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Experimental Investigation and Optimization of Machining Parameters in Electrical Discharge Machining

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ABSTRACT: This experimental aims at achieving the integrated approach to solve the optimization problem of EDM process. At any stage, the dominance factor of the input variables and output variables contained in the constraints and objective functions can be computed. Electric discharge machining is categorized as a thermoelectric process in which heat energy of spark is used to remove material from the work piece. The machining process involves controlled erosion of electrically conducting material by the initiation of rapid and repetitive electrical spark discharges between the tool and work piece separated by the dielectric medium. The present work is aimed at characterizing the electric discharge machining of HCHCR steels on EDM. Since an electrode with micro features is employed to cut its mirror image in the work piece, it is necessary to investigate the machining efficiency of the electrodes used. Furthermore, to improve the machining efficiency. The combination of gap voltage, Ampere setting were new line considered for maximum Material Removal Rate (MRR), Surface Roughness (SR), constrained circularity error and overcut. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of such as Ampere rating, sparking voltage while machining

KEYWORDS: EDM, Material removal Rate, D3, Optimization.

1. INTRODUCTION

Electric discharge machining is a thermo-electric non-traditional machining process. Material is removed from the work piece through localized melting and vaporization of material. Electric sparks are generated between two electrodes when the electrodes are held at a small distance from each other in a dielectric medium and a high potential difference is applied across them. Localized regions of high temperatures are formed due to the sparks occurring between the two electrode surfaces. Work piece material in this localized zone melts and vaporizes. Most of the molten and vaporized material is carried away from the inter-electrode gap by the dielectric flow in the form of debris particles. To prevent excessive heating, electric power is supplied in the form of short pulses. Spark occurs wherever the gap between the tool and the work piece surface is smallest. After material is removed due to a spark, this gap increases and the location of the next spark shifts to a different point on the work piece surface. In this way several sparks occur at various locations over the entire surface of the work piece corresponding to the work piece-tool gap. Because of the material removal due to sparks, after some time a uniform gap distance is formed throughout the gap between the tool and the work piece. Thus, a replica of the tool surface shape is formed on the work piece. If the tool is held 3 stationary, machining would stop at this stage. However if the tool is fed continuously towards the work piece then the process is repeated and more material is removed. The tool is fed until the required depth of cut is achieved. Finally, a cavity corresponding to replica of the tool shape is formed on the work piece.



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II. LITERATURE REVIEW

Shailesh Dewangan[1] et.al were analyzed Surface integrity remains one of the major areas of concern in electric discharge machining (EDM).During the current study, grey-fuzzy logic-based hybrid optimization technique is utilized to determine the optimal settings of EDM process parameters with an aim to improve surface integrity aspects after EDM of AISI P20 tool steel. The experiment is designed using response surface methodology (RSM)considering discharge current (Ip), pulse-on time (Ton), tool-work time (Tw) and tool-lift time (Tup) as process parameters. Various surface integrity characteristics such as white layer thickness (WLT), surface crack density (SCD) and surface roughness (SR) are considered during the current research work. Grey relational analysis (GRA) combined with fuzzy-logic is used to determine grey fuzzy reasoning grade (GFRG). The optimal solution based on this analysis is found to be Ip ¹/₄ 1 A, Ton ¹/₄ 10 ms, Tw ¹/₄ 0.2 s, and Tup ¹/₄ 0.0 s. Analysis of variance (ANOVA) results clearly indicate that Ton is the most contributing parameter followed by Ip, for multiple performance characteristics of surface integrity.**Milan Kumar Das**[2] were investigated combination of process parameters for optimum surface roughness and material removal rate (MRR) in electro discharge machining (EDM) of EN31 tool steel using artificial bee colony (ABC) algorithm. For experimentation, machining parameters viz., pulse on time, pulse off time, discharge current and voltage are varied based on central composite design (CCD).

M.Dastagiri[3] were experimentally analyzed pursue the influence of four design factors current (I), voltage are the most connected parameters to be controlled by the EDM process over machining specifications such as material removal rate (MRR) and tool wear rate(TWR) and characteristics of surface integrity such as average surface roughness (Ra) and the hardness (HR) and also to quantify them. Vikas[4] were presented an idea about the effect of the various input process parameters like Pulse ON time, Pulse OFF time, Discharge Current and Voltage over the Surface Roughness for an EN41 material. Here, 5 different output parameters concerned with surface roughness like Ra, Rq, Rsk, Rku and Rsm are taken and optimized accordingly, using the Grev-Taguchi method. M. Durairai [5] et.al were analyzed Surface roughness and kerf width are of crucial importance in the field of machining processes. This paper summarizes the Grey relational theory and Taguchi optimization technique, in order to optimize the cutting parameters in Wire EDM for SS304. The objective of optimization is to attain the minimum kerfs' widthand the best surface quality simultaneously and separately. Y.H. Guu[6] et.al were analyzed surface morphology, surface roughness and microcrack of AISI D2 tool steel machined by the electrical discharge machining (EDM) process were analyzed by means of the atomic force microscopy (AFM) technique. Experimental results indicate that the surface texture after EDM is determined by the discharge energy during processing. M. Azadi Moghaddam[7] et.al were studied the effect of input EDM parameters on the surface quality of 2312 hot worked steel parts has been modeled and optimized. The proposed approach is based on statistical analysis on the experimental data. The input parameters are peak current (I), pulse on time (Ton), pulse off time (Toff), duty factor (h) and voltage (V). P. Balasubramanian[8] et.al were investigated work two different materials have been used as work pieces. These EN8 and D3 steel materials have been machined in an Electrical discharge machine which has wide application in Industry fields. The important process parameters that have been selected are peak current, pulse on time, die electric pressure and tool diameter. The outputs responses are material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR).

