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Experimental Study of Surface Roughness and Tool Wear Rate on Aluminum/Alumina MMC Using EDM

Engr. Sourav Rana, O.S. Bhatia

M.Tech Student, Department of Mechanical Engineering, Green Hills Engineering College, Solan, (Kumarhatti) H.P.
Associate Professor Department of Mechanical Engineering, Green Hills Engineering College, Solan, H.P.

ABSTRACT: With the advancement in machining process, it is necessary to overcome the after effects of machining. The machining processes like EDM causes lots of tool wear and surface roughness during machining of composites having improved strength and other mechanical properties. In this paper, metal matrix composite having alumina particles as reinforcements is used. The machining is done on the electric discharge machining setup and result shows that best parametric combinations for lesser tool wear rate and better surface quality.

I. INTRODUCTION

Today is the era of advancement in manufacturing as well as machining technology. A lot new machining techniques are being developed in the field of micro machining. In the field of micromachining, electric discharge machining (EDM) process is a quite familiar name. A part of it,EDM drilling is excellent for machining deep and narrow holes regardless of material hardness and location, whereas die-sinking EDM works well to machine micro-parts and perpendicular walls of die and molds [1].Current paper investigates the carbonaceous layer and its formation during the erosion. During Electric Discharge Machining process several material loadings take place on the workpiece surface within the processing zone. To model the comprehensive material removal and its effects on the resulting material properties especially in the rim zone and on surface integrity it is necessary to describe these loadings on several length scales in detail [3]. The influence of EDM parameters on material removal rate, electrode wear, machining time and micro-hole quality when machining Ti6Al4V is studied and conclusion says that due to an inefficient removal of debris when increasing hole depth, a new strategy based on the use of helical-shaped electrodes has been proposed[4].Dhar and Purohit [5] evaluated the effect of current (c), pulse-on time (p) and air gap voltage (v) on MRR, TWR, ROC of EDM with Al–4Cu–6Si alloy–10 wt. % SiC_pcomposites. The MRR was found to decrease with an increase in the percent volume of SiC, whereas the TWR and the surface roughness increase with an increase in the volume of Sic. it shown the graph between interactive effect of the percent volume of Sic and the current on MRR [6]. Taweel [7] fabricated Tool electrode material such as Al–Cu–Si–Tic composite produced using powder metallurgy (P/M) technique and using workpiece material CK45 steel. B.Mohan et.al [8]explains the evolution of effect of the EDM Current, electrode marital polarity, pulse duration and rotation of electrode on metal removal rate. TWR and SR. EDM of Al-Sic with 20-25 vol. %, the MRR increased with increased in discharge current and specific current it decreased with increasing in pulse duration. The EDM process's workpiece generated by the superposition of multiple discharges, as it happens during an actual EDM operation, by diameter of the discharge channel and material removal efficiency can be estimated using inverse identification from the results of the numerical model [9].

II. EXPERIMENTAL WORK

The experiments were performed on the specimens prepared from the fabricated composite. The fabrication of the present composite completes with the use of aluminum as matrix and alumina as reinforcement. The aluminum was heated to around 750 degree Celsius before mixing with alumina particles. The molten aluminum is mixed with the

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reinforcement using mechanical stir process. The final metal matrix composite was prepared using mechanical casting method. The investigation on metal removal rate is completed using the electric discharge machining process. The table 1 shows the metal removal rate of the different specimens at different levels using design of experiments. Table 2 shows the analysis of variance and figure 2 shows the S/N ratio generated.

Table 1 Tool Wear Rate

S.no	TWR 1	TWR2	TWR3	Average TWR	S/N Ratio, η (dB)
1	0.000769	0.000769	0.000769	0.000769	62.2815
2	0.000625	0.000625	0.000625	0.000625	64.0824
3	0.001429	0.001429	0.001429	0.001429	56.8994
4	0.0025	0.0025	0.0025	0.0025	52.0412
5	0.000769	0.000714	0.000667	0.000717	62.8896
6	0.001667	0.002	0.001667	0.001778	55.0014
7	0.005	0.005	0.005	0.005	46.0206
8	0.006667	0.003333	0.003333	0.004444	47.0445
9	0.001667	0.002	0.001667	0.001778	55.0014

A. MATHEMATICAL MODE FOR TOOL WEAR RATE

The mathematical model for tool wear rate has been developed using regression. Equation (1) shows the mathematical model prepared using MINITAB software.

$$TWR = 0.00248937 - 0.00130411\ IP - 0.00166819\ Ton - 0.00286182\ Toff + 0.00296408\ Volt + 0.000676002\ IP*Ip + 0.000280169\ Ton*Ton + 0.000721866\ Toff*Toff - 0.000528134\ Volt*Volt \quad (1)$$

B. ANALYSIS OF VARIANCE FOR TOOL WEAR RATE

Analysis of variance has been carried out utilizing experimental data to study the significance of process parameters on responses. From the analysis of variance Tables 2, it is concluded that the current is the most significant parameter for tool wear rate. Pulse off time has a minimal significant effect on tool wear rate.

