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OPTIMIZATION OF PARAMETER FOR METAL MATRIX COMPOSITE IN WIRE EDM

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ABSTRACT

The bronze alumina (Al2O3) alloy is an Metal Matrix Composite (MMC) of interest in several applications like bearing sleeve, piston and cylinder liners etc., The reinforcement used in this MMC makes it difficult to machine using traditional technique. Wire-Electric Discharge Machine (WEDM) seems to be a viable option to machine. This paper presents an investigation on the optimization of machining parameters in WEDM of bronze-alumina MMC. The main objective is to find the optimum cutting parameters to achieve a low value of Surface roughness and high value of material removal rate (MRR). The cutting parameters considered in this experimental study are, pulse on time (Ton), pulse off time (Toff) and wire feed rate. The settings of cutting parameters were determined by using Taguchi experimental design method. An L9 orthogonal array was chosen. Signal to Noise ratio (S/N) and analysis of variance (ANOVA) was used to analyze the effect of the parameters on surface roughness and to identify the optimum cutting parameters. The contribution of each cutting parameters towards the surface roughness and MRR is also identified. The study shows that the Taguchi method is suitable to solve the stated problem with minimum number of trails as compared with a full factorial design.

KEYWORDS: Composites; Wire cut EDM, Taguchi Techniques, ANOVA.

INTRODUCTION

Electrical discharge wire cutting (EDWC) commonly called as wire-EDM, is a special form of electric discharge machining that uses a small diameter wire as the electrode to cut a narrow kerf in the work. The cutting action in wire EDM is achieved by thermal energy from electric discharges between the electrode wire and the work piece. The work piece is fed continuously and slowly past the wire in order to achieve the desired cutting path, numerical control is used to control the work part motion during cutting. As it cuts, the wire is continuously advanced between a supply spool and take –up spool to present a fresh electrode of constant diameter to the work. This helps to maintain a constant kerf width during cutting. As in EDM, wire EDM must be carried out in the presence of a dielectric. This is applied by nozzles directed at the tool to work interface or the work part is submerged in a dielectric bath. Wire-EDM process involves a number of machine setting parameters such as applied voltage (V), ignition pulse current (IAL), pulse duration (TA), pulse off time (TB), range of speed variation (S), servo-control reference mean voltage (Aj), wire speed (WS), wire tension (Wb), and injection pressure (Inj). The material of work piece and its height (H) also influence the process. All these parameters influence surface finish and cutting speed to varying degree. Taguchi Methods is a system of cost-driven quality engineering that emphasizes the effective application of engineering strategies rather than advanced statistical techniques. It includes both upstream and shop-floor quality engineering. Upstream methods efficiently use small-scale experiments to reduce variability and find cost-effective, robust designs for large-scale production and the marketplace. Shop-floor techniques provide cost-based, real-time methods for monitoring and maintaining quality in production.

LITERATURE SURVEY

A suitable selection of machining parameters for the WEDM process is most relies on the operator's

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experience and manufacturer guidelines. Machining parameters table provided by the manufacturer are more generic in nature and does not address recent materials. Hence the needs to optimize the parameters for newer / advanced materials arise. Various research works has been carried out in WEDM of advanced materials. The following paragraphs summarize the outcome of those researches.

An experimental investigation carried out by Ahmet Hascalyk (2004) on machining characteristics of AISI D5 tool steel in WEDM process. During the experiments open circuits voltage, pulses duration, wire speed and dielectric fluid pressure are the parameters optimized to achieve good surface roughness. Optical and scanning electron microscopy, surface roughness and micro hardness tests are used to study the characteristics. From this study the surface roughness is increased when pulse duration and open circuit voltage were increased and dielectric fluid pressure and wire speed are many influences while machining. Dr.A.Manna and Dr.B.Battacharyya carried out an investigation on Taguchi method (2004) to optimize the CNC- Wire cut EDM parameters for effective machining of Al-SiC MMC to determine the significant factors for surface roughness using analysis of variance and 'F' test values and from the conformation test results mathematical model have been developed. From this research found that the wire tension and wire feed rate are most significant parameters to achieve good surface roughness. A study on kerf and material removal rate in wire electrical discharge machining based on Taguchi method has been carried out by Nihat Tosum et al (2004) to optimize the machining parameters for kerf and MRR. The author concluded that the pulse duration and open circuit voltage are highly significant and wire feed and dielectric-flushing pressure has lees significant. P.M.George et al (2004) were investigated the optimal setting of the process parameters for the electro – discharge machining of carbon-carbon composites. Pulse current, gap voltage and pulse on time are the considered parameters considered and the responses are electrode wear rate and MRR. Based on the Taguchi design methodology the experiment were planned, conducted and analyzed by analysis of variance (ANOVA). The stated responses are achieved by additional experiment and pulse on time is insignificant to machine carbon-carbon composites. The significant factors affecting –machining performance such as MRR, gap width, surface roughness, sparking frequency, average gap voltage and normal ratio are determined for the material SKD II alloy steel in WEDM. Based on the Taguchi design method and the analysis of variance, the optimization problem is solved using the feasible direction method by LEE et al. (1997). From the literature survey, it is seen that not much work has been carried out on the study of the effect of cutting parameters in WEDM of Bronze – alumina (Al2O3). Hence this research attempts to the study the optimum cutting parameters for machining of bronze – alumina in WEDM by using Taguchi design methodology.

