International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 08, August-2015

Optimization of Wire EDM Parameters of EN 24 Steel by Taguchi Method

Sheril Cyriac [1]
Department of Mechanical Engineering,
TKM College of Engineering,
Kollam, India

Prof. Sharos. H [2]
Department of Mechanical Engineering,
TKM College of Engineering,
Kollam, India

***Abstract*— The quality of wire EDM surface is strongly influenced by its process parameter settings and material to be machined. This work presents an experimental study and optimization of wire EDM on EN 24 steel. In the present research parametric analysis of wire EDM parameter is performed by Taguchi method on surface roughness (SR). The Design of experiments is carried out considering Taguchi technique with four input parameters, namely, pulse-on, pulse-off, current and speed. L16 orthogonal array is used to conduct experiments. ANOVA is used to find out the most significant parameter that affects the surface roughness. Optimizations of parameters are done by finding out the S/N ratios of each experiment runs. Regression Analysis is carried out to generate a mathematical model of surface roughness and to predict the value of surface roughness obtained from the optimal parameter settings.**

Keywords—Wire-EDM, Taguchi Method, Surface Roughness, EN24, Regression Analysis.

I. INTRODUCTION

Wire EDM is one of the most popular technique of the manufacturing process is modern manufacturing scenario. The wire EDM utilizes the wire which acts as a tool upon passing current so as to erode the work material by the generation of sparks between the work and tool. The work piece and tool are partially or completely immersed in a dielectric fluid in order to remove the material by erosion and avoid over heating of the material [1]. The gap between work piece and wire is usually ranges from 0.025-0.05 mm and is maintained constant by computer controlled positioning system. The process is mainly used in mould and die making, aerospace and automotive industries.

Higher productivity with minimum cost is motive of almost all the industries. With increasing demand for quality product as well as for higher productivity, wire EDM need to be performed more efficiently. Thus one of the most interesting and investigating areas is the modeling and optimization of process parameters to achieve a high quality product with the reduction of manufacturing cost. Out of all other performance measures Surface Roughness is the most significant one.

EN24 is used as a work piece. EN24 is a popular grade of alloy steels due to its excellent machinability. These alloys are widely used in aircrafts, heavy vehicle crankshafts, connecting rods, camshafts, propeller shafts. Clutches etc.

Table 1: Chemical Composition of EN 24 steel.

No	Metal	Range (%)
1	Carbon	0.36-0.44
2	Silicon	0.10-0.35
3	Manganese	0.45-0.75
4	Sulphur	0.040
5	Phosphorous	0.035
6	Chromium	1.00-1.40
7	Molybdenum	0.20-0.35
8	Nickel	1.30-1.70

II. DESIGN OF EXPERIMENTS

Taguchi's approach has been built on traditional concepts of Design of Experiments (DOE), such as full factorial, fractional factorial design and orthogonal arrays based on signal to noise ratio. DOE is a powerful technique introduced by R.A Fisher in England in 1920.

DOE is used to plan the experiments [2]. Since the present work is concentrated on the experimental work, it is very important to plan the experiments properly. In order to reduce total experimental runs orthogonal arrays were introduced in 1940s. The orthogonal array is a distillation mechanism by which the engineers can select the experimental process [1]. DOE is used to reduce the number of experiments needed to be performed than the full factorial experiments.

The total degree of freedom of an experiment is direct function of total number of trials. If the number of levels of a parameter increases, the degree of freedom of the parameter also increases because degree of freedom of a parameter is the number of levels minus one. Thus increasing number of levels for a parameter increases total degree of freedom in the experiment which in turn increases the total number of trials.

In the present work L16 orthogonal array is used. Thus means that sixteen experiments are to be carried out to study four variables with four levels. The number of experiments is reduced to sixteen.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

Based on machine tool and work piece capability the process parameters and the level for the process parameters were selected and listed in Table 2.

Table 2 : Machining parameters and their levels.

