PARAMETRIC OPTIMIZATION OF WEDM PROCESS USING GENETIC ALGORITHM

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ABSTRACT

Wire electric discharge machine (WEDM) is one of the non-traditional machining process. WEDM process is based on thermo electric energy between the workpiece and a wire electrode. The main aim of this research article is to optimize the cutting parameter of WEDM by optimizing the response material removal rate, surface roughness and kerf width. The cutting parameter are taken for this study include pulse on time, pulse off time, peak current, and wire feed rate. After the machining parameter are optimized using genetic algorithm. Face centered compositedesign has been used as the experimental strategy.

Keywords-WEDM, Genetic Algorithm, HSS M-2, MRR, SR,Kerf Width.

I INTRODUCTION

WEDM, is a special form of electric discharge machining that uses a small diameter wire as the electrode to cut a narrow kerf in the work. The cutting action in wire EDM is achieved by thermal energy from electric discharges between the electrode wire and the workpiece. Wire EDM is illustrated in Figure 1. The workpiece is fed past the wire to achieve the desired cutting path, somewhat in the manner of a bandsawoperation[1].

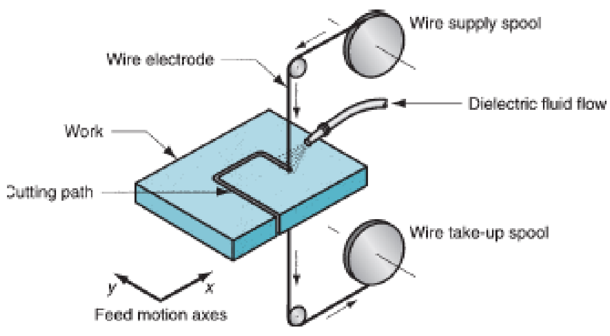

Figure 1. Representation of WEDM process.

Literature survey shows that wire electric discharge machining (WEDM) process adds a major role in manufacturing sectors. An attempt has been made by Gupta et al.[2] to optimise the kerf width for HSLA steel on WEDM. Central composite design were used by them for conducting experiment using parameter gap voltage, pulse on time, pulse off time and peak current.Chalisgaonkar [3]employedTaguchi L27 orthogonal array for optimizing response surface roughness and cutting speed for pure titanium alloy.Mahapatra and patnaik[4] used genetic algorithm with L16 for optimizing the wedm parameter for D2 tool steel, machining with 0.25 mm zinc coated copper wire as electrode. Pasam et al.[5] applied genetic algorithm with regression analysis for optimizing the response surface roughness for titanium alloy. Kumar [6] researched the effect of wedm parameter of the surface integrity of die steel D7 namely surface finish, cutting speed, and material removal rate using L16 orthogonal array.Jaganathan et al.[7] investigated the set of operating condition for EN31 using L27 orthogonal array.

II EXPERIMENTAL DETAIL

On the basis of above study parameters pulse on time (T_{on}), pulse off time (T_{off}), peak current (I), and wire feed rate (W_f) are selected for this work to optimize the material removal rate, surface roughness and kerf width using Genetic algorithm. The experimentation was planned under response surface methodology. Experiments were performed on a wire-cut EDM machine of model EZEECUT NXG manufactured by RATNAPARKHI. The HIGH SPEED M-2 grade material pieces of 20mm×30mm×7.2mm was selected as workpiece (hardened to 60 HRC) from this specimens of 10mm.x10mmx7.2mm size are cut by molybdenum wire 0.18 mm diameter which act as an electrode. Dielectric water was used as dielectricthroughout the experiment.

