Optimisation of Process Parameters in Wedm for Stainless Steel 316 by using Taguchi Method

[1] R. Ramesh Babu,
Professor - Department of Mechanical Engineering,
VSB College of Engineering Technical Campus,
Coimbatore.

S. Subhair
B.E Mechanical Engineering,
VSB College of Engineering Technical Campus,
Coimbatore.

[3] S. Siva
B.E Mechanical Engineering,
VSB College of Engineering Eechnical Campus,
Coimbatore.

***Abstract* - This paper makes over a suitable approach to optimize process parameters for Wire electrical discharge machining (WEDM) for Steel 316 using Taguchi method. Material Removal Rate and Surface Roughness are of vital to the resolution of a crisis in the field of machining processes. The ultimate strategy of optimization is to attain the maximum Material Removal Rate (MRR) and minimum Surface Roughness (SR) simultaneously and distinctly. The Design of Experiments (DOE) is done in Taguchi's L9 Orthogonal Array (OA). Three input process parameters of WEDM namely Pulse on (T-ON), Pulse off (T-OFF), Current (I) were chosen as versatile to study the process performance in terms of MRR and SR. The phenomenon of each control factor on the performance measure is studied uniquely using the plots of signal to noise ratio. The work establishes that the WEDM process parameters can be rectified so as to accomplish better metal removal rate, surface finish.**

Keywords: WEDM, DOE, Orthogonal array, Steel 316, MRR, SR, Taguchi method.

1. INTRODUCTION

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. WEDM process with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process, alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, accurate, corrosion and wear resistant surface.

WEDM is considered as a unique adoption of the conventional EDM process, which uses an electrode to initialize the sparking process. However, WEDM utilizes a continuously travelling wire electrode made of thin copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. The wire is kept in tension using a mechanical tensioning device reducing the tendency of producing inaccurate parts. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. The working principle is shown in the figure 1.

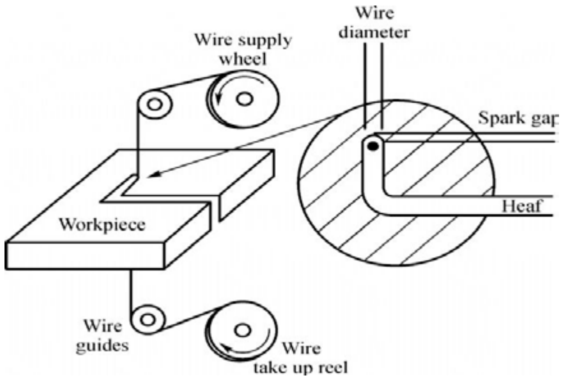

Fig 1: Working Principle of WEDM

In this paper, narration of unique process parameters and their respective responses have been presented. Now days, WEDM is an important unconventional process for producing complex and intricate shapes of components in areas such as tool and die making industries, automobile, aerospace, nuclear, computer, and electronics industries. Finally, the recommendations and future trends in WEDM research have been outlined.

2. LITERATURE REVIEW

For determining the better parametric settings, lot of work has been done in the engineering design. The WEDM processes are having several performance characteristics like Metal Removal Rate, Surface roughness, Kerf width; Dimensional error etc. The optimal parametric settings with respect to different performance characteristics are different. Some of the research contributions to cite are [1]. Neeraj Sharma et.al.,(2003) described about the optimization of process parameter during the machining of WEDM is a spark erosion non-conventional machining method to cut hard and conductive material with help of wire electrode. This deals with the Surface roughness and Metal removal rate of the material is described. [2] P. Raju et.al.,(2014)demonstrates the optimization of process parameter for Surface Roughness of the 316L material by using ANOVA table. This type is used to investigate the SR of the 316L material. [3] S. Sivakiran et.al.,(2012)deals about the effect of process parameters on MRR in wire electrical discharge machining of En31 Steel. The relationship between control parameters and output

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parameter (MRR) is developed by means linear regression.[4] Frederik Vogeler et.al.,(2016)explain about the Technical ceramics have numerous applications in the industrial and biomedical field because of material properties such as: high hardness, high Young's modulus, chemical resistance and dimensional stability. This helps to find the strength of ceramic material in wire EDM.[5] M.Durairaj et.al.,(2013) enumerates the experiments for finding the effects of process parameters in Wire EDM with Stainless steel using single objective Taguchi method and Multi objective Grey Relational Grade. This paper summarizes the grey relational theory and taguchi optimization technique, in order to optimize the cutting parameters in wire EDM for SS304.[6] K. Kumar et.al.,(2013) establishes the modeling and optimization of wire EDM process by using the Taguchi's L-27 orthogonal array. In this paper work, predicted data have been utilized for identification of the parametric influence in the form of graphical representation for showing influence of the parameters on selected responses.[7]Jaganathan P.et.al.,(2012)This paper enumerates the experiments based on machining parameters optimization of WEDM process using Taguchi method. 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 Ra as the objective, which is done by taguchi method.

