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Optimization of Machining Parameter for Surface Roughness on Wedm of En36 Alloy Steel

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Abstract: *Machining of hard metal is difficult by conventional method to get high accuracy. Modern or non conventional machining method are widely use now a days. Wire electrical discharge machining (WEDM) is also a non conventional machining process which is mostly used. In machining of conductive materials by using precisely controlled sparks that occur between a very thin wire and a work piece in the presence of a dielectric fluid. The thin wire considered as a cutting tool. The aim of present study is to examine the effect of various WEDM parameters on the surface roughness of EN36 alloy steel and to find out the set of parameters to optimize the surface roughness of EN36. This study based on WEDM parameters like pulse on time, pulse off time, peak current and voltage on surface roughness. In the present work we take thin brass wire (0.25mm) as cutting tool. With the help of Taguchi method the experimental orthogonal array was designed and three levels corresponding to each of the variables was taken. It is observed that current has the maximum effect and other parameters have comparatively less effect during machining.*

Keywords:- *EN36 alloy steel, pulse on time, pulse off time, peak current, voltage, Wire electrical discharge machining (WEDM)*

I. Introduction

Wire Electrical Discharge Machining (WEDM) is an electro thermal production process in which a thin single strand metal wire in conjunction with de-ionized water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks. Due to the inherent properties of the process, WEDM can easily machine complex parts and precision components out of hard conductive materials. WEDM is typically used to cut plates as thick as 300 mm and to make punches, tools, and dies from hard metals that are difficult to machine with other conventional methods.

Here we use EN36 as a work piece. EN36 is a case hardening steel. EN36 is a 3% nickel, chromium, molybdenum grade. Carburised EN36 gives a hard case with a strong core, whilst retaining a remarkable degree of toughness., As a carburising steel grade it is suitable for roller and ball bearings of extra light section, aeroplane and motor crankshafts requiring hard surfaces for roller paths, connecting rods with case-hardened ends, as well as highly stressed gudgeon pins, gears and certain types of collets. The chemical composition of the material is below in table.

Table 1. Chemical composition of EN36

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	V %
0.1376	0.5868	0.01207	0.01241	0.3319	0.0333	3.429	0.847	0.0245

II. Experimentation Process

A number of experiments were conducted to study the effects of various machining parameters of WEDM process. These studies have been undertaken to investigate the effects of peak current (Ip), voltage(V),pulse on time (T-ON),pulse off time(T-OFF). The selected work piece material for the work is EN36 alloy steel. The material for the wire is brass. Having a diameter of 0.25mm. For the calculation of surface roughness we cut the small pieces of EN36 alloy steel say 10x10mm and measure the surface roughness of the pieces with the help of surface roughness tester SRT-6210.

III. Design of experiment and analysis

3.1 Design of experiment

The experimental layout for the machining parameters using the L9 orthogonal array was used in this study.

Table 3.1:Input Machining Parameters

S.NO.	INPUT PARAMETER	LEVEL			OBSERVED VALUE
		1	2	3	
1	CURRENT (Ip)	4	6	8	SURFACE ROUGHNESS IN Ra
2	VOLTAGE(V)	65	70	75	
3	PULSE ON TIME (T-ON)	3	4	5	
4	PULSE OFF TIME(T-OFF)	2	3	4	

The array we design consists of 4 control parameter, that are current, voltage, pulse on time and pulse off time. By the help of Taguchi method, most of the observed values are calculated based on 'lower is the better'. After that the optimization of the observed values was determined by comparing the standard analysis and analysis of variance (ANOVA) which was based on the Taguchi method.

3.2 Observation table

While performing all the 9 experiments with different set of input parameters observation were made for the surface roughness of all 9 work pieces with the help of surface roughness tester in the Ra. After completion of all 9 experiment and measuring surface roughness, there values are filled in the orthogonal array.

Table no. 3.2 Average Table for surface roughness for Material

S.NO	CURRENT (A)	VOLTAGE (V)	T-ON (µs)	T-OFF (µs)	SR (Ra)			SNRA1	MEAN1
					SR1	SR2	SR3		
1	4	65	3	2	1.928	2.345	2.918	-7.7161	2.39700
2	4	70	4	3	2.879	1.693	2.644	-7.8165	2.40533
3	4	75	5	4	2.254	2.149	2.944	-7.8689	2.44900
4	6	65	4	4	1.570	3.231	3.204	-8.8780	2.66833
5	6	70	5	2	2.032	2.579	1.400	-6.2806	2.00367
6	6	75	3	3	1.967	2.332	2.123	-6.6321	2.14067
7	8	65	5	3	5.784	5.602	4.403	-14.4831	5.26300
8	8	70	3	4	6.828	4.586	4.873	-14.8382	5.42900
9	8	75	4	2	6.279	5.107	6.384	-15.4926	5.92333

3.3 Analysis of variance – SR

The results were analyzed using ANOVA for identifying the significant factors affecting the performance measures. The Analysis of Variance (ANOVA) for the mean SR ANOVA table shows that current, pulse on time, pulses off time, voltage are the factors that significantly affect the SR. Current has highest contribution to SR. Main effect plot for the mean SR is shown in the graph2.1 which shows the variation of SR with the input parameters. As can be seen SR increases with increase in current.

