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Process parameter of WEDMoptimized by using Response Surface Methodology

ValaTushar S.1 Dr.Ashish V. Gohil2

[1]*Department of Mechanical Engineering,Ph.D Scholar, Rai University, Ahmedabad, India.*
[2]*Department of Production Engineering, Ph.D Supervisor, Shantilal Shah Engineeirng College, Bhavnagar, India.*

ABSTRACT - *A little research has been conducted to obtain the optimal levels of machining parameters that yield the best machining quality in machining of difficult to machine materials like hot die steel H-11. The hot die steel H-11 is extensively used for hot-work forging, extrusion, manufacturing punching tools, mandrels, mechanical press forging die, plastic mould and die-casting dies, aircraft landing gears, helicopter rotor blades and shafts, etc. The consistent quality of parts being machined in wire electrical discharge machining is difficult because the process parameters cannot be controlled effectively. These are the biggest challenges for the researchers and practicing engineers. Manufacturers try to ascertain control factors to improve the machining quality based on their operational experiences, manuals or failed attempts. Keeping in view the applications of material H-11 hot die steel, it has been selected and has been machined on wire-cut EDM (Elektra Sprint cut 734) of Electronica Machine Tools Limited. The response surface methodology (RSM) in conjunction with second order central composite rotatable design has been used to develop the empirical models for response characteristics. Desirability functions have been used for simultaneous optimization of performance measures. Also, the Taguchi technique and utility function have been used for multi- response optimization. Confirmation experiments are further conducted to validate the results*

I. INTRODUCTION

The present chapter gives the application of the response surface methodology. The scheme of carrying out experiments was selected and the experiments were conducted to investigate the effect of process parameters on the output parameters e.g. cutting rate, surface roughness, gap current and dimensional deviation. the experimental results are discussed subsequently in the following sections. The selected process variables were varied up to five levels and central composite rotatable design was adopted to design the experiments. Response surface methodology was used to develop second order regression equation relating response characteristics and process variables. The process variables and their ranges are given in table 1.

Table 1: Process Parameters and their Levels

Coded Factor	Real Factor	Parameters	Levels				
			(-2)	(-1)	(0)	(+1)	(+2)
X1	Ton	Pulse on Time	105	110	115	120	125
X2	Toff	Pulse off Time	43	48	53	58	63
X3	SV	Spark Gap Set Voltage	10	20	30	40	50
X4	IP	Peak Current	150	170	190	210	230
X5	WT	Wire Tension	4	6	8	10	12

II. LITERATURE REVIEW

The process was successfully modelled using RSM and model adequacy checking was also carried out. WEDM process was optimized using which generally makes use of the desirability function approach. But it was observed that lot of trial and error and manual tuning was required to obtain the true optimal solution. By using developed computer program based upon pareto optimization algorithm, the 33 pareto-optimal solutions were searched out from the set of all 206561 outputs.

It was observed that the developed pareto optimization strategy eliminates the guess work. It was also seen that the surface quality decreases as the cutting speed increases and varies almost linearly up to surface roughness value of 1.22 μm and cutting speed of 13.88 mm/min. Beyond this value of cutting speed, surface roughness deteriorates drastically. Kanlayasiri and Boonmung (2007) investigated influences of wire-EDM machining variables on surface roughness of newly developed DC 53 die steel of width, length, and thickness 27, 65 and 13 mm, respectively. The machining variables included pulse-on time, pulse-off time, pulse-peak current, and wire tension.