3. EXPERIMENTATION

3.1 Selection of Orthogonal Array

The experimentation was done based on the Taguchi Method. Genichi Taguchi a Japanese scientist exhibited a practical method based on Orthogonal Array of conducting a controlled test. This technique has been vastly used in distinct fields of engineering experimental works. Orthogonal arrays were introduced in the 1940s and have been widely used in designing experiments. It is used to render the number of experiments needed to be performed than the full factorial experiment. This technique has been broadly used in variant fields of engineering to optimize the process parameters. The command factors considered for the study are Pulse-on, Pulse-off, and Current. Three levels for each command factor will be used. Based on number of command factors and their levels, L9 orthogonal array (OA) was selected. Represents various levels of command factors and table-2 represents experimental plans with assigned values

Input factors for conducting experiments are:

1. Pulse-on time
2. Pulse-off time
3. Current.

Responses measured:

1. Material Removal Rate
2. SURFACE ROUGHNESS

Table-1: Levels of Process Parameters

SL No	Commend Factors	Units	Level I	Level II	Level III
1	Pulse ON(A)	Ms	1	5	10
2	Pulse OFF(B)	Ms	1	5	10
3	Voltage(C)	Volts	25	37.5	50

Table-2: Experimental Plan with Assigned Values

SL No	Pulse ON (A)	Pulse OFF (B)	Voltage (C)
1	1	1	25
2	1	5	37.5
3	1	10	50
4	5	1	37.5
5	5	5	50
6	5	10	25
7	10	1	50
8	10	5	25
9	10	10	37.5

3.2 Selection of Material

316 is an austenitic chromium nickel stainless steel containing molybdenum. This addition increases general corrosion resistance, improves resistance to pitting from chloride ion solutions, and provides increased strength at elevated temperatures. Properties are similar to those of Type 304 except that this alloy is somewhat stronger at elevated temperatures. Corrosion resistance is improved, particularly against sulfuric, hydrochloric, acetic, formic and tartaric acids; acid sulfates and alkaline chlorides. Type 316L is an extra-low carbon version of Type 316 that minimizes harmful carbide precipitation due to welding. Typical uses include exhaust manifolds, furnace parts, heat exchangers, jet engine parts, pharmaceutical and photographic equipment, valve and pump trim, chemical equipment, digesters, tanks, evaporators, pulp, paper and textile processing equipment, parts exposed to marine atmospheres and tubing. Type 316L is used extensively for weld elements where its immunity to carbide precipitation due to welding assures optimum corrosion resistance.

Table-3: Chemical Composition of STEEL 316

SL NO	COMPOSITION	PERCENTAGE
1	Fe	68.28
2	C	0.030
3	Si	0.427
4	Mn	0.978
5	P	0.023
6	Cr	16.31
7	Mo	2.657
8	Ni	10.56
9	Cu	0.300
10	Nb	0.041
11	Ti	0.004
12	V	0.078
13	Al	0.013
14	W	0.073
15	Sn	0.017
16	N	0.020
17	B	0.002
18	Ca	0.002
19	Co	0.175

3.3 Experimental Work

The experiments were carried out on a WEDM machine ELECTRONICA installed at ORIGIN AUTOMATIONS, Coimbatore. A Wire EDM system is comprised of four major components is Computerized Numerical Control (CNC), Power Supply, Mechanical Section, and Di-electric System. The specimen is prepared as a Square Blank of 12mm thickness, 140mm length made of Stainless steel 316 which is machined by WEDM as

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shown in fig 3.1.The experiment was conducted in “ELECTRONOICA” Wire Electrical Discharge Machine having an operating current of range, power supply of 23VAC, wire diameter 0.18-0.25mm; nine pieces of 5mm in diameter are machined on the work piece.

Figure 2: Wire Electrical Discharge Machining Setup

Figure 3: Stainless Steel 316

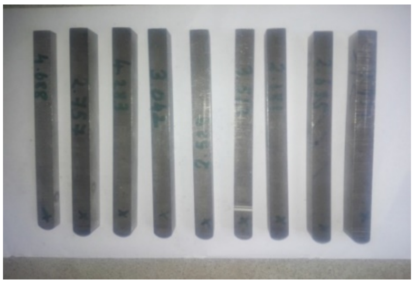

Figure 4: Material After Machining

The observations of the machining process are based on Second Order Central Composite Rotatable design using SS 316. Four in total machining parameters (Pulse on, Pulse off, Current) were chosen. The machining results after WEDM process are evaluated based on two machining performances MRR and SR. The observations of the WEDM process are shown in Table 4.

