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Mathematical Modeling and Process Parameters Optimization for Surface Roughness in Edm for En31 Material by Response Surface Methodology

KEYWORDS: electrical discharge machining; surface roughness; response surface methodology; MRR, ANOVA, Process parameters, etc

P.B.Wagh	Dr. R.R.Deshmukh	R.D.Gurav
Sr.lecturer in mechanical engineering department, T.P.C.T.COE, Osmanabad.	Professor in mechanical engineering department, J.N.E.C, Aurangabad.	lecturer in mechanical engineering department, T.P.C.T.COE, Osmanabad.

ABSTRACT *In this investigation, response surface methodology (RSM) is used to investigate the effect of four controllable input variables namely: discharge current, pulse duration, pulse off time and gape voltage on surface roughness (Ra). A face centred central composite design matrix is used to conduct the experiments on EN31 with copper electrode. The response is modelled using RSM on experimental data. The significant coefficients are obtained by performing analysis of variance (ANOVA) at 95% confidence level. It is found that discharge current and pulse duration are significant factors. RSM is a precision methodology that needs only 31 experiments to assess the conditions and is very effectual.*

1.INTRODUCTION

Electrical Discharge Machining (EDM) is an unconventional manufacturing process based on removal of material from a part by means of a series of repeated electrical sparks created by electric pulse generators at short intervals between an electrode tool and the part to be machined immersed in dielectric fluid. At present, EDM is a widespread technique used in industry for high precision machining of all types of conductive materials such as metallic alloys, metals, graphite, composite materials or some ceramic materials. The selection of optimized manufacturing conditions is one of the most important aspects to consider in the die sinking electrical discharge machining (EDM) of conductive steel, as these conditions are the ones that are to determine such important characteristics: surface roughness, electrodes wear (EW) and material removal rate (MRR). In this paper, a study will be perform on the influence of the factors of peak current, pulse on time, interval time and power supply voltage. Isothermal aging of material varies the EN-31 steel, which is mainly used gears, axels, drive shafts, induction hardening pins and high strength shafts. Design of experiments (DOE) technique to select the optimum machining conditions for machining.

2. Principal of EDM

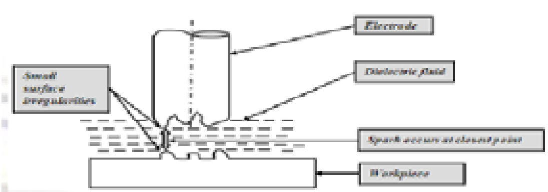

Figure 1: Working principle of EDM

The working principle of EDM is shown in Fig. 1. This technique has been developed in the late. The electrode moves toward the work piece reducing the spark gap so that the applied voltage is high enough to ionize the dielectric fluid. Short duration discharges are generated in a liquid dielectric gap, which separates electrode and work piece. The material is removed from tool and work piece with the erosive effect of the electrical discharges. The dielectric fluid serves the purpose to concentrate the discharge energy into a channel of very small cross sectional areas. It also cools the two electrodes, and flushes away the products of machining from the gap. The electrical resistance of the dielectric influences the discharge energy and the time of spark initiation. Early discharge occurs due to low resistance. If resistance is more, the capacitor will obtain higher charge value before initial discharge. A servo system is present to compares the gap voltage with a reference value and to ensure that the electrode moves at a proper rate to maintain the correct spark gap and also to retract the electrode if short circuiting occurs. When the measured average gap voltage is higher than that of the servo reference voltage, preset by the operator, the feed speed increases. On the contrary, the feed rate decreases or the electrode is retracted when the average gap voltage is lower than the reference voltage, which is the case for smaller gap widths resulting in a smaller ignition delay. Thus, short circuits occurred by eroded particles and humps of discharge a crater are avoided.

3. Experimental Setup

Figure 2 EDM machine

For this experiment the whole work is done by using Electric Discharge Machine, model ELECTRONICA- ELECTRAPULS PS 50ZNC (die-sinking type), having provision of programming in the Z-vertical axis and manually operated X and Y axes. The tool is made of cathode and the work piece as anode. Commercial grade EDM oil (specific gravity= 0.763 kg/m3), freezing point= 94°C) was used as dielectric fluid with lateral flushing (pressure of 0.3 kgf/cm2) system for effective flushing of machining debris from working gap region. The pulsed discharge current was applied in various steps in positive mode.

