Multi Response Optimization of EDM Process Parameters using Assignments of Weight Method

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***Abstract*—Since electrical process parameters are determining the machining characteristics of Electrical Discharge Machining (EDM), it is important to find the optimum values of those parameters and contribution of each parameter, AISI304 stainless steel was selected as work piece material whereas copper, brass and tungsten carbide were selected as tool material. The experiments were conducted with different levels of input factors such as gap voltage, discharge current and duty factor based on L_9 orthogonal table. The purpose of the present study is to investigate the contribution of electrical process parameters on machining characteristics and optimal combination of those parameters using Taguchi – Assignments of weight method. From the results, it has been revealed that electrical parameters have significant role in EDM process and the optimal values have been found using proposed multi response methodology.**

Keywords—EDM, Optimization, Surface

I. INTRODUCTION (*HEADING 1*)

Electrical Discharge Machining (EDM) is an important unconventional manufacturing process for making complex dies, shapes and moulds. The mechanism of EDM process involves the erosion of material due to higher temperature with applying the electrical pulses between tool and work piece separated by a dielectric medium. These high frequency DC pulses are generated by semi conductor based pulse generator. The gap between tool and work piece is controlled by micro controller. Whenever the air gap is minimized enough to breakdown the strength of the dielectric medium, ionization is happened between tool and work piece. This leads to produce higher temperature on surface of work piece. Due to this temperature, the work piece is melted and vaporized. Figure.1. shows the EDM process setup. Ho and newman [1] explained about the EDM process in detailed manner with the researches on recent development to improve the process performance. Mohan et al.[2] described the importance of electrical parameters on machining characteristics in thermal erosion process. Fuzhu han et al. [3] indicated the contribution of pulse generators and electrical parameters on determining surface quality during machining process.

Fig 1. EDM process setup

Lin et al.[4] applied the taguchi method for finding optimal combinational of process parameters on machining high speed steel by EDM process. Mukherjee and Shankar [5] discussed about bio-geography based optimization in EDM process. Chakravorty et al.[6] explained about importance of the optimization in EDM process. From above literatures, it is clearly understood that the electrical parameters contributed very much on determining machinability in EDM process and importance of optimizing those parameters.

There is no literature available to obtain multi response optimizing parameters in EDM process using Taguchi with assignments of weight method. In the present study, taguchi method has been used with assignment of weights method to optimize the multi responses involved in EDM.

II. EXPERIMENTS AND METHODS

Since the importance of electrical process parameters in EDM process, gap voltage, discharge current and duty factor have been taken as input parameters with three different types of electrode such as brass, copper and tungsten carbide. The ranges of process parameters for the present study are shown in Table.1. AISI 304 stainless steel has been chosen as workpiece.

Table.1. Range of process parameters

Process parameters	Symbol	Values
Gap voltage	GV	40,60,70
Discharge current	DC	9,12,15
Duty factor	DF	0.4,0.6,0.8
Tool Material	TE	WC, Br, Cu

A. *Design of Orthogonal array*

The experiments have been conducted with die-sinking electrical discharge machining. Since the present study considered four input parameters such as gap voltage, discharge current, duty factor and tool electrode, L_9 orthogonal table design has been selected based on taguchi design of experiments. Table.2. the selection of process variables for L_9 orthogonal table. Kerosene has been utilized as dielectric medium. The depth of cut has been selected as 2mm. Tool electrode diameter has been chosen as 4mm.

Table.2. Taguchi L9 orthogonal table design

Trial	A	B	C	D
1.	1	1	1	1
2.	1	2	2	2
3.	1	3	3	3
4.	2	1	2	3
5.	2	2	3	1
6.	2	3	1	2
7.	3	1	3	2
8.	3	2	1	3
9.	3	3	2	1

Material Removal Rate (MRR), Electrode Wear Rate (EWR) and Surface Roughness(SR) have been selected as response parameters. Due to optimize three responses, it is needed to carry out multi response optimization in this study. In the present study, MRR has been selected as larger the better whereas EWR and SR have been chosen as smaller the better responses.

III. ASSIGNMENTS OF METHODS

In this method, a set of original responses are mapped into a ratio so that the optimal levels can be found based on this ratio. This value can be treated as MRPI value to find the optimal combinations of the process parameters. The following steps are involved in Assignments of weight:

1. Determine the weights(w) for each response for all experiments. Weight of response is the ratio between response at any trial to the summation of all responses.
2. Transform the data of response into weighted data by multiplying the observed data with its own weight.
3. Divide the data as larger the better with smaller the better.
4. Treat this value as multi response performance index (MRPI).

The following relation has been used to find the MRPI for the present study.

$$MRPI = W_{MRR}Y_{MRR} + W_{SR}Y_{SR} + W_{EWR}Y_{EWR} \quad (1)$$

The weights for all the response variables have been computed as the following equations

$$W_{MRR} = MRR/\Sigma MRR \quad (2)$$

$$W_{EWR} = (1/EWR)/\Sigma\ (1/EWR) \quad (3)$$

$$W_{SR} = (1/SR)/\Sigma\ (1/SR) \quad (4)$$

IV. RESULTS AND DISCUSSION

Totally 9 experiments have been conducted according to the Taguchi design of experiments for investigating the effects of electrical parameters on machinability of AISI 304 stainless steel in EDM process. Table.3. shows the experimental results of all 9 trials have been conducted. The material removal rate has been calculated as ratio between the differences in weight of tool before and after the trial to the machining time.

