Process Parameter Optimization of Wire EDM on Aluminium 2219 using Taguchi Method

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Abstract: ***This paper investigates the effect of various process parameters of wire* electric discharge machining (WEDM) *on surface roughness, material removal rate and kerf width with Aluminium 2219 alloy. Taguchi method is used to find out the optimal process parameters as well as the most significant parameters affecting the machine performance. The input parameters chose for optimization are pulse on time, pulse off time, wire feed and gap voltage.***

Keywords: WEDM, Taguchi Method, Parameter Optimization, SN Ratio

Nomenclature

T_{on}	Pulse on time (μs)
T_{off}	Pulse off time (μs)
W_f	Wire feed rate (mm/min)
V_g	Gap voltage (v)
MRR	Material removal rate (gm/min)
R_a	Surface roughness (μs)
K_w	Kerf width (mm)

1. Introduction

WEDM is regularly the most practical method for machining hard materials like tool steel, carbides and exotic alloys like inconel and hastaloy. It has the upside of not putting any cutting powers into the workpiece, so there's no contortion, making it conceivable to create thin segments. With the increasing demand for quality product as well as for higher productivity, WEDM need to be performed more efficiently. Therefore, one of the most investigating areas is the optimization of process parameter to achieve a high quality product with the reduction of manufacturing cost.
Durairaj et al. came with the result that pulse on time has significant effect on surface roughness and kerf width. According to Tilekar et al., surface roughness is influenced significantly by spark on time and wire feed rate and spark on time together has major effect on kerf width. Gaikwad and Jatti noted that work piece electrical conductivity, gap voltage and pulse on time plays major role in material removal rate. Niamat et al. suggested the effect of different di-electrics on material removal rate and electrode wear rate. According to Kumar et al., material removal rate is most affected by discharge current. It is noted that the input parameters like pulse on time, pulse off time and wire feed plays significant role in WEDM and material removal rate, surface roughness and kerf width plays major role in quality of the part machined. Hence this paper made an attempt to analyse the process parameters of WEDM on various output responses with Aluminium 2219 alloy.

2. Experimentation

The work material is acquired as a square piece of aluminium 2219 whose estimated measurements are 50 mm in cross section and of length 230 mm. The specimens are produced from this material of the size 20mm x 20mm x 10mm thickness. Experiments are done on Electronica Ultracut S1 Wire EDM Machine (Figure 1).

Figure 1: WEDM Machine

After the experimentation, the MRR, surface roughness and kerf width is calculated. L9 orthogonal array is used for the experimental design. Process parameters and their levels for the work are shown in the Table 1.

Table 1: Process Parameters and Levels

Parameters	Levels		
	1	2	3
Pulse On Time	105	110	115
Pulse Off Time	50	55	60
Wire Feed	4	6	8
Gap Voltage	10	15	20

The designed matrix of input parameters and the output parameters are shown in the Table 2.

Table 2: The Designed Matrix

S. No.	T_{on}	T_{off}	W_f	V_g	MRR	R_a	K_w
1	105	50	4	10	0.058	3.10	0.26
					0.052	3.28	0.30
					0.065	2.54	0.28
2	105	55	6	15	0.039	3.26	0.22
					0.034	3.16	0.26
					0.039	2.72	0.28
3	105	60	8	20	0.022	2.98	0.20
					0.025	3.10	0.19
					0.031	3.30	0.21
4	110	50	6	20	0.068	3.96	0.23
					0.067	3.58	0.18
					0.067	3.48	0.14
5	110	55	8	10	0.060	3.18	0.36
					0.066	2.96	0.32
					0.065	3.30	0.38
6	110	60	4	15	0.076	3.42	0.36
					0.068	3.78	0.41
					0.068	3.66	0.47
7	115	50	8	15	0.099	3.84	0.41
					0.117	3.76	0.39
					0.106	3.90	0.50
8	115	55	4	20	0.106	3.78	0.58
					0.106	4.54	0.53
					0.097	4.08	0.47
9	115	60	6	10	0.107	4.20	0.46
					0.107	4.72	0.51
					0.107	4.08	0.48

3. Results and Discussions

3.1 Effect of Input Parameter on MRR

It is found that the material removal rate is most influenced by pulse on time. Then, wire feed, gap voltage and pulse off time (Table 3). The optimized parameter settings for material removal rate are pulse on time 115µs, pulse off time 50µs, wire feed rate 4mm/min and gap voltage 10V (Figure 2).

