https://dx.doi.org/10.22161/ijaers.5.9.8 *ISSN: 2349-6495(P) | 2456-1908(O)*

Analysis of Process Parameters in Wire EDM on D2 Tool Steel using Taguchi Method

Murahari M.[1], Dileeplal J.[2]

[1]PG Scholar, Department of Mechanical Engineering, College of Engineering and Management Punnapra, Alappuzha, Kerala, India

[1]Email: murahariin@gmail.com

[2]Associate Professor, Department of Mechanical Engineering, College of Engineering and Management Punnapra, Alappuzha, Kerala, India

Abstract*—*Thispaper focuses on the effect of input parameters like pulse on time, pulse off time, servo voltage, and kerf width on the output characteristics of CNC wire EDM process such as material removal rate (MRR), surface roughness (SR), and kerf width (KW). The optimum process parameters and corresponding output responses are found out using Taguchi Method. In this research, High carbon high chromium D2 tool steel is used as the work piece with 0.25mm brass wire as tool.

Keywords*—*WEDM, MRR, SR, KW, S/N Ratio.

I. INTRODUCTION

Achieving high accuracy and tighter tolerances during machining of materials is essential for many industries. Wire electric discharge machining (WEDM) helps to produce parts in economical way than traditional manufacturing process. In WEDM the material removal is through, electro erosion machining process, in which electric spark is generated between tool and work piece, flushed with de-ionised water. The material removal takes place due to repeated electric discharges between work piece and wire connected in an electrical circuit.

The literatures related with experiments focussing on characteristic features of WEDM, it is found that parameters like pulse on time, pulse off time, voltage and wire feed have significant role in determining the performance characteristics like material removal rate, surface roughness and kerf width. *Kumar and Agarwal* performed the experiments based on Taguchi`s parameter design, which were carried out to study the effect of various input parameters on the material removal rate and surface finish. *Duraraj et al.* performed the experiments to find out the effect of process parameters on surface roughness and kerf width .*Lia et al.* performed conducted experiments on WEDM to investigate the surface integrity of INCONEL 718 with respect to varying energy. *Rozenek et al.* studied the effect on surface roughness and machining feed rate during WEDM of metal matrix. *Meena et al.* carried out an experimental study to find out the effect of wire feed rate and wire tension on surface roughness during machining of Ti-10V-2Fe-3Al.*Liao et al.* conducted an experimental study with the implementation of the pulse generating circuit and capacitance on the surface roughness. *Manna et al.* investigated the effect of various machining performance criteria such as MRR,SR,gap current, spark gap.

II. DESIGN OF EXPERIMENTS

According to the capability of machine tool, cutting tool and work piece, various process parameters and the levels for each parameters are selected and are listed in the Table 1.

Table.1: Machining Parameters and Levels

Sl. No.	Process Parameters	Level 1	Level 2	Level 3
1	Pulse On Time (μs)	115	120	125
2	Pulse Off Time (μs)	48	50	52
3	Servo Voltage(V)	20	25	27
4	Wire Feed (mm/min)	2	3	4

The designed combination of input parameters based on L9 orthogonal array are shown in Table 2and its corresponding material removal rate, surface roughness and kerf width are shown in the Table 3.

Table.2: Combination of Input Parameters

Sl. No.	Pulse On Time (μs)	Pulse Off Time (μs)	Servo Voltage (V)	Wire Feed (mm/min)
1	115	48	20	2
2	115	50	25	3
3	115	52	27	4
4	120	48	25	4
5	120	50	27	2
6	120	52	20	3

https://dx.doi.org/10.22161/ijaers.5.9.8 ISSN: 2349-6495(P) | 2456-1908(O)

7	125	48	27	3
8	125	50	20	4
9	125	52	25	2

Table.3: Experimental Results

Sl. No.	MRR	SR	KW
1	0.43	3.7	0.36
	0.476	3.762	0.4
	0.44	3.731	0.38
2	0.85	2.294	0.23
	0.9	2.256	0.21
	0.89	2.283	0.2
3	0.161	1.871	0.17
	0.14	1.91	0.15
	0.156	1.892	0.17
4	0.36	3.462	0.16
	0.340	3.491	0.17
	0.375	3.483	0.14
5	1.172	2.81	0.4
	0.911	2.781	0.41
	1.166	2.798	0.44
6	0.259	3.016	0.43
	0.17	3.126	0.46
	0.2	3.032	0.45
7	1.38	3.418	0.51
	1.52	3.571	0.48
	1.4	3.502	0.5
8	0.185	2.812	0.76
	0.152	2.921	0.71
	0.166	2.845	0.78
9	1.15	2.754	0.35
	1.12	2.718	0.39
	1.136	2.748	0.37

III. ANALYSIS OF PROCESS PARAMETERS

Process parameters are optimized to obtain high quality maintaining cost economy via Taguchi technique. The optimum combinations are obtained from the S/N ratios. According to Taguchi method, the S/N ratio is the ratio of signal to noise, where signal represents the desired value and noise represents the undesired value. The output responses are used to calculate the S/N ratios given in Table 4.

