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OPTIMIZATION OF PROCESS PARAMETERS USING TAGUCHI'S DESIGN OF EXPERIMENT IN WIRE CUT ELECTRICAL DISCHARGE MACHINING

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Abstract - *Nowadays globalization forces the industries to concentrate more on quality of products and process in order to survive in the market. In the current scenario, non-traditional machining processes are replacing the traditional machining process. The wire cut EDM (WEDM) is very important among the non-traditional machining processes. To achieve good surface finish on the tool as well as in the component, optimum process parameter setting is a crucial factor. Process parameters are optimized by using different techniques for improving the quality. In the present study, Taguchi's Design of Experiment technique is used to optimize the WEDM parameters so as to improve the surface finish of the components produced out of these manufacturing methods. A key component of Taguchi's philosophy is reduction of variability and the quality characteristics as a target or nominal value. The experiments have been designed by using Taguchi's orthogonal array. The Analysis of Variance (ANOVA) has been carried out to determine the significant parameters which are having more influence on surface finish. The critical parameters via, pulse on time, pulse off time, peak current, wire tension, wire feed, fluid rate and fluid pressure are being used in WEDM machine. Each sample was measured for surface roughness using surface roughness tester equipment. The quality characteristic "smaller is better" is used. Applying Qualitek-4, Minitab 18 and ANOVA analysis techniques, the factors influencing the surface roughness were identified. The difference between expected result and confirmation experiment result of surface finish was found to be minimum.*

1.INTRODUCTION

In view of improvement in wire cut electric discharge machining (WEDM) process performance, optimization of process parameters assumes significant importance. This research article deals with the investigation on optimization of the process parameters of the wire cut EDM of mild steel and stainless steel. material removal rate, surface roughness, were studied against the wire cut EDM process parameters, such as pulse on, voltage and wire feed rate. The obtained results show that the Taguchi's robust design analysis is being an effective technique to optimize the machining parameters for the WEDM process [1]. In WEDM process rough machining gives lesser accuracy and finish machining gives fine surface finish, but it reduces the machining speed. Hence we have to improve the MRR and reduce the Ra as the objective, which is done by taguchi method [2].The objective of the present work is to investigate the effects of the various WEDM process parameters on the machining quality and to obtain the optimal sets of process parameters so that the quality of machined parts can be optimized. The raw data and S/N analysis are employed to find the influence of selected parameters on MRR. Objective of the present work is to reveal the influence of four different process parameters Peak current, Pulse on time (TON), Pulse off time (TOFF) and Wire feed rate on Material Removal Rate (MRR) of SS 304 material for cutting on WEDM [3].This paper deals with optimized model to investigate the effects of peak current, pulse on time, pulse off time and Tool lift time in Electrical Discharge Machining (EDM) process .It is observed that the developed model is within the limits of 6% error when compared to experimental results. For required MRR and TWR the input parameters can be predicted from the established model [4].The relatively significant parameters were determined by Analysis of Variance. The variation of output responses with process parameters were mathematically modeled by using non-linear regression analysis. The models were checked for their adequacy. Result of confirmation experiments showed that the established mathematical models can predict the output responses with reasonable accuracy[5]. paper presents the optimization of wire electrical discharge machining (WEDM) process parameters such as pulse on time (Ton), pulse off time (Toff) and wire tension (WT) to yield maximum material removal rate (MRR) and minimum surface roughness (Ra) of copper. The machining experiments were carried out according to the Taguchi parametric design (L9) using 0.25 mm diameter brass wire as a cutting tool. Analysis of variance (ANOVA) was used to find the significance of each process parameter [6-7]. Since the introduction of the process, WEDM has evolved as a simple means of making tools and dies to the best alternative of producing micro-scale parts with the highest degree of dimensional accuracy and surface finish. This paper outlines the development of a model and its application to optimize WEDM machining parameters. Experiments are conducted to test the model and satisfactory results are obtained [8-9].This research outlines the Taguchi's Parameters Design Approach which is applied to optimize machining parameters of dimensional accuracy in wire cut electric discharge machining (WEDM). In this study MINITAB 15 is used to: find out the effect of each parameter on response characteristic and to predict the optimum setting of control parameters. In this study EN24 Steel is used for the experimental work as work piece[10] Based on the above literature review we came to know about the wire cut electrical discharge machine (WEDM) is used for machining materials by the complex shapes. By using the Taguchi's effect of input parameters such as pulse on time

(T-ON), pulse off time (T-OFF), peak current (IP), wire feed (WF), wire tension (WT),fluid rate(FR),fluid pressure(FP). Taguchi's orthogonal array (L8) used to conduct experiments on randomly chosen materials. The objective is about the surface finish of the material.

2. EXPERIMENTAL PROCEDURE

In this experimental study, 7 factors and 2 levels are used and L8 orthogonal array suitable for this experimental design was selected. The experimental runs were performed based on the basis of mixed orthogonal array, L8 (2ʌ 7). A total of 4 (4*4) experimental runs were performed. The process parameters considered are pulse on-time, pulse off-time, peak current, wire tension, wire feed, fluid rate, and fluid pressure and their levels are shown in table-1.