4. Selection of work piece

EN31 is used in components such as gears, shafts, studs and bolts. EN24T can be further surface-hardened to create components with enhanced wear resistance by induction or

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nitriding processing.

4.1 Composition of EN31 material

Element	Composition weight (%)
C	0.36-0.44
SI	0.10-0.35
MN	0.45-0.70
S	0.040 max
P	0.035 max
Cr	1.00-1.40
Mo	0.20-0.35
Ni	1.30-1.70

Table 1Composition of EN31 material

4.2 selection of tool electrode

A cylindrical shaped pure copper of diameter 12mm is used for machining of EN31 material.

4.3 selections of process parameters

Factor/level (coding)	-2	-1	0	1	2
Discharge current	2	6	10	14	18
Spark on time	20	40	60	80	100
Spark off time	2	4	6	8	10
Spark gap	0.05	0.0875	0.125	0.1625	0.2

Table 2 levels of process parameters

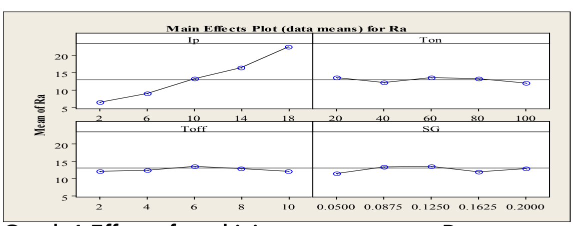
5. Design of experiment

Input variables: Discharge current (Ip); Spark on time (Ton); Spark off time (Toff); Spark gap (SG)

Response Variables: Surface Roughness (Ra)

Design of experiment was done by RSM.

5.1 Experimental results for surface roughness (Ra) for Material EN31



Graph 1 Effect of machining parameters on Ra

Run	Ip (A)	Ton (µs)	Toff (µs)	S.G (mm)	Machining time (sec)	density (gm/mm3)	Ra value (µm)
1	14	80	8	0.0875	5	0.0072	20.0
2	18	60	6	0.125	5	0.0072	22.5
3	14	40	8	0.0875	5	0.0072	15.4
4	14	80	4	0.1625	5	0.0072	16.0
5	10	60	6	0.125	5	0.0072	14.7
6	6	80	8	0.1625	5	0.0072	9.5
7	10	60	6	0.125	5	0.0072	13.8
8	6	40	4	0.1625	5	0.0072	8.2
9	10	60	6	0.125	5	0.0072	12.2
10	6	80	4	0.1625	5	0.0072	6.8
11	10	60	6	0.05	5	0.0072	11.5
12	10	20	6	0.125	5	0.0072	13.5
13	14	40	8	0.1625	5	0.0072	14.2
14	10	60	6	0.125	5	0.0072	14.0
15	10	60	6	0.125	5	0.0072	14.4
16	6	80	8	0.0875	5	0.0072	10.3
17	6	80	4	0.0875	5	0.0072	10.4
18	10	60	6	0.125	5	0.0072	15.1
19	6	40	4	0.0875	5	0.0072	9.2
20	10	100	6	0.125	5	0.0072	12.0
21	14	40	4	0.0875	5	0.0072	17.4
22	10	60	6	0.2	5	0.0072	13.0
23	14	80	4	0.0875	5	0.0072	15.9
24	10	60	6	0.125	5	0.0072	13.7
25	6	40	8	0.1625	5	0.0072	9.3
26	14	80	8	0.1625	5	0.0072	16.6
27	6	40	8	0.0875	5	0.0072	8.6
28	10	60	10	0.125	5	0.0072	12.2
29	14	40	4	0.1625	5	0.0072	15.3
30	2	60	6	0.125	5	0.0072	6.5
31	10	60	2	0.125	5	0.0072	12.1