The variables affecting the surface roughness were identified using ANOVA technique. Results showed that pulse-on time and pulse-peak current were significant variables to the surface roughness of wire-EDMed DC53 die steel. The maximum prediction error of the model was less than 7% and the average percentage error of prediction was less than 3%. Ramakrishnan and Karunamoorthy (2008) developed artificial neural network (ANN) models and multi response optimization technique to predict and select the best cutting parameters of wire electro-discharge machining (WEDM) process. Inconel 718 was selected as work material to conduct experiments and brass wire of 0.25mm diameter was used as tool electrode. Experiments were planned as per Taguchi‟s L-9 orthogonal array. Experiments were performed under different cutting conditions of pulse on time, delay time, wire feed speed and ignition current. It was found that the pulse on time, delay time and ignition current had more influence than wire feed speed on the performance characteristics considered in the study. An MRR was improved with increase in pulse on time and ignition current. But the surface quality of the work specimen was affected adversely with increased value of pulse on time and ignition current. Gauri and Chakraborty (2008) suggested a modified approach of the principal component analysis (PCA) based procedure for multi-response optimization. Analysis was done data on experimental data on WEDM processes obtained by the past researchers i.e. on γ-titanium aluminized alloy with the settings of six controllable factors. Quality characteristics were material removal rate (MRR) (larger the better type), surface roughness (SR) (smaller the better type) and wire wear ratio (WWR) (smaller the better type). Rao and Sarcar (2009) analyzed the effects of process parameters on machining characteristics for CNC WEDM for brass work pieces of varying thickness. Mathematical relations were obtained for cutting speed, spark gap and MRR.

III. EXPERIMENTAL SET-UP AND PROCESS PARAMETER SELECTION

The experiments were carried out on a wire-cut EDM machine (ELEKTRA SPRINTCUT 734) of Electronica Machine Tools Ltd. The WEDM machine tool (Figure 1.) has the following specifications:

Design	: Fixed column, moving table
Table size	: 440 x 650 mm
Max. Work piece height	: 200 mm
Max. Work piece weight	: 500 kg
Main table traverse (X, Y)	: 300, 400 mm
Auxiliary table traverse (u, v)	: 80, 80 mm
Wire electrode diameter	: 0.25 mm (Standard), 0.15, 0.20 mm (Optional)
Generator	: ELPULS-40 A DLX
Controlled axes	: X Y, U, V simultaneous / independent
Interpolation	: Linear & Circular
Least input increment	: 0.0001mm
Least command input	: 0.0005mm
Input Power supply	: 3 phase, AC 415 V, 50 Hz
Connected load	: 10 KVA

Apart from the parameters mentioned above following parameters were kept constant at a fixed value during the experiments:

Work Material	: Hot Die Steel, H-11
Cutting Tool	: Brass wire of diameter 0.25 mm
Servo Feed	: 2050 unit
Flushing Pressure	: 1 unit
Peak Voltage	: 2 units (110 volt DC)
Conductivity of Dielectric	: 20 mho
Work Piece Height	: 24 mm

Fig. 1 Pictorial View of WEDM Machine Tool

IV .EXPERIMENTAL RESULTS

The WEDM experiments were conducted, with the process parameter levels set as given in Table 1, to study the effect of process parameters over the output parameters. Experiments were conducted according to the test conditions specified by the second order central composite design (Table 2). Experimental results are given in Table 2 for cutting rate, surface roughness, gap current and dimensional deviation. Altogether 32 experiments were conducted using response surface methodology.

Table :2 Coded Values and Real Values of the Variables.

S.No.	**X1(Ton)**		**X2(Toff)**		**X3(SV)**		**X4(IP)**		**X5(WT)**	
	Coded	**Real**	**Coded**	**Real**	**Coded**	**Real**	**Coded**	**Real**	**Coded**	**Real**
1	-1	110	-1	48	-1	20	-1	170	1	10
2	1	120	-1	48	-1	20	-1	170	-1	6
3	-1	110	1	58	-1	20	-1	170	-1	6
4	1	120	1	58	-1	20	-1	170	1	10
5	-1	110	-1	48	1	40	-1	170	-1	6
6	1	120	-1	48	1	40	-1	170	1	10
7	-1	110	1	58	1	40	-1	170	1	10
8	1	120	1	58	1	40	-1	170	-1	6
9	-1	110	-1	48	-1	20	1	210	-1	6
10	1	120	-1	48	-1	20	1	210	1	10
11	-1	110	1	58	-1	20	1	210	1	10
12	1	120	1	58	-1	20	1	210	-1	6
13	-1	110	-1	48	1	40	1	210	1	10
14	1	120	-1	48	1	40	1	210	-1	6
15	-1	110	1	58	1	40	1	210	-1	6
16	1	120	1	58	1	40	1	210	1	10
17	-2	105	0	53	0	30	0	190	0	8
18	2	125	0	53	0	30	0	190	0	8
19	0	115	-2	43	0	30	0	190	0	8
20	0	115	2	63	0	30	0	190	0	8
21	0	115	0	53	-2	10	0	190	0	8
22	0	115	0	53	2	50	0	190	0	8
23	0	115	0	53	0	30	-2	150	0	8
24	0	115	0	53	0	30	2	230	0	8
25	0	115	0	53	0	30	0	190	-2	4
26	0	115	0	53	0	30	0	190	2	12
27	0	115	0	53	0	30	0	190	0	8
28	0	115	0	53	0	30	0	190	0	8
29	0	115	0	53	0	30	0	190	0	8
30	0	115	0	53	0	30	0	190	0	8
31	0	115	0	53	0	30	0	190	0	8
32	0	115	0	53	0	30	0	190	0	8