Mona A.[9] were studied the effect of electrode material was studied to avoid resulting residual stresses, the surface roughness and cracks resulted during Electrical Discharge Machining (EDM). Two types of EDM electrode materials were chosen, Dura graphite 11 and Pico graphite EDMC-3. Two grades of tool steels are chosen as test materials, DIN 1.2080 and DIN 1.2379. **P.B.Wagh**[10] were investigated, 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 centered central composite design matrix is used to conduct the experiments on EN31 with copper electrode. The response is modeled using RSM on experimental data.

III. EXPERIMENTAL SETUP

The electrode were machined to a cylindrical shape of 32 mm diameter and 50mm length. A cylindrical size and thickness 12 mm of HCHCR steel was taken. It was subjected to a standard hardening cycle and it has a hardened



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at the range of 40 to 45 HRC.One surface of the work piece was then ground on a surface grinder to remove surface irregularities and minor scaling. The hardness of this surface was measured on Rockwell Hardness Tester C scale using a diamond cone. After mounting the work piece and one of the electrodes on the machine, the depth of machining was set at 25mm. The work piece was machined with various amps A discharges current and other standard machine settings. The time of machining was recorded in minutes and final weights of the work piece were taken. The machining cycle was repeated for the next value of discharge current. Similarly, the observations were made for the other two electrodes.

For each electrode material, the effect of variation in discharge current was studied on output parameters, namely, material removal rate (MRR), machined surface roughness. Surface roughness readings were taken on the bottom surface of the machined cavity. Surface roughness was measured on Surf test equipment giving Ra value in microns.



Figure 6.1 General Experimental Setup

3.1 PROCESS PARAMETERS AND THEIR LEVELS

	··· ···		
s.no	Pulse on time	Pulse off	Gap
		time	current
1	4	5	8
2	5	6	10
3	6	7	12



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EXPERIMENTAL DATA

Table 8.1 EXPERIMENTAL DATA

TRIAL	DESIGNATI	T ON	T/OFF	AMPS	RA	MT	MRR
NO.	ON						
1	A1B1C1	4	5	8	2.938	21	0.476
2	A1B2C2	4	6	10	4.093	17	0.529
3	$A_1B_3C_3$	4	7	12	4.259	13	0.769
4	A2B1C2	5	5	10	4.210	16	0.635
5	A2B2C3	5	6	12	3.938	11	0.909
6	$A_2B_3C_1$	5	7	8	3.290	20	0.500
7	A3B1C3	6	5	12	3.196	10	1.000
8	A3B2C1	6	6	8	3.319	17	0.588
9	A3B3C2	6	7	10	3.172	14	0.642



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IV. RESULT AND DISCUSSION

S/N RATIOS VALUES FOR THE EXPERIMENTS

Table 8.2 ANALYSIS OF RESULT

S.No.	DESIGNA TION	Pulse ON time	Pulse OFF time	AMPS	RA	S/N Ratio	MRR	S/N Ratio
1	A1B1C1	4	5	8	2.938	-9.3610	0.476	-6.44786
2	$A_1B_2C_2$	4	6	10	4.093	-12.2408	0.529	-5.53089
3	$A_1B_3C_3$	4	7	12	4.259	-12.5862	0.769	-2.28147
4	$A_2B_1C_2$	5	5	10	4.210	-12.4856	0.635	-3.94453
5	$A_2B_2C_3$	5	6	12	3.938	-11.9055	0.909	-0.82872
6	$A_2B_3C_1$	5	7	8	3.290	-10.3439	0.500	-6.02060
7	$A_3B_1C_3$	6	5	12	3.196	-10.0921	1.000	0.00000
8	$A_3B_2C_1$	6	6	8	3.319	-10.4201	0.588	-4.61245
9	$A_3B_3C_2$	6	7	10	3.172	-10.0267	0.642 0.476	-3.84930 -6.44786



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Main Effects Plot for SN ratios (Ra)



Main Effects Plot for SN ratios (Machining Time)





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OPTIMAL CONTROL FACTOR

- 1. Surface Roughness-A2 (T-ON –4 µs)B3(T-OFF –7 µs)C1(Amps-8)
- 2. Machining Timing- A2 (T-ON -4μ s)B3(T-OFF -7μ s)C1(Amps-8)
- 3. Material Removal Rate- A2 (T-ON -4 µs)B3(T-OFF -7 µs)C1(Amps-8)

Percentage of contribution of Process parameter

- 1. Surface Roughness-Pulse on time- Amps- 37%
- 2. Machining Timing- Amps- 84%
- 3. Material Removal Rate-Amps 84%

V. CONCLUSION

In this study, the Taguchi technique and ANOVA were used to obtain optimal EDM parameters in the machining of HCHCR. The experimental results were evaluated using Taguchi technique. Optimal control factor and percentage of contribution were evaluated. Through this experimental finally we have found efficient machining optimum parameter for HCHCR material machining with graphite electrode.

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