Table 3 Experimental results for surface roughness (Ra) for Material EN31

5.2 Regression Analysis: The regression equation is Ra = 3.54 + 0.943 Ip + 0.0102 Ton + 0.102 Toff - 9.22 SG

Predicator	Coefficient	SE Coefficient	T	P
Constant	3.543	1.698	2.09	0.047
Ip	0.94271	0.07061	13.35	0.000
Ton	0.01021	0.01412	0.72	0.476
Toff	0.01021	0.01412	0.72	0.476
SG	-9.222	7.532	-1.22	0.232

S = 1.38375 R-Sq = 87.4% R-Sq(adj) = 85.5%

5.3 Analysis of Variance:

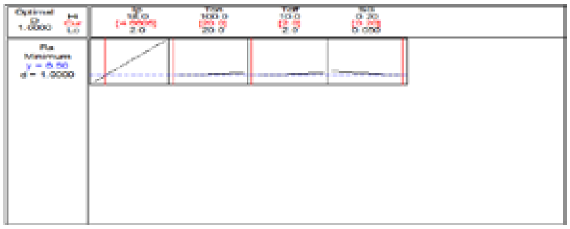
Source	DF	SS	MS	F	P
Regression	4	346.132	86.533	45.19	0.000
Residual error	26	49.784	1.915		
Total	30	395.915			

Source	DF	Seq. SS
Ip	1	341.260
Ton	1	1.0000
Toff	1	1.0000
SG	1	2.870

Table 4 Analysis of Variance

6. Response Optimization

Response	Goal	Target	Upper
Ra	Minimum	6.5	22.5



Graph 2 D- Optimality plot

From this graph we can predict the optimum values of process parameters

Process parameters	units	Optimum values
Discharge current (Ip)	A	4.6603
Spark on time (Ton)	µs	20
Spark off time (Toff)	µs	2
Spark gap (SG)	mm	0.2

Table 5 optimum values of process parameters

Confirmation test and their comparison with results

Trial No.	Optimum conditions	Ra (µm)		Error (%)
		Experimental	Predicted	
01	Ip=4.6603A, Ton =20µs, Toff = 2 µs, SG = 0.2mm	6.76	6.5	4.00
02	Ip=4.6603A, Ton =20µs, Toff = 2 µs, SG = 0.2mm	6.68	6.5	2.76

Table 6 Confirmation test and their comparison with results

7. conclusions

The choice of the electrical parameters of the EDM process depends largely on the material combination of the electrode and the work piece and the EDM manufactures only supply these parameters for a limited amount of material combinations.

The industrialist can directly use the optimum values so that Ra value will be minimum.

MINITAB software was used for DOE and analysis of the experimental result and the response was validated experimentally.

REFERENCE [1] Manish Vishwakarma, v.K.Khare, vishal Parashar, Response surface approach for optimization of Sinker Electric Discharge Machine process parameters on AISI 4140 alloy steel; International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com, Vol. 2, Issue 4, July-August 2012, pp.185-189. | [2] Md. Ashikur Rahman Khan, M.M. Rahman1, K. Kadirgama1, M.A. Maleque and M. Ishak PREDICTION OF SURFACE ROUGHNESS OF TI-6AL-4V IN ELECTRICAL DISCHARGE MACHINING: A REGRESSION MODEL Journal of Mechanical Engineering and Sciences (JMES) e-ISSN: 2231-8380; Volume 1, pp. 16-24, December 2011. | [3] M.K. Pradhan and C.K. Biswas, Effect of process parameters on surface roughness in | EDM of tool steel by response surface methodology; Int. J. Precision Technology, Vol. 2, No. 1, 2011 | [4] Mohan Kumar Pradhan and Chandan Kumar Biswas, Modelling of machining parameters for MRR in EDM using response surface methodology, Proceedings of NCMSTA'08 Conference National Conference on Mechanism Science and Technology: from Theory to Application November 13-14, 2008 National Institute of Technology, Hamirpur | [5] B. C. Routara, P. Sahoo, A. Bandyopadhyay, APPLICATION OF RESPONSE SURFACE METHOD FOR MODELLING OF STATISTICAL ROUGHNESS PARAMETERS ON ELECTRIC DISCHARGE MACHINING.