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EXPERIMENTAL ANALYSIS OPTIMIZATION OF PROCESS PARAMETERS OF WIRE EDM ON STAINLESS STEEL316L

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Abstract -*The electrical discharge machining (EDM) is one of the latest non-traditional machining processes, based on thermoelectric energy between the work piece and tool. The performance of the process, depends on the tool material, work piece material & manufacturing method of that tool. A suitable selection of tool can reduce the cost of machining. The performance of the EDM is based on Material Removal Rate (MRR), Machining timing and Surface Roughness (SR). The important machining parameters of EDM which affecting the performance parameters are discharge current, pulse on time, pulse off time, arc gap, flushing pressure, voltage and duty cycle. Taguchi design of experiments is used to conduct experiments by different controllable factors. The process performance is measured in terms of Material Removal Rate (MRR). In this research WEDM experiments has to be conducted by a tool of Copper. The AISI 316LStainless Steel also act as the work piece and it has to be investigated for verifying various output response to standard the optimum level machining.*

Key Words: *Wire cut electrical discharge machine (WEDM),SS316L,**Taguchi method, orthogonal array, s/n ratio.MRR ,surface roughness.*

1. INTRODUCTION

Wire EDM is an electrical discharge machining process with a continuously moving conductive wire as tool electrode. The mechanism of metal removal in wire electrical discharge machining (WEDM) involves the complex erosion effect of electric sparks generated by a pulsating direct current power supply between two closely spaced electrodes in dielectric liquid. The high energy density erodes material from both the wire and work piece by local melting and vaporizing. Because the new wire keeps feeding to the machining area, the material is removed from the work piece with the moving of wire electrode. Eventually, a cutting shape is formed on the work piece by the programmed moving trajectory of wire electrode. The equipment is extensively used in making dies and molds.

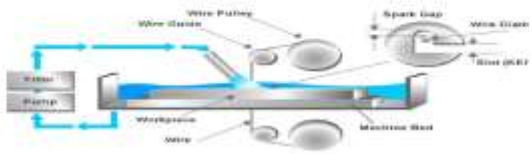

Fig **1 .wire EDM process**

The EDM process has the ability to machine hard, difficult-to-machine materials. Parts with complex, precise and irregular shapes for forging, press tools, extrusion dies, difficult internal shapes for aerospace and medical applications can be made by EDM process. Grade 316L, the low carbon version of 316 and is immune from sensitization (grain boundary carbide precipitation).

Thus it is extensively used in heavy gauge welded components (over about 6mm). There is commonly no a The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures. Compared to chromium-nickel austenitic stainless steels, 316L stainless steel offers higher creep, stress to rupture and tensile strength at elevated temperatures. Appreciable price difference between 316 and 316L stainless steel.

2.LITERATURE REVIEW

Gaurav Ragav et.al 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. This technique helps in getting the reliable multi-objective decisions under constrained penalties for the constrained optimization of such processes. In the present work, relationships have been developed between the input decision variables and the desired goals by applying the statistical regression analysis of investigations obtained by Electro Discharge machining process for a considerable variation in the crisp sets of variables. The objectives functions were maximized or minimized by using the generalized Genetic Algorithms and the data are stored for a given set of objectives. The results are interpreted with respect to those obtained by using the bi-criterion approach. It is concluded that the results obtained by bi-criterion approach are approximately of the same order of accuracy as calculated experimentally but the computational simplicity of this method makes this methodology favorable to use to solve such mechanical engineering complex problems.

Vishnu D Asal has investigated the optimum process parameters for a particular work piece-tool material combination on Fuzzy Logic Control based Electrical Discharge Machine. In this experiment, two levels of current, tools material and spark gap are kept as the main variables. The work piece material was taken as S.S.304, and tool material changed at various levels of the performance as copper and brass. The DEF-92 was used as the dielectric fluid. The Design of experiment is used to design the E.D.M experiments. The various tools of D.O.E are used to analyze the final results of the experiment with the help of graphs in this paper.

The analysis is being done with the help of Minitab-15 software. The analysis of variance (ANOVA) is also performed to indentify the statistical significance of parameters. The result of the experiments are the optimimum values of MRR (material removal rate), TWR (tool wear ratio), and surface finish with the help of ANOVA. The conclusions arrived are discussed at the end.

J. Laxman has investigated optimization of EDM process parameters using the grey relational analysis (GRA) based on an orthogonal array for the multi response process. The experiments are conducted on Titanium super alloys with copper electrode based on the Taguchi design of experiments L27 orthogonal array by choosing various parameters such as peak current, pulse on time, pulse off time and tool lift time for EDM process to obtain multiple process responses namely Metal removal rate (MRR) and Tool Wear Rate (TWR). The combination of Taguchi method with GRA enables to determine the optimal parameters for multiple response process.