EXPERIMENTAL TECHNIQUES AND PROCEDURES

The Bronze-alumina is one of the hard materials and its hardness is approximately 38 HRC and the tensile strength is 171 X 103 psi. The optimized cutting parameters for bronze – alumina (Al2O3) in WEDM are not available, which takes more production time and poor surface finish. Factors are the design parameters that influence the performance and the input that can be controlled. The control factors that a manufacturer can control either in the design of a product or design of process or during the process. Noise factors are cannot control by the manufacture. During an experiment the noise factors may be controlled temporarily, but in an actual production may not or cannot be controlled. In this study three controllable factors are given in Table 1.

Table 1 Factor and Levels

Sl.No	**Symbol**	**Cutting Parameters**	**Levels**		
			1	2	3
1	A	Pulse on time (Ton)	1	5	10
2	B	Pulse off time (Toff)	1	5	10
3	C	Wire feed (WF)	1	2	3

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Table 2 Experimental Results with S/N Ratio for surface roughness

Exp	Surface Roughness (SR)					S/N Ratio
1	2.9	3.53	2.67	3.72	4.56	-10.98
2	2.71	3.09	3.08	2.8	2.68	-9.18
3	3.45	2.64	2.75	3.73	2.85	-9.87
4	2.66	2.24	3.04	4.12	2.76	-9.63
5	3.07	3.17	2.78	2.71	2.43	-9.08
6	2.47	3.27	2.67	3.41	3.71	-9.94
7	3.38	2.51	3.39	2.6	3.38	-9.77
8	2.57	3.28	3.1	2.8	2.94	-9.39
9	2.88	2.57	2.47	2.31	3.01	-8.5

The selected three parameters have different influences on the machining performance. The significant parameters are found by the analysis of variance (ANOVA) and the optimal cutting parameters are obtained using the main effects plot. The characteristics that lower value represent better machining performance such as surface roughness is called “lower is better (LB)” in quality engineering. The S/N ratio (signal to noise) could be an effective representation to find the significant parameter by evaluating the minimum variance. By applying these equations, the S/N values of machining performance for each experiment of L9 OA can be calculated. (Appendix shows the calculations) for the Ra values obtained the S/N ratio values are computed and given in Table 2. In order to obtain the effects for machining parameters for each level, the S/N values of each fixed parameter and level in each machining performance is summed up. The combination of machining parameters pulse on time, pulse off time, wire feed with larger S/N ratio has resulted in lower surface roughness value. From the calculation of main effects for each level of the factors, the main effects values are shown in Table 3 and the values are plotted and shown in fig. 1, 2 and 3 for factors pulse on time, pulse off time and wire feed rate respectively. The main effects plot shows the influence of each level of factors on the machining performance. The level having the major contribution is selected from the plot and is the optimized levels for the particular factor. Interpreting the main effects plot, it can be seen that the optimum machining settings are pulse on time at level 3 (10 μ sec.), pulse off time at level 2 (5μ sec.) and wire feed at level 2 (2 m/min.).