Table.3. Experimental results in EDM

Factors				MRR (mm^3/min)	SR (μm)	EWR (mm^3/min)
GV	DC	DF	TE			
40	9	0.4	WC	0.783	0.326	0.0157
40	12	0.6	Br	6.436	5.785	0.73
40	15	0.8	Cu	9.558	10.158	1.1469
60	9	0.6	Cu	8.323	4.464	0.9988
60	12	0.8	WC	1.305	0.748	0.0261
60	15	0.4	Br	6.587	7.549	1.7785
70	9	0.8	Br	10.647	8.934	2.8747
70	12	0.4	Cu	10.952	3.982	1.3142
70	15	0.6	WC	1.335	0.802	0.0267

Table.4. shows the value of MRPI of all the experiments. MRPI is the ratio between the summation of larger the better data to the summation of smaller the better data. In the present study, material removal rate has the larger the better quality characteristics whereas the electrode wear rate and surface roughness has the smaller the better quality characteristics.

Table.4. MRPI values of experiments

Trial No.	Weights			MRPI
	MRR (mm^3/min)	SR (μm)	EWR (mm^3/min)	
1.	0.014001	0.461823	0.44117	0.168443
2.	0.115081	0.026025	0.009488	0.898142
3.	0.170904	0.014821	0.006039	1.790978
4.	0.148822	0.033726	0.006935	1.396125
5.	0.023334	0.201276	0.265378	0.187932
6.	0.117781	0.019944	0.003895	0.933308
7.	0.190377	0.016852	0.002409	2.184425
8.	0.19583	0.037809	0.00527	2.302211
9.	0.023871	0.187724	0.259415	0.189349

Table.5. shows the consolidated MRPI of all the input factors with all the levels. The Values have been computed by the adding the all MRPI values for corresponding level of each process parameters.

Table.5. Total MRPI values all trials

Factors	Levels			Max-Min
	1	2	3	
GV	0.952521	0.839122	1.558662	0.71954
DC	1.249664	1.129428	0.971212	0.278453
DF	1.134654	0.827872	1.387778	0.559906
TE	0.181908	1.338625	1.829771	1.647863

The maximum level value of each process parameters indicates the optimal level of input parameters on determining the machining characteristics [7]. From the Table.5, it has been found that A3 B1 C3 D3 is optimal combination of process parameters in the present study. The corresponding values are 70V, 9A, 0.8 DF and copper electrode. The max-max value indicates the higher influent on determining performance measures in any process. It has been observed that the electrical conductivity has most influent nature in EDM process.

V. CONCLUSION

In the present study Taguchi- Assignment of weights based multiple response optimization methodology has been utilized to obtain optimal combination process parameters on machining AISI 304 stainless steel in EDM process.

a) The values of optimal parameters to obtain larger MRR and lower SR with low EWR in EDM process are 70V, 9A with 0.8 duty factor.
b) Copper tool electrode could give better multi responses nature.
c) Tool conductivity has most influent nature in EDM process.

REFERENCES

[1] K.H. Ho and S.T. Newman, "State of the art electrical discharge machining", International Journal of Machine Tool Manufacturing, Vol.43, No.13, pp. 1287-1300, 2003.

[2] B.Mohan, A.Rajadurai and K.G.Satyanarayana, "Effect of SiC and rotation of electrode on electric discharge machining of Al-SiC composite", Journal of Materials Processing Technology, Vol.124, No.3, pp.297-304, 2002.

[3] Fuzhu Han , Li Chen , Dingwen Yu and Xiaoguang Zhou ,"Basic study on pulse generator for micro EDM", International Journal of Advanced Manufacturing Technology, Vol.33, No.5-6, pp.474-479,2007.

[4] Yan-Cherng Lin, Chao-Hsu Cheng, Bo-Lin Su and Lih-Ren Hwang, "Machining characteristics and optimization of machining parameters of SKH %& high speed steel using electrical discharge machining based on taguchi method", Materials and Manufacturing processes, Vol. 21, No.8, pp. 922-929, 2006.

[5] Rajarshi Mukherjee and Shankar Chakraborty, "Selection of EDM Process Parameters Using Biogeography-Based Optimization Algorithm", Materials and Manufacturing Processes, Vol.27, No.9, pp. 954-962, 2012.

[6] Rina Chakravorty, Susanta Kumar Gauri, Shankar Chakraborty," Optimization of Correlated Responses of EDM Process", Materials and Manufacturing Processes, Vol.27, No.3, pp. 337 -347,2012.

[7] T.Muthuramalingam, B. Mohsn, "Multi response optimization of electrical process parameters on machining characteristics in EDM using Taguchi-DEAR methodology", Journal of Engineering and Technology, Vol.3, No.1, pp. 57 – 60, 2013.