Gray relational analysis is used to obtain a performance index called gray relational grade to optimize the EDM process with higher MRR and lower TWR and it is clearly found that the performance of the EDM has greatly increased by optimizing the responses the influence of individual machining parameters also investigated by using analysis of variance for the grey relational grade.

P. Balasubramanian 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). The Cast Copper and Sintered Powder Metallurgy Copper (P/M Copper) have been considered as tool electrodes to machine the fore said work pieces. Response surface methodology(RSM) has been used to analyze the parameters and analysis of variance (ANOVA) has been applied to identify the significant process parameters. The influences of interaction of parameters have also been studied. Scanned electron microscope(SEM) images have been taken after machining on the work pieces for both electrodes to study the structure property correlation. The input parameters were optimized in order to obtain maximum MRR, minimum TWR and minimum SR.

Mona A. 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 ofEDM electrode materials were chosen, Dura graphite 11 and Poco graphite EDMC-3. Two gradesof tool steels are chosen as test materials, DIN 1.2080 and DIN 1.2379. Different machining methods were chosen ‘‘rough, medium, and soft’’, it was found that the Dura graphite 11 exhibits more surface cracks upon DIN 1.2379 less micro-cracks appeared on the surface than on DIN 1.2080 while the higher surface roughness appeared in DIN 1.2080 using Dura Graphite 11 electrode, also Residual stresses were studied upon the surface and it was found that POCO Graphite EDMC-3 electrode results higher residual stresses compared with Dura Graphite 11 electrode. Also Soft EDM machining exhibits higher residual stresses as a result of higher pulse on duration time.

3.DESIGN OF EXPERIMENT BY TAGUCHI

The techniques in which laying out the conditions of experiments all the multiple functions are first proposed by Englishman, Sir R.A FISHER. The method is popularly known as the factorial design will identify all possible combinations for a of factors. All the industrial experiments usually involve a significant number of factors. A fully factorial design is a big number of experiments. The small set from which all the possibilities is selected to reduce the number of experiments. In our experiment , I select L9 orthogonal array design matrix and higher the better criteria was selected for S/N ratio calculation, because the higher response values are required.

Table 1 . metal removal rate calculation

MRR FORMULA Before weight-After weight/Time taken X Density

B. Weight	264	247	269	261	265	245	261	268	265
A. Weight	240	241	238	238	242	240	245	241	241

TABLE 1. Machining parameters and their level

Machining parameter	Units	Notation	levels					
			Original			Coded		
			Level I	Level II	Level III	1	2	3
Pulse on time	Ms	A	30	31	32	1	2	3
Pulse off time	Ms	B	5	6	7	1	2	3
Gap current	mm/min	C	50	60	70	1	2	3

TABLE 2. An Orthogonal Array L_9 Formation

TRIAL NO.	DESIGNATION	PULSEON (Micro sec)	PULSEOFF (Micro sec)	Gap current mm/min
1	$A_1B_1C_1$	30	5	50
2	$A_1B_2C_2$	30	6	60
3	$A_1B_3C_3$	30	7	70
4	$A_2B_1C_2$	31	5	60
5	$A_2B_2C_3$	31	6	70
6	$A_2B_3C_1$	31	7	50
7	$A_3B_1C_3$	32	5	70
8	$A_3B_2C_1$	32	6	50
9	$A_3B_3C_2$	32	7	60

Table 3. Experimental results and corresponding S/N ratios and MRR

Trial no	Process parameters			responses	S/N ratio (dB)
	Pulse on time [A] µs	Pulse off time [B] µs	Gap current [C] mm/min	MRR	
1	30	5	50	0.166	-15.59
2	30	6	60	0.046	-26.74
3	30	7	70	0.176	-15.08
4	31	5	60	0.205	-13.76
5	31	6	70	0.191	-14.37
6	31	7	50	0.041	-27.74
7	32	5	70	0.133	-17.52
8	32	6	50	0.225	-12.95
9	32	7	60	0.187	-14.5
				Average S/N ratio	**-17.58**

Table 4. S/N response table for MRR

Parameters	character	Level 1	Level 2	Level 3	Delta =maximum-minimum	Rank
Pulse on time [A] µs	A	-19.13	-18.62	-14.99	4.14	1
Pulse off time [B] µs	B	-15.62	-18.02	-19.10	3.48	2
Gap current [C] mm/min	C	-18.76	-18.3	-15.65	3.10	3

Table 5. Results of the ANOVA for MRR

Character	parameters	Degree of freedom	Sum of squares (ss)	Variance	Corrected sum of squares	contribution (%)	Rank	Significant.
A	Pulse on time [A] µs	2	0.004302	0.002201	0.813	12	1	Yes
B	Pulse off time [B] µs	2	0.001681	0.000840	0.945	5	2	No
C	Gap current [C] mm/min	2	0.000945	0.00472	0.968	3	3	Yes
Error		2	0.028646	0.014323		80		
Total		8	0.035574			100		