Table 3 shows the main effects at each levels

Factors	Level 1	Level 2	Level 3
Pulse on Time	- 10.01	- 9.55	- 9.22
Pulse off Time	- 10.13	- 9.22	- 9.44
Wire feed	-10.10	-9.10	-9.57

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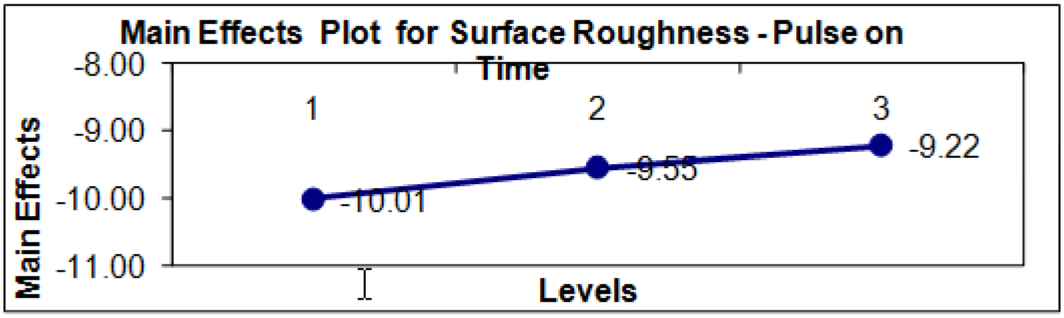

Fig.1 Main Effects Plot for Surface Roughness - Pulse on Time

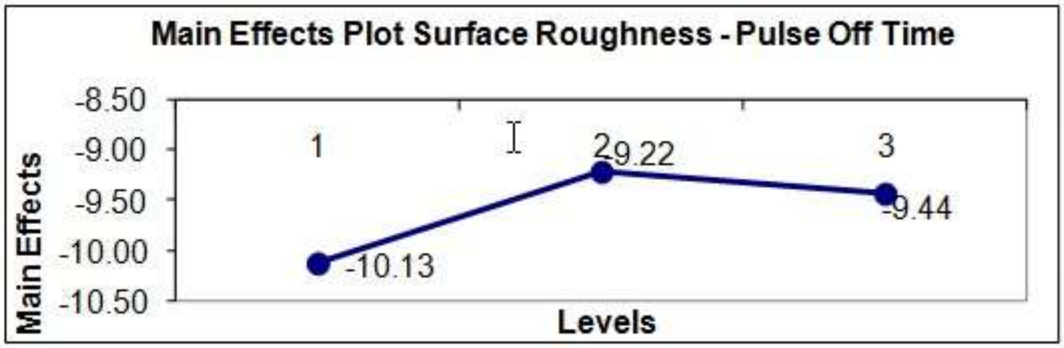

Fig. 2 Main Effects Plot Surface Roughness - Pulse Off Time

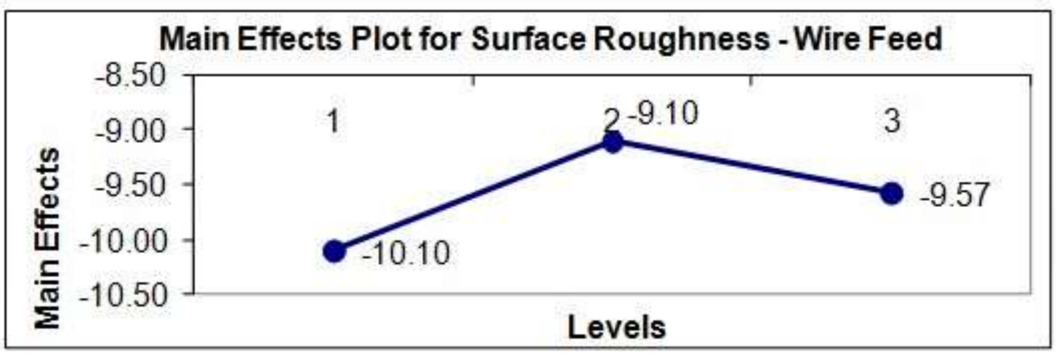

Fig. 3 Main Effects Plot for Surface Roughness - Wire Feed

Table 6 Analysis of Variance

Factors	Sum of Squares	Degree of freedom	Variance	'F' Ratio	% Contribution
Pulse On	0.94	2	0.47	47	24.6
Pulse Off	1.34	2	0.68	68	35.4
Wire Feed	1.5	2	0.75	75	39.4
Error	0.02	2	0.01		0.6
Total	3.82	8			100

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CONCLUSION

From the experimental results, calculated S/N ratio, analysis of variance and 'F' test values, the following conclusions are drawn for machining of bronze-alumina MMC of WEDM.

- The wire feed rate is the most significant machining parameter for surface roughness (SR) for machining of bronze-alumina (Al2o3) MMC.
- For better surface finish the recommended parametric combination is pulse on time at level 3, pulse off time at level 2 and wire feed rate at level 2 for machining of bronze-alumina (Al2O3) MMC.

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