X1, X2, X3, X4, and X5 represent coded values of various factors

V. ANALYSIS AND DISCUSSION OF RESULTS

The experiments were designed and conducted by employing response surface methodology (RSM). The selection of appropriate model and the development of response surface models have been carried out by using statistical software, "Design Expert (DX-7)". The regression equations for the selected model were obtained for the response characteristics, viz., cutting rate, surface roughness, gap current and dimensional deviation. These regression equations were developed using the experimental data and were plotted to investigate the effect of process variables on various response characteristics.

VI. CONCLUSIONS

Desirability function in combination with response surface methodology has been used for single response optimization. Optimal sets of process parameters, predicted optimal response and desirability value for single response optimization are summarized in the table.

FACTORS→ **RESPONSE↓**	**Ton**	**Toff**	**SV**	**IP**	**WT**	Desirability
CR &SR	120.00	48.00	40.00	210.00	6.00	0.554
CR,SR&IG	120.00	48.00	40.00	210.00	6.00	0.571
CR,SR&DD	119.6.1	48.00	39.94	204.00	6.01	0.613
CR,SR,IG&DD	120.00	48.00	40.00	210.00	6.00	0.644

VII. REFERANCES

[1] Chiang, K.T., Chang, F.P. (2006), "Optimization of the WEDM process of particle-reinforced material with multiple performance characteristics using grey relational analysis", Journal of Materials Processing Technology, 180, 96-101.

[2] Electronica Machine Tools Ltd., "Technology manual for Wire cut Edm-Elektra Sprintcut 734", 1-2

[3] Elsayed, E.A. and Chen, A. (1993), "Optimal levels of process parameters for products with multiple characteristics", International Journal of Production Research, 31(5), 1117-1132.

[4]Gauri, S.K. and Chakraborty, S. (2009), "Multi-response optimization of wedm process using principal component analysis", International Journal of Advanced Manufacturing Technology, 41, 741-748.

[5] Gokler, M. I., Ozanozgu, A. M.(2000), "Experimental investigation of effects of cutting parameters on surface roughness in the WEDM process", International Journal of Machine Tools & Manufacture, 40,1831–1848

[6] Gu,Y.H. and Hocheng, H. (2001), "Improvement of fatigue life of electrical discharge machined AISI D2 tool steel by TiN coating", Material Science Engineering, 318, 155–162.

[7] Guiqin, L., Fanhui, K., Wenle, L., Qingfeng, Y., Minglun, F. (2007), "The neural-fuzzy modeling and genetic optimization in WEDM", IEEE International Conference on Control and Automation.

[8] Han, F., Jiang, J., Dingwen, Yu. (2007), "Influence of machining parameters on surface roughness in finish cut of WEDM", International Journal of Advanced Manufacturing Technology, 34, 538–546.

[9] Hargrove, S. K., Ding, D. (2007), "Determining cutting parameters in wire EDM based on workpiece surface temperature distribution", International Journal of Advanced Manufacturing Technology, 34, 295-299.