Table-1:Design Factors and their levels

Factors	Level-1	Level-2
Pulse on-time (μs)	125	130
Pulse off-time (μs)	35	40
Peak current (Amps)	11	12
Wire tension (Grams)	1000	1200
Wire feed (M/Min)	7	8
Fluid rate (LPM)	8	9
Fluid pressure (Kg/cm^2)	13	15

Table-2: Orthogonal array

The L8 orthogonal array used for experiment is shown in the Table-2

Trial	1	2	3	4	5	6	7
Trial-1	1	1	1	1	1	1	1
Trial-2	1	1	1	2	2	2	2
Trial-3	1	2	2	1	1	2	2
Trial-4	1	2	2	2	2	1	1
Trial-5	2	1	2	1	2	1	2
Trial-6	2	1	2	2	1	2	1
Trial-7	2	2	1	1	2	2	1
Trial-8	2	2	1	2	1	1	2

Experiments were carried out based on mixed orthogonal array L8 (2ʌ 7). The experiments were performed on ELEKTRA wire-cut electric discharge machine by taking Mild steel as work material and zinc chromium as tool electrode material. A total of 8 experimental runs were performed.

3.RESULT AND DISCUSSION

The experiments were performed on each work pieces based on the orthogonal array method. The surface roughness values are measured by using surface roughness tester on the work pieces. The measured values are tabulated in the Table -3.

Table -3: Surface Roughness Values

Trials	Surface roughness (μm)
Trial-1	2.5275
Trial-2	2.3520
Trial-3	2.2540
Trial-4	2.4650
Trial-5	2.7000
Trial-6	2.8125
Trial-7	2.3500
Trial-8	2.2875
Average	2.468

The main effect from the qualitek-4 software was shown in Table -4.The study of the main effects indicates some interaction between the factors.

Table -4: Main Effects

Column	Factors	Level-1	Level-2	L2-L1
1	Pulse on-time	2.399	2.537	.137
2	Pulse off-time	2.597	2.338	-.259
3	Peak current	2.378	2.557	.178
4	Wire tension	2.457	2.478	.021
5	Wire feed	2.47	2.466	-.005
6	Fluid rate	2.494	2.441	-.054
7	Fluid pressure	2.538	2.398	-.14

Analysis of variance for Mild steel materials was shown in Table 5.3

Table-5:Anova Value

Column	Factors	DOF	Sum of	Variance	Percent
1	Pulse on-time	1	.037	.037	13.472
2	Pulse off-time	1	.133	.133	47.537
3	Peak current	1	.063	.063	22.686
4	Wire tension	1	0	0	.318
5	Wire feed	1	0	0	.009
6	Fluid rate	1	.005	.005	1.974
7	Fluid pressure	1	.039	.039	13.968
Other Error		0			
Total		7			100%

DOF -The number of independent pieces of information that went into calculating the estimate. In order to get the DF for the estimate you have to subtract 1 from the no of items (2 level-1= 1).Sum of squares- It is the sum of squares of the deviations of all observations yi, from their mean. In the context of ANOVA this quantity is called the total sum of squares. Variance – the ANOVA table also shows the statistics used to test hypotheses about the population means. When the null hypothesis of equal means is true, the two mean squares estimate the same quantity (Error variance) and should be approximately equal magnitude. In other words the ratio should be close to 1.

The significant factor, which is having more influence for surface finish is obtained, and optimum conditions and performance shown in Table-6.

Table -6: Optimum conditions and performance

Column	Factors	Level Description	Level	Contribution
1	Pulse on-time	125	1	-.069
2	Pulse off-time	40	2	-.13
3	Peak current	11	1	-.09
4	Wire tension	1000	1	-.011
5	Wire feed	8	1	-.002
6	Fluid rate	9	2	-.027
7	Fluid pressure	15	2	-.071

Total contribution from all factors = -.397

Current grand average of performance = 2.468

Expected results at optimum condition = 2.071

The significant factor and interaction influences shown in the pie chart figure-1.

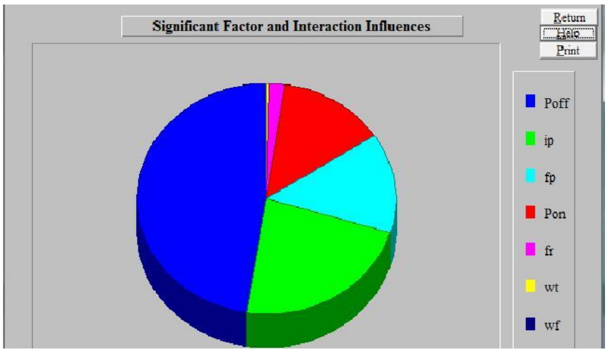

Figure- 1: significant factor and interaction influences 43

The performance distribution of the experiment is shown in the figure -2, in this figure the performance of the current condition and the improved condition is showed.