SL NO	A	B	C	MRR (gm./min)	SR (mμ)
1	1	1	1	0.036	2.739
2	1	2	2	0.0412	2.635
3	1	3	3	0.0434	2.171
4	2	1	2	0.0442	3.513
5	2	2	3	0.0538	2.529
6	2	3	1	0.06774	3.042
7	3	1	3	0.0442	4.283
8	3	2	1	0.0646	2.757
9	3	3	2	0.0712	4.688

Table No 4: Observations of WEDM Process Based on CCRD

Where,

A= pulse ON
B= Pulse OFF
C= Voltage

4. RESULTS AND DISCUSSION

The results acquired are dissected using S/N Ratios, Response table and Response Graphs with the help of Minitab software. Minitab is a computer program designed to perform basic and advanced statistical functions. It is a popular statistical resolution package for scientific applications, in particular for design and analysis of experiments.

Taguchi Analysis: MRR and SR versus Pulse on, Pulse off, Current is carried out on response graphs for means and S/N ratios are shown in figure-3, 4, 5 & 6.

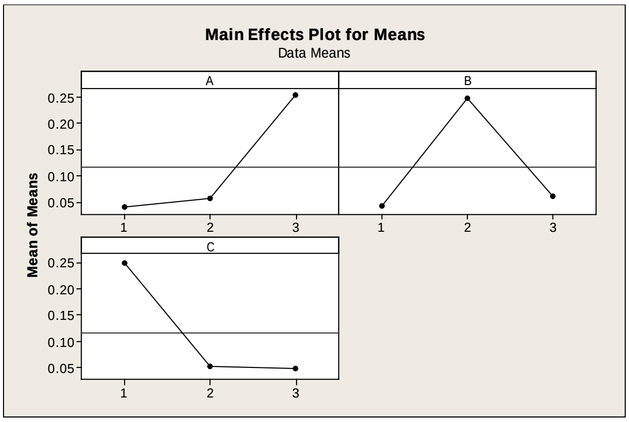

Figure 5:Effects of control factor on MRR (means)

LEVEL	A	B	C
1	0.04020	0.04147	0.24991
2	0.05525	0.24700	0.05220
3	0.23580	0.06078	0.04713
DELTA	0.21360	0.20553	0.20278
RANK	1	2	3

Table 5: Taguchi Analysis: MRR versus A, B,C

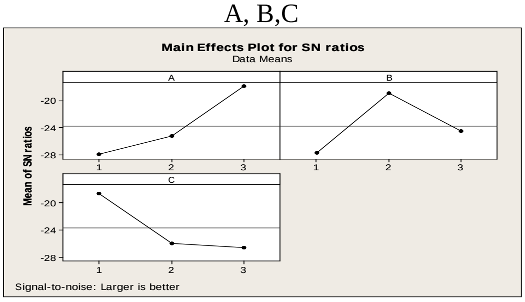

Figure 6:Effects of control factor on MRR

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Table 6: Responsible table for S/N ratio (MRR)

LEVEL	A	B	C
1	-27.94	-27.69	-18.68
2	-25.29	-18.96	-25.91
3	-17.95	-24.53	-26.58
DELTA	10.00	8.73	7.89
RANK	1	2	3

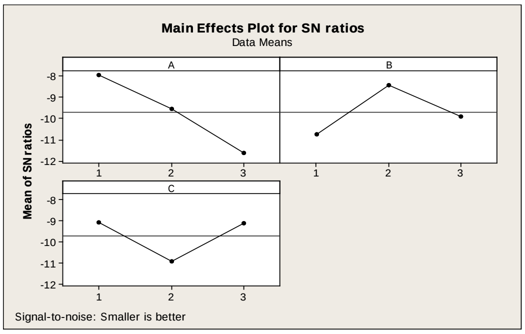

Figure 7:Effects of control factors on SR

LEVEL	A	B	C
1	-7.967	-10.767	-9.075
2	-9.545	-8.428	- 10.916
3	-11.621	-9.939	-9.142
DELTA	3.654	2.339	1.842
RANK	1	2	3

Table 7: Responsible table for S/N ratio (SR)