3.4 Confirmation test

From mean of each level of every factor we will construct response table for SR is given below:

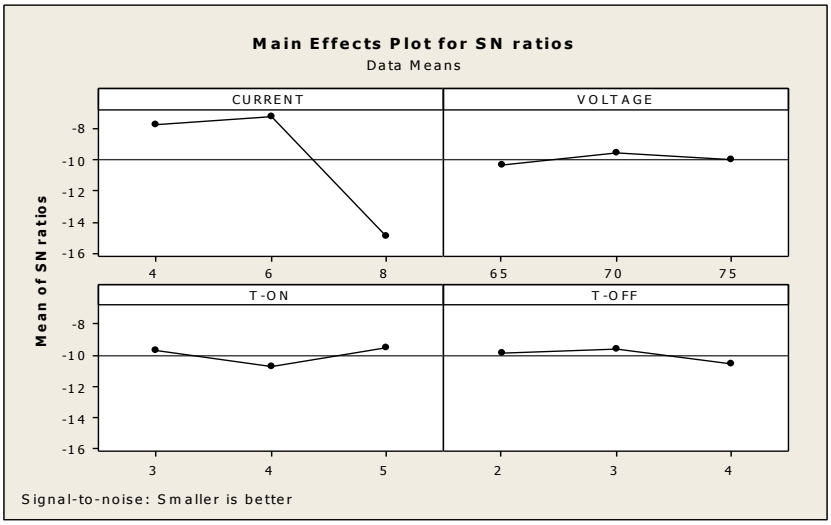
Table 3.4.1: Response Table for Signal to Noise Ratios

LEVEL	CURRENT (A)	VOLTAGE (B)	T-ON (C)	T-OFF (D)
1	-7.801	-10.359	-9.729	-9.830
2	-7.264	-9.645	-10.729	-9.644
3	-14.938	-9.998	-9.544	-10.528
DELTA	7.674	0.714	1.185	0.884
RANK	1	4	2	3

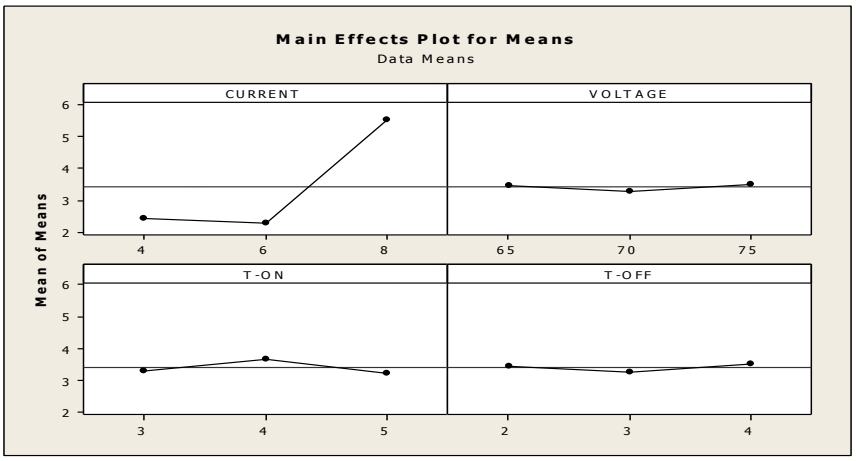
Table 3.4.2: Response Table for Means

LEVEL	CURRENT	VOLTAGE	T-ON	T-OFF
1	2.417	3.443	3.322	3.441
2	2.271	3.279	3.666	3.270
3	5.538	3.504	3.239	3.515
DELTA	3.268	0.225	0.427	0.246
RANK	1	4	2	3

From above main effect plot of SR we can conclude the optimum condition for SR is A2, B2, C3, D2 i.e. current (6), voltage(70), pulse on time(5),pulse off time(3).



Graph 2.1 Main Effect Plot for S/N Ratio of SR



Graph 2.2 Main Effect Plot for Means of SR

The table showing the S/N ratio of SR where we check the value of p which is less than of 0.05 and in the table 0.046 for current .which have been showing current factor have more contribution for surface roughness.

Table 3.4.3:ANOVA For S/N Ratio of SR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
CURRENT	1	76.415	76.415	76.415	8.21	0.046
VOLTAGE	1	0.196	0.196	0.196	0.02	0.892
T-ON	1	0.051	0.051	0.051	0.01	0.944
T-OFF	1	0.732	0.732	0.732	0.08	0.793
Error	4	37.242	37.242	9.311		
Total	8	114.636				

S=3.05131 R-Sq=67.51% R-Sq(adj)=35.03%

Table 3.4.4 ANOVA For Mean Ratio Of SR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
CURRENT	1	14.614	14.614	14.614	9.30	0.038
VOLTAGE	1	0.006	0.006	0.006	0.00	0.955
T-ON	1	0.011	0.011	0.011	0.01	0.939
T-OFF	1	0.008	0.008	0.008	0.01	0.946
Error	4	6.286	6.286	1.572		
Total	8	20.925				

S=1.25363 R-Sq=69.96% R-Sq(adj)=39.91%

** Significant at 95% confidence level
Seq SS= Sum of squares, DOF= degree of freedom, Adj MS= adjusted mean square or variance.

3.5 Optimal design for Surface Roughness(SR)

In the experimental analysis, main effect plot of S/N ratio is used for estimating the SR with optimal design condition. As shown in the graph 2.1 the highest value which effect the surface roughness which are current(A2),voltage(B2),pulse on time(C3),pulse off time(D2).

IV. Conclusion

In the present study, for W EDM process the effect of current, pulse-on time, pulse off time and voltage has been investigated. The effect of input parameter on output response like Surface roughness were analyzed for work material EN36. L9 orthogonal array based on Taguchi design and ANOVA was performed for analyzing the result. And the optimal parameters values are the current (6),voltage(70),pulse on time(5),pulse off time(3).The most predominant factor for the SR is current, rest three factors (pulse on time, pulse off time, voltage) has less impact as compared to the current.

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