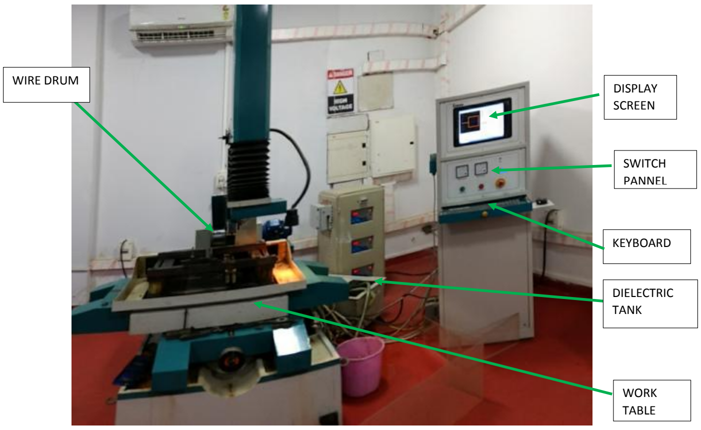

Fig. 2: Schematic diagram of WEDM EZEECUT NXG

Table 1: Chemical Composition of the Material HSS-M2

Constituent	C	Mn	Si	S	P	Cr	V	Mo	W	Co	Cu
%Composition	0.92	0.23	0.18	0.016	0.018	3.85	2.19	4.80	6.40	0.90	0.18

The different levels of a factor consider for this study are depicted in table 2. The fixed process parameter are : voltage, wire material: molybdenum, work material: HSS M2 grade, dielectric fluid: deionised water, wire tension, dielectric pressure.

Table 2:Process parameters and their levels

Variable	Unit	Level		
		-1	0	1
Pulse on time Ton(A)	μs	20	30	40
Pulse off time Toff(B)	μs	5	10	15
Current IP (C)	A	1	2	3
Wire Feed W_f(D)	mm/s	30	40	50

III MEASUREMENT OF RESPONSES

3.1 MRR

The rate of material removal from the work piece is known as material removal rate. It is measured in g/min. $\mathbf{MRR = \frac{W_i - W_f}{t}}$, w_i, w_f, initial and final weight respectively and t is time period of machining.

3.2 Surface finish

It shows the quality of machining. Its lower value is desirable as it assure the quality of the machined surface. It is measured in µm. It is measured by veeco optical profilometer.

3.3 Kerf Width

It denote the amount of material get wasted during machining. It assure the accuracy of machining. It is measured in mm. It is measured by tool maker microscope.

IV RESULTANDOPTIMIZATION

On the basis of FCCD, 26 experiment has been conducted [8]. The different responses has been measured corresponding to different operating parametric condition given in the table below.

Table 3: Experimental results for four parameter in un-coded units

Run order	Process parameter				Responses		
	A (Ton) µs	B (Toff) µs	C (IP) A	D (Wf) mm/s	MRR g/min	Surface Roughness µm	Kerf Width mm
1	40	15	3	30	0.0349	3.77	0.22
2	30	10	3	40	0.0314	4.48	0.22
3	40	15	3	50	0.0263	3.66	0.23
4	40	10	2	40	0.0357	4.85	0.25
5	20	5	3	50	0.0253	3.96	0.215
6	30	10	2	50	0.0268	4.23	0.2

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7	40	15	1	30	0.0095	3.55	0.24
8	30	10	2	30	0.0383	4.5	0.225
9	30	5	2	40	0.0298	5.5	0.23
10	40	5	1	50	0.0163	5.82	0.225
11	20	5	1	50	0.019	4.19	0.19
12	20	15	3	30	0.0277	2.94	0.199
13	20	5	3	30	0.028	4.4	0.22
14	20	10	2	40	0.0276	3.04	0.19
15	20	15	3	50	0.0208	2.32	0.19
16	20	15	1	50	0.0088	2.61	0.19
17	30	10	2	40	0.0309	4.42	0.21
18	40	15	1	50	0.0141	3.3	0.21
19	40	5	3	30	0.0529	6.55	0.24
20	30	10	1	40	0.0201	4.35	0.205
21	30	10	2	40	0.0304	4.38	0.2
22	20	15	1	30	0.0073	2.78	0.195
23	40	5	3	50	0.0283	6.38	0.225
24	40	5	1	30	0.0101	5.9	0.24
25	30	15	2	40	0.0278	3.27	0.19
26	20	5	1	30	0.0064	4.21	0.22

4.1 Optimization using Genetic Algorithm.

Regression model for MRR, SR and Kerf Width are used as the objective functions in GA. The algorithm is implemented in MATLAB.