Table.4: S/N Ratios for MRR, SR and KW

Sl. No.	MRR	SR	KW
1	-6.98598	-11.4375	8.396315
2	-1.11836	-7.15002	13.40401
3	-16.3877	-5.53414	15.72406
4	-8.93534	-10.8283	16.07303
5	0.508556	-8.93186	7.597004
6	-13.9509	-9.70984	6.996944
7	3.103569	-10.8753	6.075962
8	-15.5947	-9.1264	2.492089
9	1.101711	-8.75515	8.627514

Since material removal rate is desired to be at maximum, larger the better characteristic is used, meanwhile for getting lower surface roughness &kerf width, lower the better characteristic is used for calculating S/N ratio.

The mean values of S/N ratio for MRR are shown in the Table 5 (larger the better for MRR).

Table.5: Mean of S/N Ratio for MRR

Process Parameters	Level 1	Level 2	Level 3	Delta Value
Pulse On Time	-8.164	-7.459	-3.796	4.368
Pulse Off Time	-4.273	-5.402	-9.746	5.473
Servo Voltage	-12.177	-2.984	-4.259	9.193
Wire Feed	-1.792	-3.989	-13.639	11.847

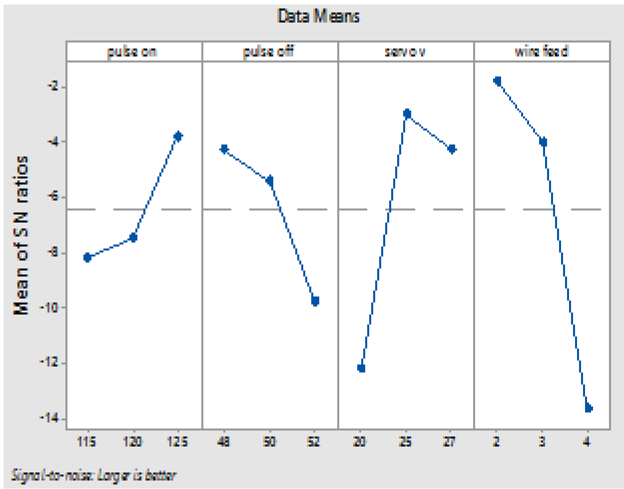

Fig. 1: Main Effects Plot for S/N Ratio of MRR

The delta value is the variation of mean S/N ratio from first level to the third level, and thus shows how on each parameter affect the particular response.It can be seen that wire feed has the highest delta value and hence wire feed has the highest influence on MRR.From the main effects plot of MRR (Fig. 1) it is clear that the optimum process parameters for getting the optimum MRR is Pon = 125μs, P off = 48, μs V = 25V, wire feed = 2mm/min. The regression equation for MRR is found as follows;

$$MRR = -2.46 + 0.04185 \text{ pulse on} - 0.0619 \text{ pulse off} + 0.0907 \text{ servo v} - 0.3314 \text{ wire feed} \quad (1)$$

The mean S/N ratio values for surface roughness are shown in Table 6 (smaller the better for SR).Here pulse off time has the highest delta value and hence influence the surface roughness the most.From the main effects plot of SR (Fig. 2), the optimum process parameters are found to be pulse on time = 120µs, pulse off time = 48µs, servo voltage = 20v, wire feed = 2mm/min. The regression equation for SR is found as follows;

SR = 12.94 + 0.0399 pulse on - 0.2515 pulse off - 0.0711 servo v - 0.1731 wire feed (2)

Table.6: Mean S/N Ratios for SR

Process Parameters	Level 1	Level 2	Level 3	Delta Value
Pulse On Time	-8.041	-9.823	-9.586	1.783
Pulse Off Time	-11.047	-8.403	-8.000	3.047
Servo Voltage	-10.091	-8.911	-8.447	1.644
Wire Feed	-9.708	-9.245	-8.496	1.212

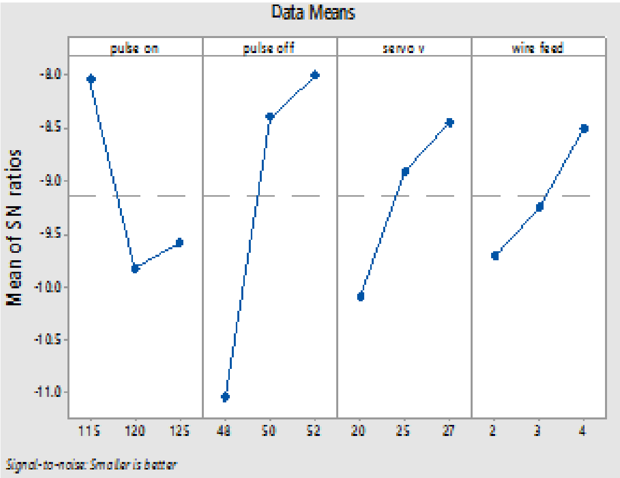

Fig. 2: Main Effects Plot for S/N Ratio of SR

The mean S/N ratio values for KWare shown in Table 7 (smaller the better for KW).Here pulse on time has the highest delta value and hence influence the surface roughness the mostly. From the main effects plot of Kerf Width (Fig. 3) the optimum process parameters for kerf width are found to be, pulse on = 125µs, pulse off = 50µs, servo voltage = 20V, wire feed = 2 mm/min. The regression equation for KW is found as follows;

