International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 6, Number 6 (2013), pp. 835-840

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Optimization of Surface Roughness Process Parameters of Electrical Discharge Machining of EN-31 by Response Surface Methodology

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Abstract

Present work aimed to investigate the surface roughness process parameter optimization during WEDM process for steel. Response Surface Methodology (RSM) is use to investigate the effect of five independent input parameter namely gap voltage (Vg), Pulse on time (Ton), pulse off time (Toff), wire feed (Wf) and flush rate (Fr) over CLA value of surface roughness (Ra).A fractional factorial Design of Experiment of two level were employed to conducted the experiment on EN-31 die steel with chromium coated copper alloy wire electrode. The responses were observed by mathematical modelling using RSM on experimental data. The significance coefficients were observed by performing analysis of variance (ANOVA) at 95% confidence level. Second order RSM modelling technique is the best method to found the significance factor affecting the surface roughness by conducting only very less experimentation.

Keywords: WEDM, RSM, SR and ANOVA etc.

1. Introduction

Wire Electrical Discharge Machining is the metal removal process by means of repeated spark created between the wire electrode and work piece. Repeated electrical spark created by electric pulse generator at very short interval between an electrode tool & part to be machined by the influence of dielectric fluid. WEDM is used for the

machining to electrical conductive and hard materials only, which cannot be machined easily by conventional machining methods.

Manufacturing process may be chosen depending on the material characteristics

And type of response required to be evaluated. The present study aimed to evaluate the response i.e. surface roughness by influence of process parameter, Vg, Ton, Toff, Wf and Fr.

2. Experimentation:

2.1 Selection of Wire Electrode: A Zn coated cylindrical copper wire having 0.25mm in diameter were selected for machining operation of AISI-EN31 steel depending upon the work piece material characteristics.

2.2 Selection of Work piece: AISI-EN31 low carbon oil quenched tool material have been used for the machining it through WEDM. Work piece rod having 14mm in diameter 0.4m in length were use for cut it 3mm thickness of the disk. Application of this material used to prepare the hard metal alloy tools for wooden work equipments.

2.3 Composition of Work piece-

Element	**C**	**Mn**	**Si**	**P**	**S**	**Cr**	**Mo,Ni**	**HRC**
By Weight (%)	0.91-1.01	0.42	0.10-0.22	0.04	0.04	1.0-1.1	Nil	61

2.4 Experimental Setup: The experiment has carried out on wire Electrical Discharge Machine model ELECTRONICA-MAXICUTe-50zp,having the facilities to hold the work piece within the place provided by the help of conductive fixture, so that they can complete the circuit between electrode and workpiece.The spark is created depending upon gap voltage applied between the conductive work piece and electrode, also machining performance influence the major independent process parameter which selected for experiment as per the characteristics of screening test. Commercial grade of ionized water (Density= 832kg/m^3) was used as dielectric fluid with lateral flushing (Pressure= 0.35 kgf/cm^2) system for effective flushing of machine debris from working gap area.

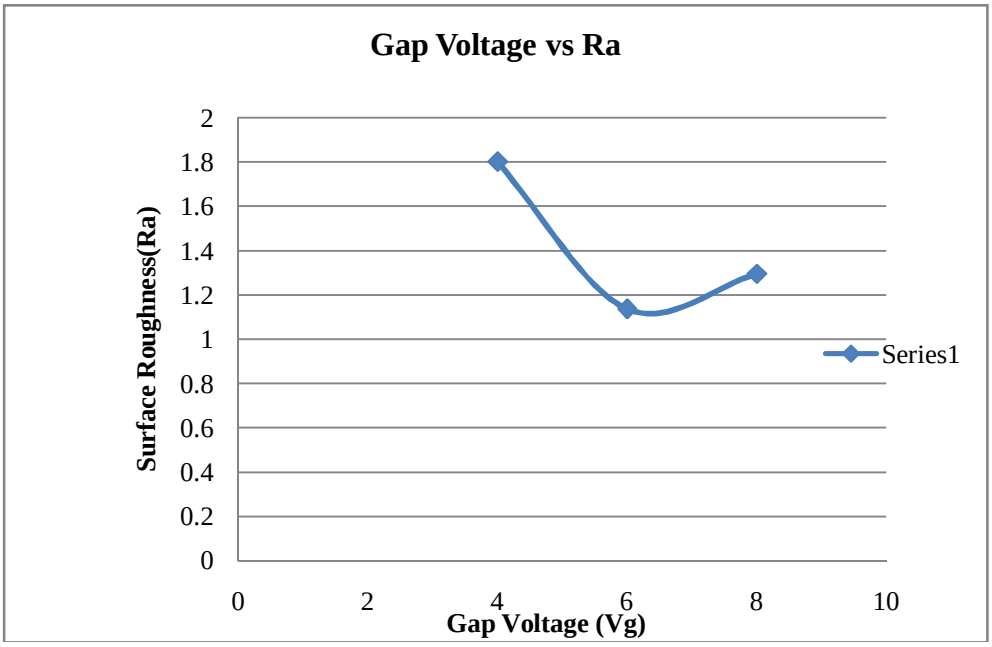
2.5 Selection of Process Parameters:

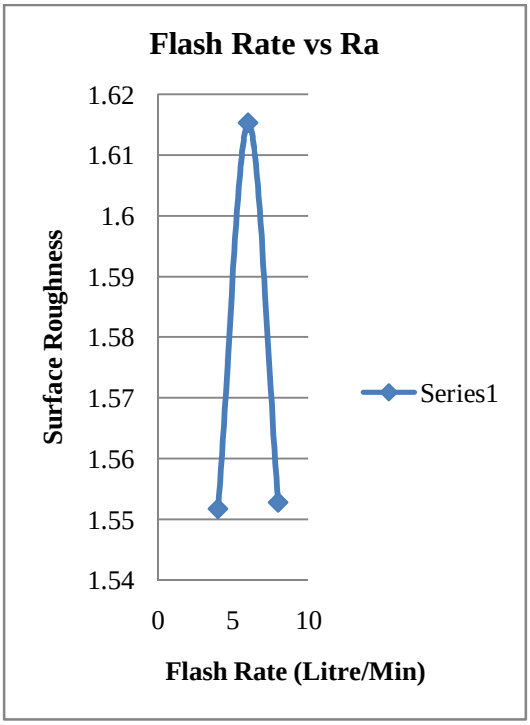
Factors/Three Level (Coding)	**-1**	**0**	**1**
Gap Voltage (Vg)	4	6	8
Flush Rate (Fr)	4	6	8
Pulse on Time(Ton)	3	5	7
Pulse of Time (Toff)	3	6	9
Wire Feed Rate (Wf)	3	6	8

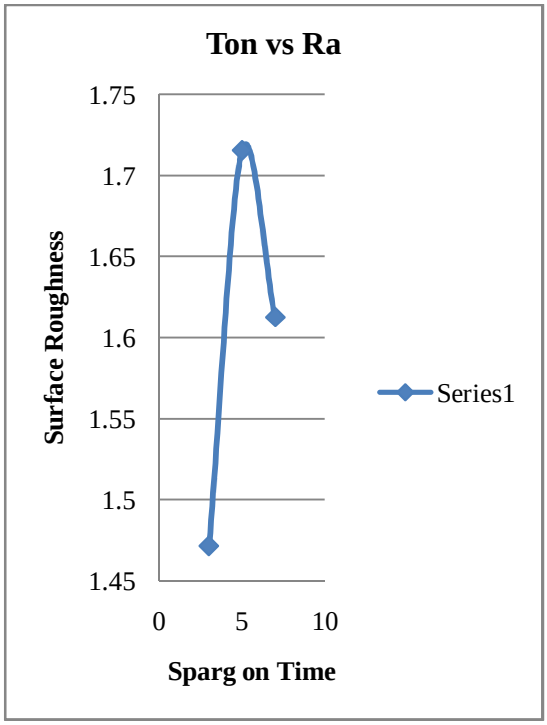
3.1 Experimental Observation for Surface Roughness on EN-31 during WEDM