4.1.1 Optimization of MRR Using Genetic Algorithm

Objective to maximise the MRR

Objective function maximise (MRR) = 0.03198 + 0.00318 A - 0.00216 B + 0.00911 C -0.00163D - 0.00667 C*C - 0.00423 C*D (coded form)

Subject to
$$\left.\begin{array}{l} -1 \le A \le 1 \\ -1 \le B \le 1 \\ -1 \le C \le 1 \\ -1 \le D \le 1 \end{array}\right\}$$

At population size 50, crossover probability 0.8 and no. of generation 100.

Optimized value of MRR is 0.04561 g/min

Optimized factors in coded form are

A = 1, B = -1, C =1, D = -1.

Optimized factors in uncoded form are

A ($T_{on)}$ = 40µs, B (Toff) = 5µs, C (IP) = 3A and D (W_f) = 30mm/s

4.1.2 Optimization of SR Using Genetic Algorithm

Objective to minimise the SR

Objective function minimise (SR) = 4.3460 + 0.7406 A - 1.0394 B + 0.0972 C - 0.1183 D - 0.3830 A*A - 0.2662 A*B + 0.1225 A*C (coded form)

Subject to

$$\left.\begin{aligned} -1 \le \mathbf{A} \le 1 \\ -1 \le \mathbf{B} \le 1 \\ -1 \le \mathbf{C} \le 1 \\ -1 \le \mathbf{D} \le 1 \end{aligned}\right\}$$

At population size 50, crossover probability 0.8 and number of generation 100.

Optimized value of SR is 2.3076 µm

Optimized factors in coded form are

A = -1, B = 1, C =1, D = 1.

Optimized factors in uncoded form are

A ($Ton_{)}$ = 20µs, B (Toff) = 15µs, C (IP) = 3A and D (W_f) = 50

4.1.3 Optimization of Kerf Width Using Genetic Algorithm

Objective to minimise the Kerf Width

Objective function minimise (Kerf Width) = 0.22059 + 0.01506 A - 0.00783 B + 0.00244 C - 0.00689 D (coded form) Subject to

$$\left.\begin{aligned} -1 \le \mathbf{A} \le 1 \\ -1 \le \mathbf{B} \le 1 \\ -1 \le \mathbf{C} \le 1 \\ -1 \le \mathbf{D} \le 1 \end{aligned}\right\}$$

At population size 50, crossover probability 0.8 and no. of generation 100.

Optimized value of Kerf Width is 0.1883 mm

Optimized factors in coded form are

A = -1, B = 1, C =-1, D = 1.

Optimized factors in uncoded form are

A (Ton) = 20μs, B(Toff) = 15μs, C(IP) = 1A and D(W_f) = 50

V CONCLUSION

The different experiments were conducted on WED-machine for finding optimal condition of machining for HSS M2 grade molybdenum wire as electrode. Optimization of the process parameters using Genetic algorithm have been described in this paper. Genetic Algorithm is a simple, systematic, reliable and most efficient tool for optimization of machining parameters. The optimal condition for wedm response MRR, surface roughness and kerf width are:

1. MRR found to be maximum 0.04561g/min at Ton, Toff, IP and Wf of 40μs, 5μs, 3A, 30mm/s respectively.
2. Surface roughness is found to be minimum 2.30μm at Ton, Toff, IP and Wf of 20μs, 15μs, 3A, 50mm/s respectively.
3. Kerf Width is found to be minimum 0.1883mm at Ton, Toff, IP, Wf of 20μs, 15μs, 1A, 50mm/s respectively.

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