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Table 2 Analysis of Variance for TWR (using Adjusted SS for Tests)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
IP	2	0.0000380	0.0000380	0.0000190	45.25	0.000
Ton	2	0.0000059	0.0000059	0.0000029	6.98	0.006
Toff	2	0.0000031	0.0000031	0.0000016	3.74	0.044
Volt	2	0.0000147	0.0000147	0.0000074	17.53	0.000
Error	18	0.0000076	0.0000076	0.0000004		
Total	26	0.0000693				

S = 0.000648109   R-Sq = 89.09%   R-Sq(adj) = 84.24%

S/N ratio graphs were generated from S/N ratio obtained based on experimental data of material removal rate. Figure1 shows the S/N ratio graph obtained for material removal rate using MINITAB.

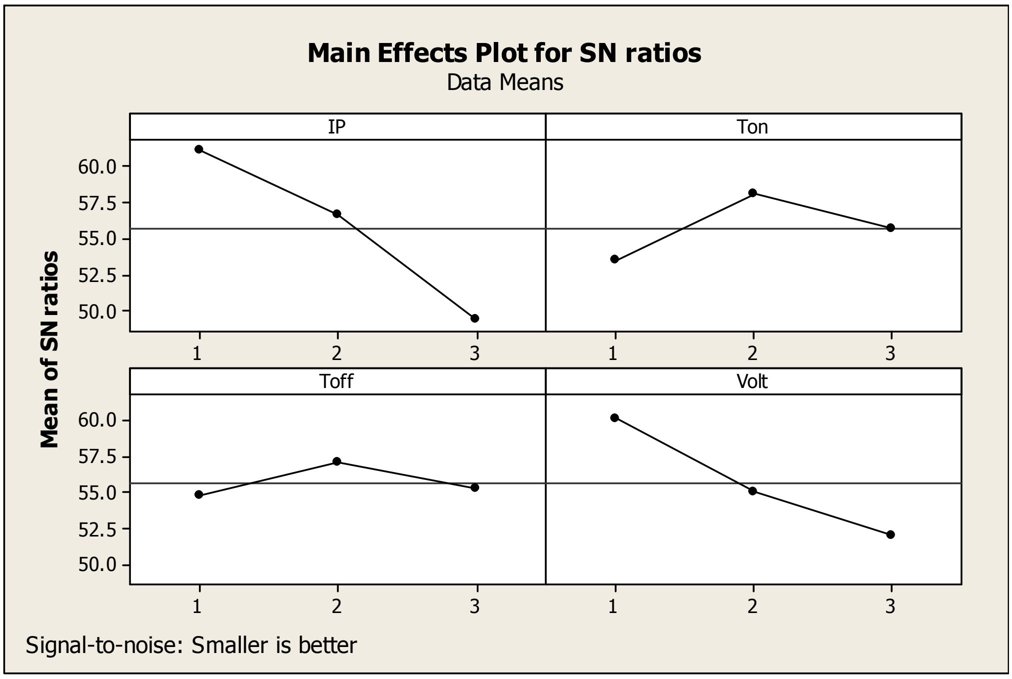

Figure 1 S/N ratio for TWR

Table 3 Surface Roughness Values

S.no	Ra1	Ra2	Ra3	Average roughness	S/N Ratio, η (dB)
1	1.8942	1.897	1.8292	1.873467	-5.45292
2	1.932	1.8587	1.794	1.828233	-5.24063
3	1.8887	1.83993	1.83993	1.856187	-5.37243
4	1.9193	1.856	1.8667	1.880667	-5.48624

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5	1.8806	1.9709	1.9452	1.932233	-5.72119
6	1.7824	1.8462	1.7935	1.807367	-5.14093
7	1.9547	1.92787	2.0043	1.96229	-5.85526
8	1.7651	1.78477	1.7268	1.75889	-4.90477
9	1.9246	1.9435	1.9176	1.928567	-5.70469

C.MATHEMATICAL MODEL FOR SURFACE ROUGHNESS

The mathematical model for tool wear rate has been developed using regression. Equation (2) shows the mathematical model prepared using MINITAB software.