KW = -2.073 + 0.02867 pulse on - 0.0044 pulse off - 0.02996 servo v- 0.0161 wire feed(3)

Table 7: Mean S/N Ratios for KW

Process Parameters	Level 1	Level 2	Level 3	Delta Value
Pulse On Time	12.508	10.222	5.732	6.776
Pulse Off Time	10.182	7.831	10.450	2.618
Servo Voltage	5.962	12.702	9.799	6.740
Wire Feed	8.207	8.826	11.430	3.223

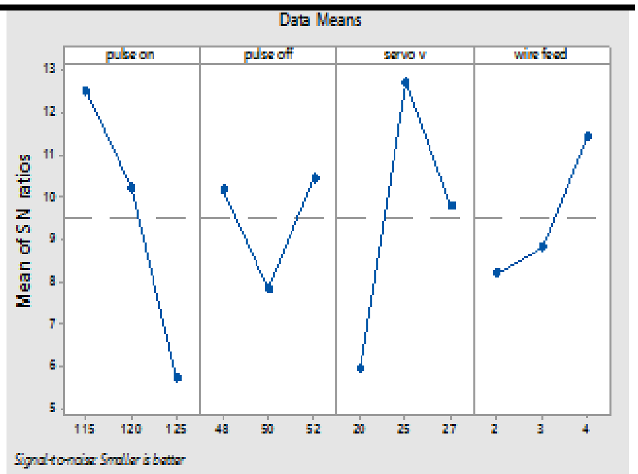

Fig. 3: Main Effects Plot for S/N Ratio of KW

The results obtained from Taguchi optimization technique to get the best MRR, minimum surface roughness and minimum kerf width are shown in the Table 8.

Table 8: Optimum Combination of Process Parameters

Process Parameters	MRR	SR	KW
Pulse On Time(µs)	125	120	125
Pulse Off Time(µs)	48	48	50
Servo Voltage (V)	25	20	20
Wire Feed (mm/min)	2	2	2

The optimum output responses are found using regression analysis as shown in Table 9.

Table.9: Optimum Output Responses

Sl. No.	Output Responses	Optimum Value
1	Material Removal Rate (gm/min)	1.42975
2	Surface Roughness (µm)	3.8878
3	Kerf Width (mm)	0.65935

IV. CONCLUSIONS

Experimental investigation of D2 tool steel has been done on wire EDM and the following conclusions were made;

- It was found thatmaterial removal rate was most influenced by wire feed, surface roughness by pulse off time and kerf width by pulse on time.
- The optimum combination of process parameters for material removal rate, surface roughness and kerf width were found.
- The optimum output responses were also found using regression analysis.

https://dx.doi.org/10.22161/ijaers.5.9.8 ISSN: 2349-6495(P) | 2456-1908(O)

REFERENCES

[1] Durairaj M., Sudharsun D. and Swamynathan N. (2013). Analysis of process parameters in wire EDM with stainless steel using single objective Taguchi method and multi objective grey relational grade, Procedia Engineering, 64, 868-877.

[2] Kumar K. and Agarwal S. (2011).Multi – objective parametric optimization on machining with wire electric discharge machining, International journal of Advanced Manufacturing Technology, 62, 617-633.

[3] Lia L, Guob Y. B., Weia X. T. and Lib W. (2013).Surface integrity characteristics in wire-EDM of Inconel 718 at different discharge energy, Procedia, CIRP 6, 220-225.

[4] Liao Y. S., Huang J. T., Chen Y. H. (2004). A study to achieve a fine surface finish in wire EDM, Journal of Materials Processing Technology, 149, 165-171.

[5] Manna A., Bhattacharya B. (2006). Taguchi and gauss elimination method: a dual response approach for parametric optimization of CNC wire cut EDM of PRAISiC MMC, International Journal of Advanced Manufacturing Technology, 28, 67-75.

[6] Meena K. L., Manna A.,Banwait S. S., Jaswanti (2013).Effect of wire feed rate and wire tension during machining of PR-AL-Sic -MMC's by WEDM, European Journal of Engineering and Technology, 1(1).

[7] Rozenek M.,Kozak J.,Daibrowski L., Ebkowski K.. (2001).Electrical discharge machining characteristics of metal matrix composites, Journal of Materials Processing Technology, 109, 367-370.