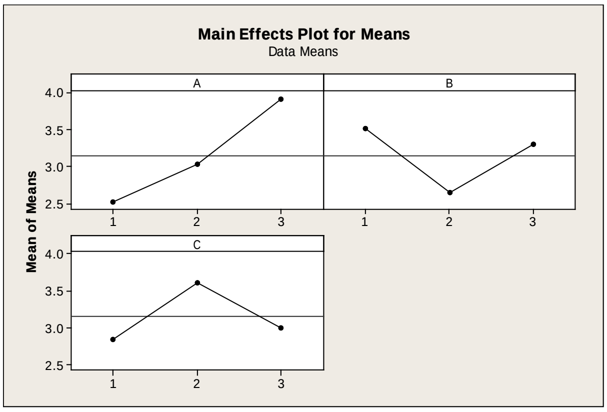

Figure 8:Effects of control factors on SR (mean)

LEVEL	A	B	C
1	2.515	3.512	2.846
2	3.028	2.640	3.612
3	3.909	3.300	2.994
DELTA	1.394	0.871	0.766
RANK	1	2	3

Table 8: Responsible table for means (SR)

In Taguchi Analysis the Material Removal Rate versus Pulse on, Pulse off and Current is carried out and mean proportion of each level is the parameter for unprepared data is given in Table 5 and average of each level in terms of S/N ratios are given in Table 6. Surface Rough versus Pulse on, Pulse off, Current is carried out and average of each level is the parameters for unprepared data is given in Table 7 and mean proportion of each level in terms of S/N is given in Table 8. After observing all response graphs, Table 9 shows the Optimal Parameters Combination for MRR and Ra.

Table-9: Optimum Conditions using Taguchi Method

S.NO	CONTROL FACTORS	MRR		SR	
		Best Level	Value	Best Level	Value
1	PULSE ON	3	10	1	1
2	PULSE OFF	2	5	2	5
3	VOLTAGE	1	25	1	25

5. CONCLUSION

The major conclusions drawn from the present investigation for machining of SS 316 is enlisted below:

- Based on the Taguchi's optimization method the optimized input parameter combinations to get the maximum MRR are pulse on 10 µs, pulse off 5 µs, voltage 25v and similarly optimized conditions to get minimum SR are pulse on 1 µs, pulse off 5 µs, voltage 25v.
- The objective such as MRR and SR are optimized using a Taguchi's L_9 Orthogonal Array (OA) has been validated using the experimental works.

6. FUTURE WORK

- ➢ The experimental work can be carried out using other design of experiments such as completely randomized design and Latin square design.
- ➢ The number of process parameters can be extended and hence, the data base can be improved by extensive experimentation.
- ➢ The experimental work can be extended to other machining operations.
- ➢ In future, the other optimization techniques such as genetic algorithm, adaptive neuro fuzzy inference system, particle swarm optimization may be used for Stainless steel 316 to optimize the process parameters of WEDM.

REFERENCES

[1] Neeraj Sharma, Rajesh Khanna, Rahuldev Guptha(2013), 'Design And Manufacturing multi quality characteristics of WEDM process parameters with RSM', Procedia Engineering 64 (2013) 710 – 719

[2] S. Sivakiran, C. Bhaskar Reddy & C. Eswara reddy(2012), 'Effect of Process Parameters on MRR in Wire Electrical Discharge Machining of En31', Procedia Engineering vol. 2, issue 6, pp. 1221-1226.

[3] P.Raju, MMM Sarcar, B.Sathyanarayana(2014), 'Optimization of WEDM Parameter for surface roughness on 316L Stainless steel Using Full Factorial Experimental Design', Procedia Materials Science 5 (2014) 1670 – 1676

[4] Frederik Vogeler, Bert Lauwrs, Eleonora Ferraris(2016), ' Analysis of Wire-EDM finishing cuts on large scale ZrO2-TiN hybrid spark plasma sintered blanks', Procedia CIRP 42 (2016) 268 – 273

[5] M. Durairaj, D. Sudharsan & N. Swamynathan(2013), 'Analysis of Process Parameters in Wire Electrical Discharge Machine with Stainless Steel using Objective Taguchi Method and Multi Objective Grey Relational Grade', procedia engineering pp. 868-877.`

[6] K. Kumar & R, Ravikumar(2013), 'Modelling and Optimization of Wire Electrical Discharge Machine Process', Procedia Engineering vol.3, issue. 3, pp. 1645-1648.

[7] Jaganathan P, Naveen Kumar T & Dr. R. Sivasubramanian(2012), 'Machining Parameters Optimization of Wire Electrical Discharge Machining Process using Taguchi Method', vol. 2, issue. 12.

[8] F.R.M Romlay & A. Mokhtar(2008), 'Machine Parameter Optimization for Wire-Electric Discharge Machine', vol. 8, issue. 4, pp. 139-144.