Table 3: Effect on Material Removal Rate

Level	T_{on}	T_{off}	W_f	V_g
1	-28.45	-22.56	-22.54	-22.72
2	-23.48	-24.11	-23.82	-23.70
3	-19.54	-24.81	-25.12	-25.05
Delta	8.91	2.25	2.58	2.34
Rank	1	4	2	3

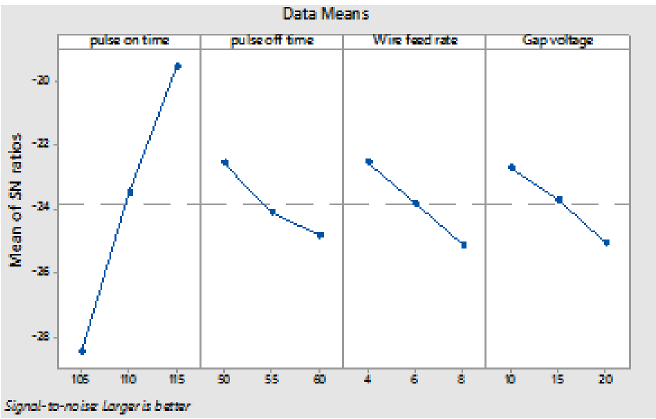

Figure 2: Mean Effects Plot of MRR

$$MRR = -0.5586 + 0.006522T_{on} - 0.000978\ T_{off} - 0.002917W_f - 0.001089V_g \qquad (1)$$

MRR for optimum input combinations is 0.119972 gm/min

3.2 Effect of Input Parameters on Surface Roughness

Surface roughness is affected mostly by pulse on time. Then wire feed, pulse off time and gap voltage (Table 4). The optimized parameter settings for surface roughness are pulse on time 115µs, pulse on time 60µs, wire feed 6mm/min and gap voltage 20V (Figure 3).

Table 4: Effect on Surface Roughness

Level	T_{on}	T_{off}	W_f	V_g
1	-9.708	-10.834	-11.015	-10.744
2	-10.821	-10.673	-11.257	-10.852
3	-12.259	-11.282	-10.516	-11.192
Delta	2.551	0.609	0.741	0.447
Rank	1	3	2	4

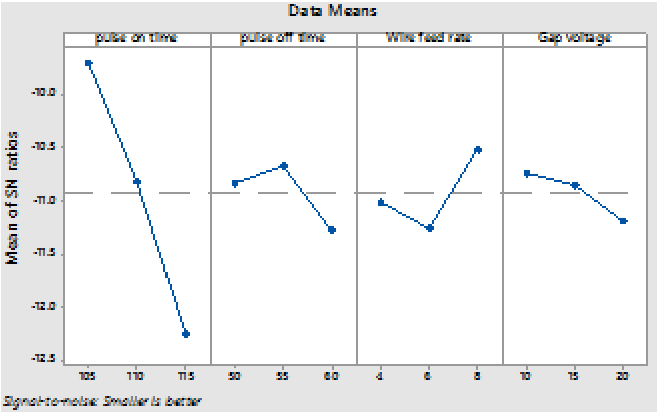

Figure 3: Mean Effects Plot of Surface Roughness

$$Surface\ Roughness = -9.05 + 0.1051T_{on} + 0.0200T_{off} - 0.0517W_f + 0.0160V_g \qquad (2)$$

Surface roughness for optimum input combinations is 4.2463 µm

3.3 Effect of Input Parameters on Kerf Width

Kerf width is mostly influenced by pulse on time. Then wire feed, gap voltage and pulse off time (Table 5). The optimized parameter settings are pulse on time 115µs, pulse off time 55 µs, wire feed 4mm/min and gap voltage 10V (Figure 4).

Table 5: Effect on Kerf Width

Level	T_{on}	T_{off}	W_f	V_g
1	12.300	10.939	8.068	8.788
2	10.400	8.812	10.918	8.906
3	6.352	9.301	10.066	11.358
Delta	5.948	2.127	2.851	2.570
Rank	1	4	2	3

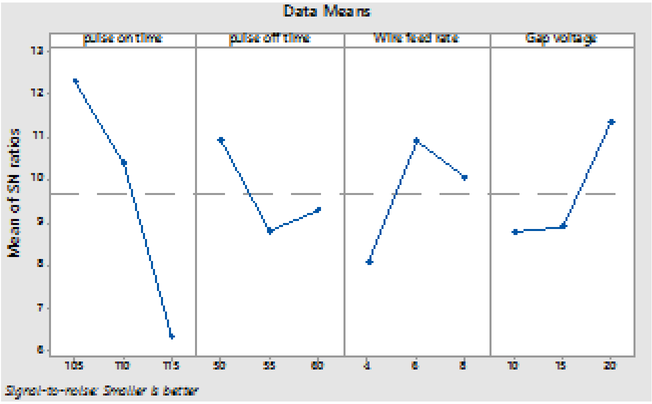

Figure 4: Mean Effects Plot of Kerf Width

Kerf width = $2.403+0.02367T_{on}+0.00667T_{off}-0.01944W_f-0.00689V_g$ (3)

Kerf width for optimum input combinations is 0.53924 mm

4. Conclusions

The conclusions made based on the experimental investigations of WEDM on Aluminum 2219 alloy are as follows;

- Pulse on time has the major effect on material removal rate, surface roughness and kerf width.
- Pulse off time and gap voltage has significantly less affected as compared to pulse on time and wire feed.
- The optimum combination for material removal rate, surface roughness and kerf width has also been identified.

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