. However, in statistics, these terms are usually used for controlled experiments. Formal planned experimentation is often used in evaluating physical objects, chemical formulations, structures, components, and materials [3].

Table: 2Coded values of input variables with levels

Coded Values	Input parameters	Notation	Units	Lower Level	Middle	Upper Level
C1	%Wt of SiC	W	Mg	10	15	20
C2	Discharge Current	I	Ampere	15	25	35
C3	Pulse On time	Ton	Ms	50	70	90
C4	Duty Cycle	T	-	05	07	09

For 4 input variables and three levels, according to the full factorial design 3^4 = 81 no of experiments require to perform. To reduce the no of experiment Taguchi method is used.

TAGUCHI METHOD:

The Taguchi method involves reducing the variation in a process through robust design of Experiments. Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies. The Taguchi arrays can be derived. Small arrays can be drawn out manually; large arrays can be derived from deterministic algorithms. The arrays are selected by the number of parameters (variables) and the number of levels (states). Taguchi array is developed by MINITAB software. For 4 factors and 3 levels L9 and L27 arrays are available. L9 array is used for design of experiments.

Table: 3 Array

Sr No.	%wtSiC (mg)	Current (A)	Ton (µ sec)	Duty Cycle	MRR (gm/min)	ROC (mm)
1	10	15	50	5		
2	10	25	70	7		
3	10	35	90	9		
4	15	15	70	9		
5	15	25	90	5		
6	15	35	50	7		
7	20	15	90	7		
8	20	25	50	9		
9	20	35	70	5		

EXPERIMENTAL PROCEDURE:

Step 1 – Tool Selection:

We used the Cu circular shaped tool for EDM machining and its specification:

Diameter of Tool – 30mm

Weight of Tool – 200gm

Material Removal Rate – High at rough surface range

Wear ratio – Low

Cost – Low

Density - 8.94 x 10 3 kg/m 3

Melting Point - 1356 K

Copper tool was selected because of its high material removal rate, low wear ratio, high melting point, high density and low cost

Fig:4Cu circular shaped Tool

Step 2 – Work piece and Tool Dialing

We used the dial for accurate machining. Dialing is necessary for accurate result because if the Tool and work piece is not perfectly hold then the there is a chance of tapper being occurred During the machining.

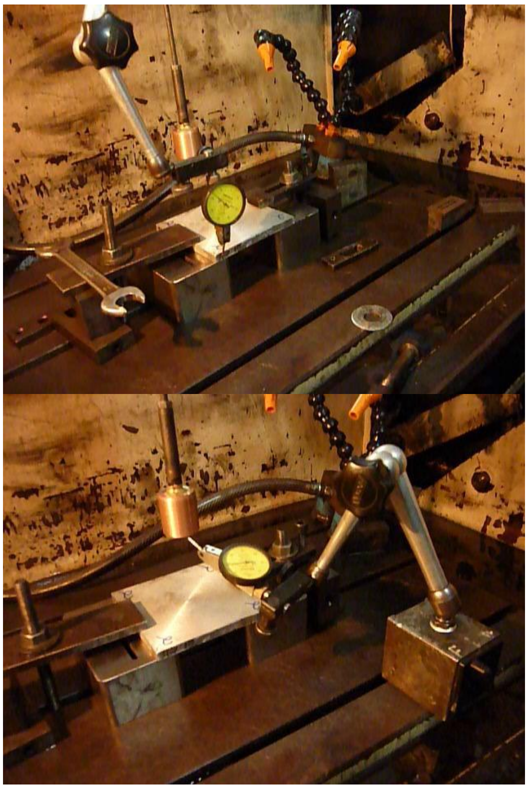

Fig:5 Work piece and Tool Dialing

Step 4 Measurements of MRR and ROC

$$MRR = \frac{Wofworkpiecebeforemachining - WoFworkpie}{time\ of\ machining}$$

Fig:6Weight measurement of work piece

$$ROC = \frac{\text{Dia of the work piece cavity} - \text{Dia Of the tool}}{2}$$

Fig:7diameter measurement of the tool and work piece

CONDUCT OF EXPRIMENT

LM 25 Aluminum material particulate was using circular shaped Copper tool with 30mm diameter. And the die-sinking type of EDM machine is used. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94°C) was used as dielectric fluid. Internal flushing with Circular-shaped copper tool with internal flushing was used to flush away the eroded materials from the sparking zone. In this experiment supply voltage was kept constant 50v. For a four factor are tackled with a total number of 9 experiments