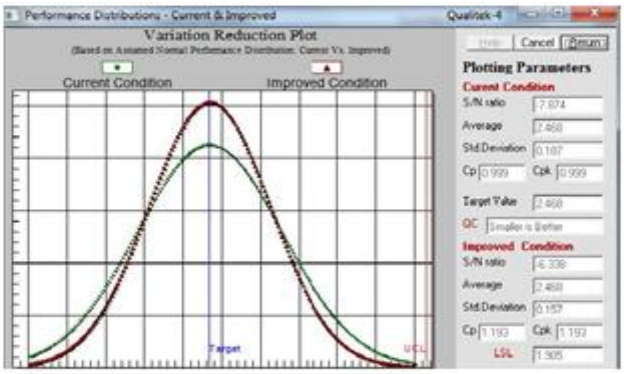

Figure-2: performance of distribution

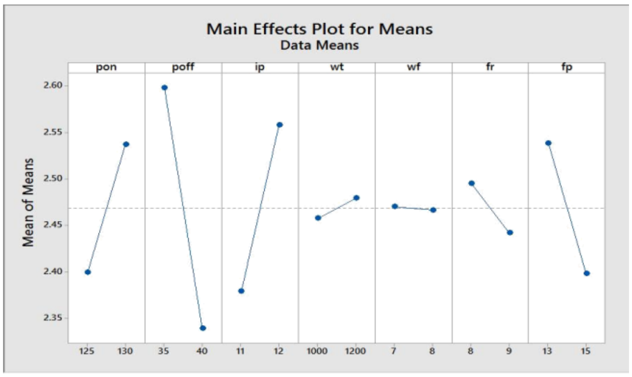

Figure-3: Main effects plot for means

Comparison of current & improved condition

Signal to noise ratio in current condition= -7.874

Signal to noise ratio in improved condition= -6.339

The average mean of the RA = 2.468

Standard deviation in current condition= 0.187

Standard deviation in improved condition= 0.157

By using the qualitek-4 software we can improve the performance and also we can increase the accuracy of the surface roughness. The optimum value is obtained by using the qualitek-4 software. By using Minitab 18 software, main effect plots and signal to noise ratio plots for Mild steel was found and shown in Figure 3 and 4.

Figure-4: main effects plots for SN ratio

Respected means and Signal to noise ratio from Minitab is shown in table-7.

Table -7: means and S/N ratio

Trials	SNRA	MEAN
Trial 1	-8.05382	2.5275
Trial 2	-7.42875	2.3520
Trial 3	-7.05908	2.2540
Trial 4	-7.83634	2.4650
Trial 5	-8.62728	2.7000
Trial 6	-8.98185	2.8125
Trial 7	-7.42136	2.3500
Trial 8	-7.18722	2.2875

Analysis of variance for means are shown in table-8.

Table-8: Analysis of variance for means

Source	DF	Seq SS	Adj SS	Adj MS
Pon	1	0.038019	0.038019	0.038019
Poff	1	0.134033	0.134033	0.134033
Ip	1	0.063814	0.063814	0.063814
Wt	1	0.000914	0.000914	0.000914
Wf	1	0.000026	0.000026	0.000026
Fr	1	0.005592	0.005592	0.005592
Fp	1	0.039410	0.039410	0.039410
Residual Error	0			
Total	7	0.281807		

Analysis of variance for regression is shown in table-9.

Table-9:Analysis of variance for regression

Source	DF	Adj SS	Adj MS	F-value
Regression	1	0.281555	0.281555	6705.28
SNRA	1	0.281555	0.281555	6705.28
Error	6	0.000252	0.000042	-
Total	8	0.281807		

To find the RA value in mathematically we have to create a regression equation. From the Minitab software we can create the regression equation, by using the regression equation we can get the predicted values of surface roughness (Ra) values.

Percentage of error from ANOVA for regression= Error/ Total*100

= 0.000252/0/021807*100

Percentage of error= 0.0894

From the Minitab software the regression equation is obtained.

Regression equation Ra = 0.1994-0.2900*SNRA1

Substituting the values from the analysis of variance table of Minitab

Ra= 0.1994-0.2900* -8.05382

=2.5350

From the regression equation the predicted values obtained. The predicted RA values are shown in table-10.

Table -10:predicted Ra values

SI.NO	Predicted Ra values
1	2.5350
2	2.3537
3	2.2465
4	2.4719
5	2.7013
6	2.8041
7	2.3515
8	2.836

CONLUSION:

From the comparison of the main effects of qualitek-4 and Minitab the effects and original Ra value and predicted Ra value is deviated below 5%. The experiment is said to be more accurate and efficient. Optimum condition for machining Mild steel material is shown in Table-11.

Table-11: Optimum conditions for Mild steel

Trial No	(Ton) μ-sec	Toff) μ-sec	(Ip) Amps	(Wt) Grams	(Wf) M/Min	(Fr) LPM	(Fp) Kg/cm²
1	125	40	11	1000	8	9	15

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