Parameter	unit	Level 1	Level 2	Level 3	Level 4
Pulse ON Time	µs	35	40	45	50
Pulse OFF time	µs	9	11	13	15
Current	A	2	3	4	5
Speed	mm/min	200	205	210	215

III. EXPERIMENTAL DETAILS

All the machining operations are conducted on concord wire EDM. Deionized water is used as dielectric fluid and brass is used as tool wire. The machine is shown in Figure 1.

Figure 1: Concord wire EDM machine.

The selected work piece sizes are 40×50×25 mm. Specimens of 4×4×25 mm are cut from the main work piece. Once the experiment is set up, the input parameters are set through the control panel. The program is written and simulation run executed on the controller. Each experiment is repeated twice and average value of the surface roughness is taken. Specimens cut from work piece are shown in Figure 2.

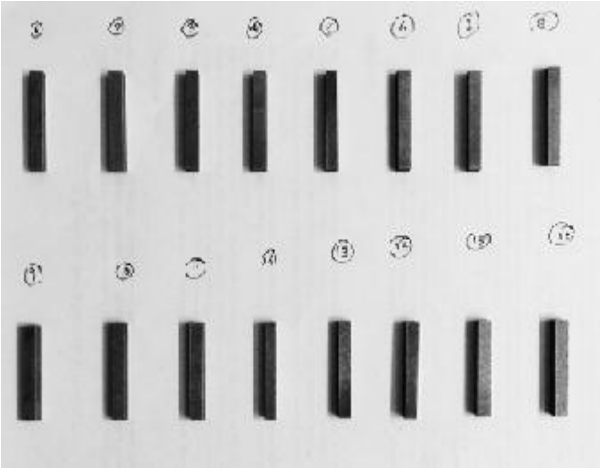

Figure 2: Specimens cut from the work piece.

Surface roughness is measured by using Mitutoyo surface roughness tester SJ-410 with wide range and high resolution which in Figure 3. There are many surface parameter used, in this work Ra value of the surface roughness is taken into account.

Figure 3: Mitutoyo surface tester SJ-410

Taguchi proposed to acquire the characteristic data by using orthogonal arrays, and to analyze the performance measures from the data to decide the optimal process parameters. The designed combination of input parameters and its corresponding surface roughness in the Table 3 below.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

Table 3: Taguchi's L16 orthogonal arrays.

No	P ON	P OFF	Current	Speed	Ra	S/N
1	35	9	2	200	4.549	-13.158
2	35	11	3	205	4.457	-12.980
3	35	13	4	210	4.840	-13.696
4	35	15	5	215	4.142	-12.344
5	40	9	3	210	4.191	-12.446
6	40	11	2	215	4.582	-13.221
7	40	13	5	200	4.303	-12.675
8	40	15	4	205	5.327	-14.529
9	45	9	4	215	5.224	-14.360
10	45	11	5	210	4.516	-13.095
11	45	13	2	205	4.471	-13.008
12	45	15	3	200	4.695	-13.432
13	50	9	5	205	4.733	-13.502
14	50	11	4	200	5.208	-14.333
15	50	13	3	215	4.904	-13.811
16	50	15	2	210	5.086	-14.127

IV. TAGUCHI'S OPTIMIZATION METHOD

Optimization of process parameters is the key step in the Taguchi method to achieve high quality without increasing cost. According to Taguchi method, the S/N ratio is the ratio of Signal to Noise where signal represents the desirable value and noise represents the undesirable value [3]. The response Ra shown in Table 3 is used to calculate the S/N ratio using the equation (1). The experimental results are now transformed into signal-to-noise ratio. Lower is Better characteristic is used for S/N ratio calculation because surface roughness is desired to be at minimum. The optimal setting would be the one which could achieve lowest S/N ratio [4]. The values of calculated S/N ratio are shown in Table 3.

$$S/N = -10\times\log (1/n\ \Sigma\ y^2) \qquad (1)$$

Where y-output characteristic (Ra) and n- no of trials.

The mean value of S/N ratio for surface roughness is tabulated for four levels and it is shown in Table 4.

