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A NOVEL OPTIMISED ELECTRO DISCHARGE MACHINING PARAMETERS FOR MRR AND SR MONEL 400 USING TAGUCHI METHOD

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ABSTRACT
Electro Discharge Machining (EDM) is an extremely prominent machining process. In EDM, the material removal of the electrode is achieved through high frequency sparks between the tool and the work-piece immersed into the dielectric. The Material Removal Rate (MRR) is the important performance attributes of EDM process. The machining parameters that achieve the highest MRR strongly depend on the size of the machining surface i.e. the engaged electrode and work-piece surface. With upcoming applications of Monel 400, machining has become an important issue which needs to be investigated in detail. Present paper summarizes the Taguchi optimization technique, in order to optimize the process parameters in EDM & SR for Monel 400.The work piece thickness has been considered as the control factor. Material Removal Rate and Surface Roughness are vital source in the field of machining process. The Design of Experiment (DOE) is prepared by using Taguchi's L9 Orthogonal Array (OA). The various input parameters of EDM namely Pulse-on (T-ON), Pulse-off (T-OFF) & Current (I) were selected to study the process performance in terms of MRR & SR. The ultimate aim is to optimization is to attain the maximum Material Removal Rate (MRR) and minimum Surface Roughness (SR).
Keywords - Monel 400, EDM, MRR, SR, Taguchi method.

1. INTRODUCTION

This paper is based on the optimization of process parameter to perform some mechanical operations using EDM. Accompanying the development of mechanical industry, the demand for alloy materials having high hardness, toughness and are impact resistance increasing. Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark.

EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries insmall batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive. To produce an optimum output, taguchi technique is used.

2. WORKING PRINCIPLE OF EDM

When a potential difference is applied between the two points of the anode and cathode, cold emission of electron starts. These emitted electrons collide with the dielectric fluid particle and break them into electrons andions. These liberated electrons again break the particles in electrons and ions and form a channel of plasma. When a discharge takes place, the intense heat is generated this melts and evaporates the material near the sparking zone. For improving the effectiveness, the work piece and the tool are submerged in the dielectric fluid. It has been observed that if both the electrodes made of the same material, the electrode connected to the Positive terminal generally erodes at a faster rate.

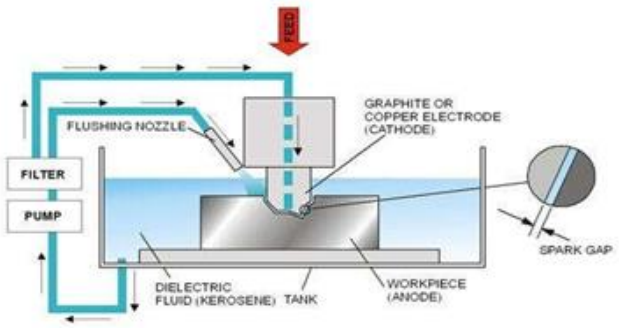

Fig 1: Working principle of EDM

For this reason, the work piece is normally made the anode. A suitable gap, known as the spark gap, is maintained between the tool and work piece surface are the closest and since the spark change after each spark (because of the material removal after each spark),the spark travel all over the surface thus a uniform material removal takes place and finally work piece get the shapeof tool.

3. LITERATURE REVIEW

For determining the better parametric settings, lotof work has been done in the engineering design. The EDM processes are having several performance characteristics like Metal Removal rate, Surface Roughness, Kerf width, Dimensional error etc…

[1] Describes about the optimization of process parameter during the machining of WEDM is a spark erosion non-conventional machining method to cut hard and conductive material with the help of wire electrode. This deals with the surface roughness and metal removal rate is described. [2] The paper demonstrates the optimization of process parameter for surface roughness by using ANOVA table. [3] By doing various experiment researchers have found out that increasing discharge energy and impulse the MRR increases and surface becomes rougher while layer thickness increases. [4] Influence of pulse time & current on MRR and surface roughness considering detrimental effect of expansion of plasma arc. [5] Study based on the least squares theory has been carried out which involves establishing the values of the EDM input parameters namely peak current level, pulse-on time and pulse-off time to ensure the simultaneous fulfillment of material removal rate, surfaceroughness (SR). [6] Importance of MRR in determinationof EDM machining performances in terms of efficiency and cost effectiveness has been explored. [7] There is nota monotonous effect of any of the EDM process parameters on MRR. Selections of most favorable process parameters are required for achieving optimal machining performance. [8] The approach is based on Taguchi method, the signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) are employed to study theperformance characteristics. [9] The effect of the machining parameters on the responses such as MRR was investigated. In this research work, Regression analysis was used to find out the optimal levels of the parameters.

Generally these desired process parameters are determined based on experiences which come from experimental study on EDM. This paper enumerates the experiments based on machining parameters optimization of EDM process using Taguchi method. In EDM process rough machining gives lesser accuracy and finish machining gives fine surface finish, but it reduces the machining speed. Hence we have to improve the MRR and reduce Ra as the objective, which is done by Taguchimethod.