Table 6. POOLED ANOVA FOR MRR

Character	Parameters	Degree of freedom	Sum of squares (ss)	Variance	Corrected sum of squares	contribution (%)
A	Pulse on time [A] µs	2	0.004302	0.002201	0.813	12
B	Pulse off time [B] µs	2	0.001681	0.000840	0.945	5
C	Gap current [C] mm/min	2	0.000945	0.00472	0.968	3
Error		2	0.028646	0.014323		80
Total		8	0.035574			100

4. REGRESSION ANALYSIS

The multiple regression analysis technique is used to ascertain the relationships among the variables. Here MINI TAB 16 used to calculate the regression modelling, the regression model are given below:

MRR = -0.241 -0.0033 Pulse On – 0.017 Pulse Off – $5.808X10^{-4}$ Gap current.

5.CONCLUSION

In this study, the Taugchi technique and ANOVA were used to obtain optimal WIRE EDM parameters in the machining of SS316L steel with copper wire electrode. The experimental results were evaluated using Taguchi technique. The effect of input parameters of WEDM process such as pulse on time, pulse off time , gap current on output parameters like surface roughness and Metal removal rate of stainless steel316L was studied.

In performing the experiment, Taguchi analysis and Anova Table are used in order to obtain the optimized value for machining SS316L.Also regression analysis method was used to predict the values of MRR and Ra for the input parameters. Pulse on time and pulse off time are most influencing parameters that affect surface roughness.

The following conclusion can be drawn.

OPTIMAL CONTROL FACTOR :

From the main effects plot for S/N ratio of MRR, pulse on time 32 µs, pulse off time 6 µs and gap current 50mm/min is selected for optimal control factor in Ra.

1. Material Removal Rate- A3 (Pulse on – 32 µs)B2(T-OFF – 6 µs)C1(GAP CURRENT-50mm/min)
2. From the main effects plot for S/N ratio of Ra, pulse on time 32 µs, pulse off time 5 µs and gap current 60mm/min is selected for optimal control factor in Ra.
3. Surface Roughness-A3(Pulse on – 32 µs)B1(T-OFF – 5 µs)C2(GAP CURRENT-60mm/min).

Percentage of contribution of Process parameter:

i. Surface Roughness-Pulse off time = 60%
ii. Material Removal Rate- pulse on time = 12%

REFERENCE

[1] Guu, Y.H.(2001) 'AFM surface imaging of AISI D2 tool steel machined by the EDM process', Applied Surface Science, Vol242, pp 245–250.

[2] Pecas, P, et al. (2008) 'Electrical discharge machining using simple and powder-mixed dielectric: The effect of the electrode area in the surface roughness and topography', journal of materials processing technology, vol 200, pp250–258.

[3] Kansal, H.K, et al., (2005) 'Parametric optimization of powder mixed electrical discharge machining by response surface methodology', Journal of Materials Processing Technology, vol169, pp427–436.

[4] Izquierdo. B, et al (2009) 'A numerical model of the EDM process considering the effect of multiple discharges', International Journal of Machine Tools & Manufacture, Vol 49, Issues 3-4, pp 220-229.

[5] Prabhu.S, et al (2008)'Analysis of Surface Characteristics of AISI D2 Tool Steel Material Using Carbon Nano Tube', International journal

of nanotechnology and application, Vol 2, No 2-3,Pp 107-122.

[6] Prabhu.S, et al (2008) 'Nano surface generation in grinding process using carbon nano tube with lubricant mixture', International journal of nanotechnology and application, Vol 2, No 2-3, Pp 149-160.

[7] Ozlem Salman., et al (2008) 'Evolutionary programming method for modeling the EDM parameters for roughness, journal of materials processing technology, v200, Pp 347–355

[8] Cao, D.M., Jiang, J., Yang, R., Meng, W.J., Fabrication of high-aspect-ratio micro scale mold inserts by parallel mEDM, Microsystems Technology 2006; 12:839-845

[9] Yeo S H, Tan L K. Effects of ultrasonic vibrations in micro electro-discharge machining of microholes. Journal of Micromech. Microeng. 1999; 9: 345-352

[10] Masuzawa, T. and Heuvelman, C. J., Self flushing method with spark-erosion machining. CIRP Annals - Manufacturing Technology.1983; 32: 109-111.

[11] Masuzawa, T., Cui, X. X. and Fujino, M. A New Flushing Method for Edm Diesinking - Effect of 2d Small Vibration of the Electrode. Bulletin of the Japan Society of Precision Engineering.1990; 24: 223-224.

[12] Ghoreishi, M. and Atkinson, J. A comparative experimental study of machining characteristics in vibratory, rotary and vibro-rotary electro-discharge machining. Journal of Materials Processing Technology.2002; 120: 374-384.