Table 4: Response table for S/N ratio

Control factor	Mean S/N ratio by factor level				delta	Rank
	L- 1	L- 2	L -3	L -4		
P ON	-13.04	-13.21	-13.47	-13.94	.898	2
P OFF	-13.36	-13.40	-13.29	-13.60	.310	3
Current	-13.37	-13.16	-14.22	-12.92	1.30	1
Speed	-13.39	-13.50	-13.34	-13.43	.105	4

It can be seen from the Figure 4 that the surface roughness for EN 24 reaches its minimum at greater values of S/N ratios. A greater S/N ratio corresponds to better performance. Therefore optimal level is the greatest S/N value level. The optimal machining performance for surface roughness was obtained as 35µs pulse-on time (Level 1), 13µs pulse-off time (Level 3), 5A current (Level 4) and 210 mm/min speed (Level 3).

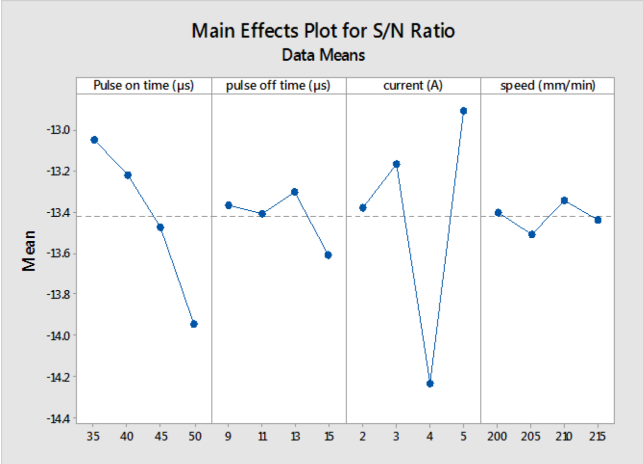

Figure 4: Factor effect on S/N ratio for surface roughness.

In the Table 4 given above the parameters are ranked according to the influence that parameter cause to the variation in the surface roughness. Those parameter has highest delta value is ranked one and so on. Thus from the selected parameters used in present work, current is the most influencing and significant parameter which affect the surface roughness and speed has the least affect.

V. STATISTICAL ANALYSIS

Statistical analysis used in this work is Analysis Of Variance (ANOVA). ANOVA was used to establish statistically significant machining parameters and percent contribution of these parameters on the surface roughness. ANOVA is a statistical tool used in several ways to develop and confirm explanations for the observed data. Analysis of Variance for surface roughness is shown in Table 5.

Table 5: Result of ANOVA for surface roughness.

Source	DOF	S.S	M.S	F	%C
P ON	3	1.8336	0.6112	0.2037	30.7995
P OF	3	0.2138	0.0712	0.0237	3.5916
Current	3	3.8498	1.2832	0.4277	64.6660
Speed	3	0.0561	0.0187	6.23×10^{-3}	0.9431
Error	3				

From the results obtained from ANOVA Table 5 above shows the percent contribution of machining parameters on surface roughness. Current id found to be the major factor affecting the surface roughness that is 64.66%. The percent contribution of pulse-on time, pulse-off time and speed on the surface roughness are 30.7995, 3.5916 and 0.9431 respectively.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

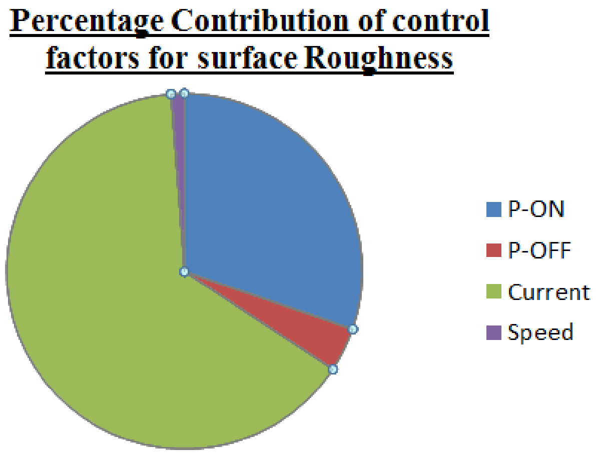

Figure 5: Percent contribution of Control factors for SR

VI. REGRESSION ANALYSIS

Regression Analysis is a statistical process for estimating the relationships among the variables. Regression is a simple technique for investigating functional relationship between output and input parameters. Regression analysis estimates the conditional expectation of the output parameters when input variables are fixed. A mathematical model is generated using regression analysis for surface roughness using the experimental results. The generated mathematical model represents the entire that has been done in this work. Regression analysis was done in the software Minitab 17. The obtained regression equation is given below