4. EXPERIMENTATION

Selection of material

Monel-400 is a group of nickel alloy primarily composed of nickel (up to 67%) and copper and stronger than pure nickel. Monel is a solid solution binary alloy commonly used in application with high corrosive

conditions. It is resistance to corrosion and acids, and some alloys can withstand a fire in pure oxygen. The alloy does not undergo a ductile-to-brittle transition even when cooled to the temperature of liquid hydrogen.
Monel alloy 400 has excellent mechanical properties at subzero temperatures. Strength and hardness increase with only slightly impairment of ductility or impact resistance. Monel-400 has typical application in marine engineering, chemical and hydro-carbon processing, heat exchanger, valves and pumps, and in aerospace applications.

S. No	COMPOSITION	PERCENTAGE
1	Ni	65.5000
2	C	0.1240
3	Si	0.0751
4	Mn	0.8450
5	P	0.0062
6	Cr	0.0348
7	Al	0.0537
8	Co	0.0372
9	Cu	31.6900
10	Ti	0.0555
11	W	0.0186
12	Pb	0.0122
13	Mg	0.0168
14	Ce	0.0010
15	B	0.0051
16	N	0.0000
17	La	0.0030
18	Fe	1.1900
19	Sn	<0.100

Table 1 : Chemical Composition of Monel 400

5. DISCUSSION ABOUT ORTHOGONAL ARRAY

To start machining having discussion of an investigational work designed earlier just before the implementation of machining. This one concerns a L9 orthogonal array by using design of experiments from Taguchi's method, choice of work piece, selection of tool, investigational set-up then by using the data of experiments calculation made for Material Removal Rate (MRR) and Surface Roughness (SR).
This technique has been broadly classified in various fields of engineering to optimize the process parameters. The common factors considered for the study are Pulse- on, Pulse-off and Current. Three levels of each factor will used. Based on no of factors and their levels L9 Orthogonal array was selected. Table-2 represents various levels of machining factors and table-3 represents experimental plans with assigned values Input factors for conducting experiments are:

A. Pulse-on time
B. Pulse-off time
C. Current

Factors to be measured

1. Material Removal Rate (MRR).

S. No	Parameter	Unit	Level 1	Level 2	Level 3
1	**Pulse-ON(A)**	µs	30	60	90
2	**Pulse-OFF(B)**	µs	1	5	9
3	**Current(C)**	Amps	5	15	25

Table 2: machining Parameter and their Level

2. Surface Roughness (SR).

S. No	Pulse ON (A)	Pulse OFF (B)	Current(C)
1	30	1	5
2	30	5	15
3	30	9	25
4	60	1	15
5	60	5	25
6	60	9	5
7	90	1	25
8	90	5	5
9	90	9	15

Table 3: Design of Experiment (DOE)

6. EXPERIMENTAL SETUP

The experiments were carried out on a EDM machine ELECTRONICA installed at A&D Sparks, Sanganoor, Coimbatore. The Specimen is Prepared as a Rectangle blank of 150mm length, 20mm breath and thickness of 2mm made of Monel 400 which is to be machine in EDM. Copper is used as electrode and the work piece has machined in nine piece of 10mm length.

S. No	A	B	C	MRR (gm./min)	SR (µm)
1	30	1	05	0.56	0.510
2	30	5	15	2.56	0.993
3	30	9	25	3.60	0.576
4	60	1	15	1.92	0.690
5	60	5	25	2.82	1.147
6	60	9	05	0.56	0.674
7	90	1	25	1.78	0.641
8	90	5	05	0.52	0.542
9	90	9	15	1.28	0.529

Table 4: Result observed on EDM Process

fig 2: Electric Discharge Machining Shop

Fig 3: Monel 400 before Machining

Fig 4: Monel 400 after Machining

The parameters chosen for machining are Pulse ON, Pulse OFF and Current. The various results after theEDM process are evaluated on two basic performances are MRR and SR. The result is tabulated as shown in the table 4.

MRR for each experiment are calculated using the following

MRR=Initial wt.of work piece wt.of work piece (gram)/matching time (min)

Fig 5: Roughness Testing Machine

RESULTS AND DISCUSSION

The objective is to improve the Material RemovalRate & reduce SR which is done by taguchi method.

TAGUCHI METHOD

The Taguchi method of optimization is a 3-step process (Jameson (2001), Montgomery (2001)), which deals with the selection of raw material at the first stage, based on the engineering properties of that material. At the 2nd stage, the optimization process is carried out on the basis of the design of experiment table. The 3rd stage is the stage, where the comparison between the experimental and the predicted values are done to validate the result.

On the basis of the different combinations of inputs obtained by the Taguchi method, the corresponding S/N ratio was generated for both the materials individually by the use of Minitab software (Minitab Manual 2010).

TAGUCHI ANALYSIS

The S/N ratio (η) is the ratio of signal to noise in terms of power. The method of calculating the S/N ratio depends on whether the quality characteristic is smaller- the better, larger-the-better, or nominal the-best. In this paper, we use the "larger-the-better" and "smaller isbetter" approach.