Performed on die sinking EDM.

DESIGN MATRIX AND OBSERVATION TABLE:

Table:4Design matrix and Observation table

RUN	%wt SiC(mg)	Current (A)	Ton (µs)	Duty Cycle	MRR (gm/min)	ROC (mm)
1	10	15	50	5	0.605	0.295
2	10	25	70	7	0.75	0.325
3	10	35	90	9	1.09	0.45
4	15	15	70	9	0.595	0.38
5	15	25	90	5	0.677	0.48
6	15	35	50	7	1.184	0.435
7	20	15	90	7	0.539	0.36
8	20	25	50	9	1.079	0.43
9	20	35	70	5	1.008	0.49

RESULT AND DISCUSSION:

I.RESPONSE TABLE:

Table: 5 response table

RUN	%Wt of SiC (mg)	Ip (A)	T on (µs)	T	Wt of Work piece (gm) Wb	Wa	Diameter (mm) Work piece	tool	Time Of Machining
1	**10**	**15**	**50**	**5**	**206**	**199**	**29.38**	**28.79**	**11min34sec**
2	**10**	**15**	**70**	**7**	**210**	**203**	**29.4**	**28.75**	**9min20sec**
3	**10**	**15**	**90**	**9**	**210**	**203**	**29.6**	**28.7**	**6min25sec**
4	**15**	**25**	**70**	**9**	**208**	**201**	**29.43**	**28.67**	**11min45sec**
5	**15**	**25**	**90**	**5**	**205**	**199**	**29.63**	**28.66**	**8min51sec**
6	**15**	**25**	**50**	**7**	**202**	**196**	**29.48**	**28.61**	**5min4sec**
7	**20**	**35**	**90**	**7**	**218**	**211**	**29.3**	**28.58**	**12min59sec**
8	**20**	**35**	**50**	**9**	**220**	**213**	**29.4**	**28.54**	**6min29sec**
9	**20**	**35**	**70**	**5**	**216**	**210**	**29.5**	**28.52**	**5min2sec**

II. TAGUCHI ANALYSIS: MRR:

Level	%wtSiC (mg)	Current(A)	Ton(µs)	Duty Cycle
1	-2.0384	-4.7476	-0.7458	-2.5613
2	-2.1436	-1.7422	-2.3131	-2.1333
3	-1.5462	0.7616	-2.6693	-1.0366
Delta	0.5974	5.5096	1.9235	1.5277
Rank	4	1	2	3

III.TAGUCHI ANALYSIS: ROC

Level	%wtSiC (mg)	Current (A)	Ton (µs)	Duty Cycle
1	9.109	9.294	8.388	7.25
2	7.337	7.823	8.121	8.622
3	7.467	6.787	7.395	7.577
Delta	1.764	2.507	0.993	1.065
Rank	2	1	4	3

CONCLUSION

Within the frame of current research work the following conclusions can be derived.

1) From taguchi analysis conclude that current has a most significant effect on MRR. Apart from current the other input parameters pulse on time, duty cycle and %wt of SiCare effect on the output respectively.
2) From taguchi analysis conclude that current has a most significantly effect on ROC. Apart from current the other input parameters %wt of SiC, duty cycle and pulse on time are effect on the output respectively.
3) Regression model developed can be used to prediction the MRR and ROC for EDM Machining of Al/SiC Metal-matrix composites accurately.

REFERENCE

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