Surface roughness= 3.27+0.0317(P ON) +0.0177(P OFF) -0.0158(current) – 0.003(speed).

Predicted value of Surface roughness Using optimal Values = 3.27+0.031(35) +0.0177(13) -0.0158(5)-0.0003(210) = 4.4431µm

VII. CONFIRMATION EXPERIMENT

The confirmation experiment is performed by conducting a test using a specific combination of the factors and levels previously evaluated. That is based on the optimum experimental conditions i.e. P-ON 35µs, P-OFF 13µs, current- 5A and speed 210 mm/min the confirmation experiment is conducted for low surface roughness value and that is achieved as 4.405 µm. Obtained value of surface roughness through confirmation experiment justifies the predicted surface roughness.

VIII. CONCLUSION

This work in focused on the process parameter optimization of EN24 steel by Taguchi method. This paper presented an optimal combination of parameters for surface roughness. The Parameters considered are pulse-on time, pulse-off time, current and speed. The experiment was designed using design of experiments and experiments are done. Based on Taguchi optimization method the optimum input parameter combination achieved for minimum surface roughness are pulse-on time 35µs, pulse-off time 13µs, current 5A and speed 210 mm/min. the effect of various parameters on surface roughness are studied. Analysis of Variance resulted that current has major influence on the surface roughness and speed has least influence. A mathematical model was generated using regression analysis in order to predict the surface roughness value. Confirmation test was conducted using the optimal set of parameters and the obtained value of surface roughness justifies the predicted surface roughness value. Thus it is capable to determine optimum parameter combinations.

REFERENCES

[1] C.Bhaskar Reddy, V. Diwakar Reddy, C. Eswara reddy," Experimental investigations on MRR and surface roughness oh EN 19& SS 420steels in wire EDM using taguchi method", International Journal of Engineering Science and Technology,Volume 4, 2012, Pages,4603-4614.

[2] Gadakh. V.S," Parametric optimization of wire electrical discharge machining using topsis method", Advances in Production Engineering and Management, Volume 7, Page 157.

[3] M. Durairaj, D. Sudharsun, N.Swamynathan," Analysis of process parameters in wire EDM with stainless stell using single objective taguchi method and multi ogjective grey relational grade", Procedia Engineering, Volume 64, 2013, Pages 868-877.

[4] Saurav Datta, Siba Sankar Mahapatra," Simulation and parametric optimization of wire EDM process usingresponse surface methodology coupled with grey-taguchi method",International Journal of Engineering Science &Technology, Volume 2(5), Page 162.

[5] K.Kanlayasiri,S.Boonmung,"An investigation on effects of wire EDM machining parameters on surface roughness of newly developed DC53 die steel",Journal of Material Processing Technology, Volume187, 2007,Pages26-29.

[6] PujariSrinivasaRao, KoonaRamji, BeelaSatyanarayana, " Experimental investigation and optimization of wire EDM parameters for surface roughness, MRR and white layer in machining of aluminium alloy",International Conference on Advances in Manufactuirng and Materials.

[7] Brajesh Kumar Lodhi, Sanjay Agarwal," Optimization of machining parameters in wire EDM of AISI D3 steel using taguchi technique", 6th CIRP International Conference on High Performance Cutting, 2014,Pages 194-199.

[8] Shivkant Tilekar, Sankha Shuvra Das, P.K. Patowari, " Process parameter optimization of wire EDM on aluminium and mild steel by using taguchi method", International Conference on Advances in Manufacturing and Material Engineering AMME 2014.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)