The S/N ratio for this type of response is given

MRR - Higher is better. SR - Lower is better.

ANALYSIS OF MEAN

The response graph for mean & S/N ratio is carried out between MRR & SR versus Pulse ON, Pulse OFF & Current are shown in fig-5,6,7,8.

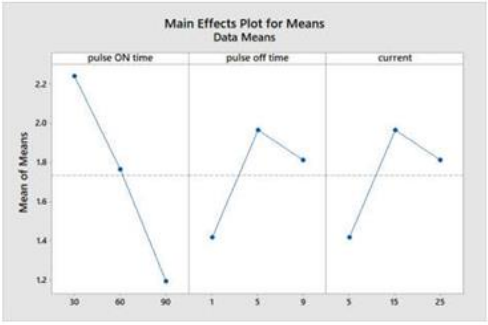

Fig 6: Effects of control factor on MRR (means)

LEVEL	A	B	C
1	2.240	1.420	1.420
2	1.767	1.967	1.967
3	1.193	1.813	1.813
DELTA	1.047	0.547	0.547
RANK	1	2.5	2.5

Table-5: Response Table for Means

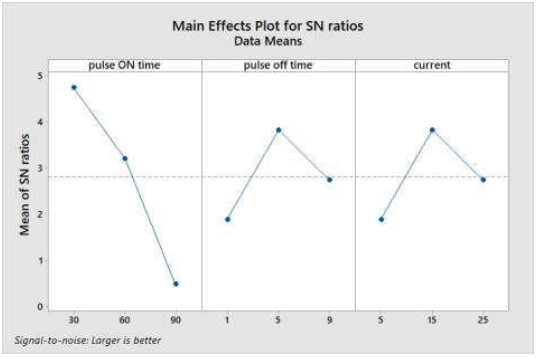

Fig 7: Effects of control factor on MRR

LEVEL	A	B	C
1	3.567	4.311	4.311
2	1.820	1.397	1.397
3	4.905	4.583	4.583
DELTA	3.085	3.186	3.186
RANK	3	1.5	1.5

Table-6: Response Table for S/N ratio (MRR)

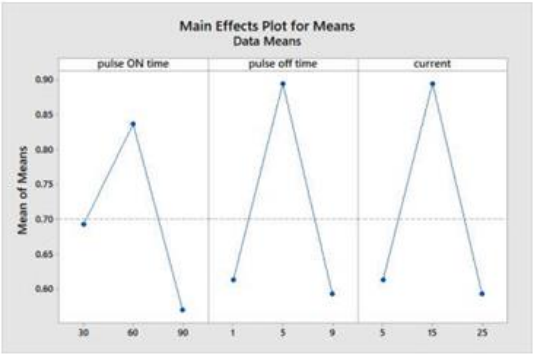

Fig 8: Effects of control factor on SR (means)

LEVEL	A	B	C
1	0.6930	0.6137	0.6137
2	0.8370	0.8940	0.8940
3	0.5707	0.5930	0.5930
DELTA	0.2663	0.3010	0.3010
RANK	3	1.5	1.5

Table-7: Response Table for Means

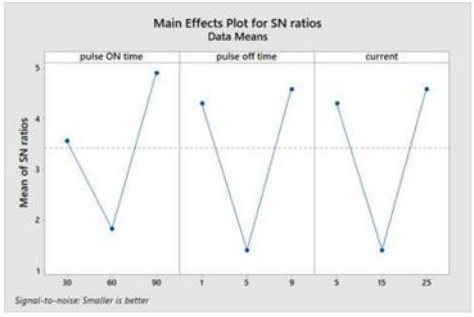

Fig 9: Effects of control factor on SR

LEVEL	A	B	C
1	4.7515	1.8794	1.8794
2	3.2116	3.8229	3.8229
3	0.4909	2.7447	2.7447
DELTA	4.2606	1.9506	1.9506
RANK	1	2.5	2.5

Table-8: Response Table for S/N ratio (SR)

S. NO	CONTROL FACTORS	MRR		SR	
		BEST LEVEL	VALUE	BEST LEVEL	VALUE
1	PULSE-ON	1	30	2	60
2	PULSE-OFF	2	5	2	5
3	VOLTAGE	2	15	2	15

Table-9: Optimum Conditions using TaguchiMethod

CONCLUSION

Based on the Taguchi's optimization method,table 9 shows the optimal parameters combination for MRR and SR.The objective such as MRR and SR are optimized using a Taguchi's L9 Orthogonal Array (OA) has been validated using the experimental works. The major conclusion drawn from the above investigation for optimization on Monel 400 is given below:

- Optimized condition to get Maximum MRR are:

Pulse-ON - 30µs, Pulse-OFF - 5µs, Voltage - 15V

- Optimized condition to get Minimum SR are:

Pulse-ON - 60µs, Pulse-OFF - 5µs, voltage – 25V

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