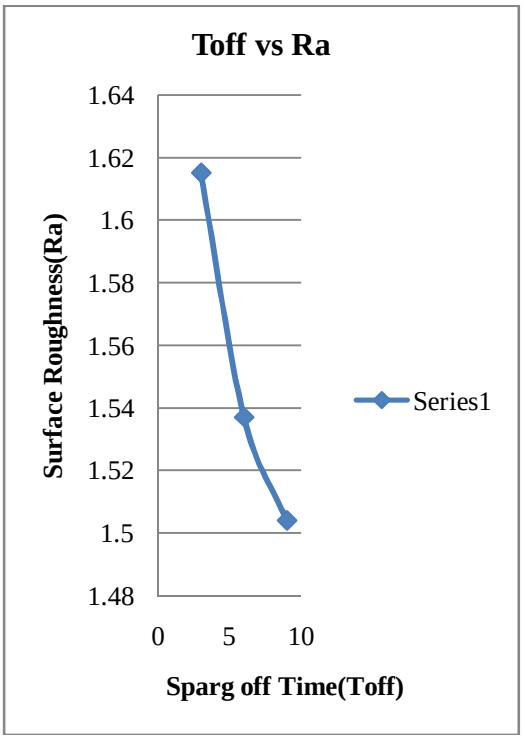
Run	Vg	Flash rate	Ton	T off	Wire feed	Ra (Average)
1	4	4	3	3	3	1.6122
2	4	4	3	6	3	1.7524
3	4	4	5	3	6	1.9982
4	4	4	5	6	6	1.735
5	4	6	3	3	6	1.6902
6	4	6	3	6	6	1.5694
7	4	6	5	3	3	2.135
8	4	6	5	6	3	1.9654
9	6	4	3	3	6	1.3274
10	6	4	3	6	6	1.2772
11	6	4	5	3	3	1.5292
12	6	4	5	6	3	1.2838
13	6	6	3	3	3	1.2308
14	6	6	3	6	3	1.2528
15	6	6	5	3	6	1.6174
16	6	6	5	6	6	1.4616
17	4	4	3	3	3	1.7528
18	4	4	3	9	3	1.6196
19	4	4	7	3	8	2.0554
20	4	4	7	9	8	1.7596
21	4	8	3	3	8	1.6418
22	4	8	3	9	8	1.5604
23	4	8	7	3	3	2.1122
24	4	8	7	9	3	1.8714
25	8	4	3	3	8	1.3296
26	8	4	3	9	8	1.3292
27	8	4	7	3	3	1.2424
28	8	4	7	9	3	1.2252
29	8	8	3	3	3	1.3278
30	8	8	3	9	3	1.2734
31	8	8	7	3	8	1.2408
32	8	8	7	9	8	1.395

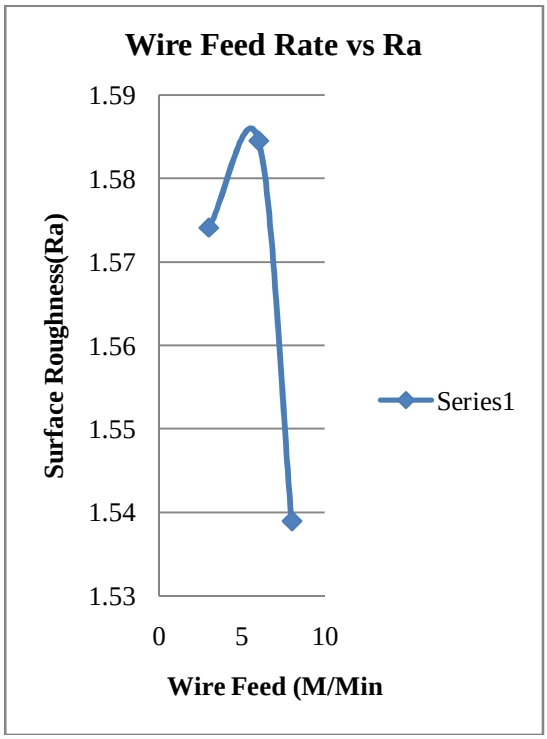
3.2 Experimental Result between process parameters vs Response











4. Response Optimization:

Response	Goel	Higher	Target
Surface Roughness (Ra)	Minimum	3	1.2252

Factors	Vg	Fr	Ton	Toff	Wf
High	4	6	5	3	6
Low	8	8	7	6	3
Optimum	6	4	3	9	8

5. Confermation Test and Their Comparison With Result

Trial No	Optimum Condition	Surface Roughness (Ra) micron Mitre				Error/Noise (Maximum)
		RSM 1st order		RSM 2nd Order		
		Experimental	Predicted	Experimental	Predicted	
1	Vg=6, Fr=4, Ton=3, Toff=9, Wf=8	1.2252	1.2565	1.2252	1.2373	1.21%

2	Vg=6, Fr=4, Ton=3, Toff=9, Wf=8	1.2745	1.2978	1.2745	1.2885	1.4%

6. Conclusion

Performance of WEDM largely depend not only upon the combination of material of workpiece and wire electrode but also the optimal combination of the independent control process parameter, which is given in the result table. Manufacturer can follow the optimal combination of parameter to achieve the most likely response during WEDM for EN-31.

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