Ra = 1.96013 + 0.0372433 IP - 0.200604 Ton + 0.108164 Toff - 0.0625739 Volt -0.00548333 Ip*Ip + 0.0449717 Ton*Ton - 0.0140833 Toff*Toff + 0.005705 Volt*Volt (2)

D. ANALYSIS OF VARIANCE

Analysis of variance has been carried out utilizing experimental data to study the significance of process parameters on responses. From the analysis of variance Tables 4, it is concluded that the pulse off time is the most significant parameter for surface roughness. Current has a minimal significant effect on surface roughness.

Table 4 Analysis of Variance for Ra (using Adjusted SS for Tests)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
IP	2	0.004400	0.004400	0.002200	1.91	0.176
Ton	2	0.019860	0.019860	0.009930	8.64	0.002
Toff	2	0.049546	0.049546	0.024773	21.55	0.000
Volt	2	0.028642	0.028642	0.014321	12.46	0.000
Error	18	0.020696	0.020696	0.001150		
Total	26	0.12314				

S = 0.0339088 R-Sq = 83.19% R-Sq(adj) = 75.72%

S/N ratio graphs were generated from S/N ratio obtained based on experimental data of material removal rate. Figure 4 shows the S/N ratio graph obtained for material removal rate using MINITAB.

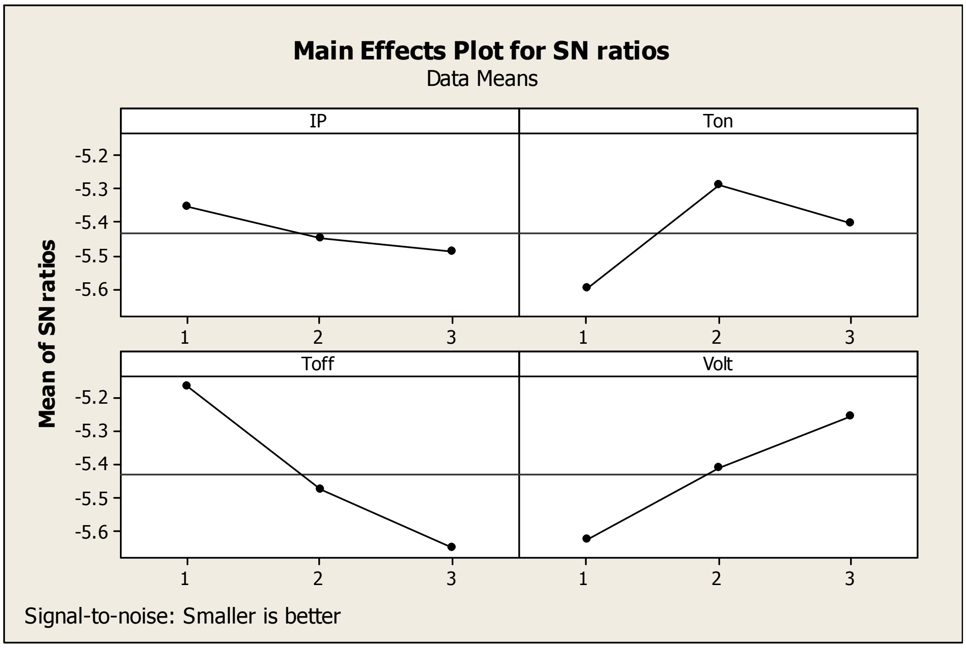

Figure 2 S/N ratio for Surface Roughness

III. CONCLUSION

This study concerns the experimental investigation of Aluminum/alumina metal matrix composite. The conclusions obtained from this investigation are as follow:

- The fabrication of Al/Aluminawas successfully completed using mechanical stir casting process.
- The composite was successfully machined using electrical discharge machining process and the best parametric combination for the better surface quality was found to be at current= 10 A, Pulse on time=8µm, Pulse of time=50 µm and Voltage =50V.
- The composite was successfully machined using electrical discharge machining process and the best parametric combination for the lesser tool wear rate was found to be at current= 10 A, Pulse on time=8µm, Pulse of time=100 µm and Voltage =30V.
- Anova results show that for Roughness Pulse off time is most significant and current is least significant parameter. For Tool wear rateCurrent is most significant parameter and Pulse off time is least significant parameter.
- Regression model were developed for roughness and tool wear rate with R^2 value of 83.19 %and 89.09% respectively.

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