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Parametric Optimization Of Electro Discharge Machining Of SAE-8620 Alloy Steel Material Using Taguchi Technique

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ABSTRACT

EDM has become an significant and cost-effective method of machining really tough and brittle electrically conductive materials. It is widely used in the process of making molds and dies and sections of compound geometry and intricate shapes. The work piece material selected in this experiment is SAE-8620 alloy steel taking into account its wide usage in industrial applications. In today's world SAE-8620 alloy steel contribute to almost half of the world's production and consumption for industrial purposes. The input variable parameters are current, pulse on time and duty cycle. With the help of MINITAB software an orthogonal array of input variables was created using the design of experiments (DOE). The effect of the variable parameters mentioned above upon machining characteristics such as material removal rate (MRR), tool wear rate (TWR) is calculated and investigated. The tool material is copper, brass.The results reveal that the primary factor affecting the MRR is peak current subsequently followed by material, duty cycle and pulse on time, In case of TWR the primary factor affecting TWR is material then duty cycle and current at last spark on time.

Key words: EDM, electrode, pulse on time, MRR, TWR

1. INTRODUCTION

Non-traditional machining has grown out of the need to machine exotic engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity. Electric discharge machinery developed in late 1940's has been accepted worldwide as a standard process in manufacturing and is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, has alloys, nitralloy, carbides, heat resistant steels etc. Being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries SAE-8620is the most preferred material for forging components consequently; an analysis on the influence of current and pulse duration and duty cycle over MRR and TWR was performed. EDM is now unquestionably recognized as an important precision machine tool forming process for producing internal shapes on work piece, this study present experimental analysis based on mixed design. The objective of this research is to study the performance of different electrode materials on SAE-8620 work piece with EDM process

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2. LITRETURE REVIEW

Macedo F. T. B., Wiessner (2016) Erosion phenomena in dry EDM under different breakdown mechanisms are characterized in the present work. Plasma of discharges in air is mostly composed of Cu species from the electrodes due to the vacuum breakdown mechanism. The dimensions of the plasma are restricted to the tool electrode borders and its interaction with the work piece tends to be concentrated in small spots, generating relatively large craters not very spread over the surface. Single sparks in air produce single or several craters on the anode surface.

Georg Wälder, Jacques Richard (2016) Metallurgical modifications of machined metal surfaces are created by nearly all machining processes based on thermal and or mechanical processes. The EDM electro-discharge machining creates a so called "white layer" or "heat affected zone" (HAZ) having a thickness ranging from a few hundred micro-meters (for roughing operation) down to a few micrometers (for finishing). This remaining HAZ is a problem for many industrial applications: the presence of micro-cracks and metallurgic in homogeneity inherent to thermal stresses reduces part lifetime of tools, etc. due to fatigue stress.

3. EXPERIMENTAL MATERIALS AND EQUIPMENTS

3.1 Tool material

The work piece material was a SAE-8620 the electrode materials were copper and brass. The chemical composition of electrode materials which is show in Table 1

Table 1 Chemical Composition of Electrode materials

Composition in %	Copper	Brass
Copper	99.750	56.700
Aluminum	0.040	0.025
Tin	0.030	0.020
Phosphorous	0.030	0.020
Lead	0.009	3.000
Iron	0.015	0.100
Zinc	0.060	39.850
Nickel	0.010	0.0770

Figure 1 Brass,Copper electrode(Dia 15mm)

3.2 Work material

Specimens were prepared through normalizing process by taking pre heating temperature 860°c and time in preheating zone is 2 hours and soaking temperature is 880°c and soaking time is 1.2hours(80 minutes)this process give a distributed pearlite in ferrite matrix with 40% barite with a hardness 363BHN .composition as shown in table-2

Table-2 Composition of SAE-8620

COMPOSITION	PERCENTAGE
Carbon	0.18-0.23%
Silicon	0.15-0.35%
Manganese	0.7-0.9%
Nickel	0.4-0.7%
Chromium	0.40-0.60%
Molybdenum	0.15-0.25%
Sulphur	0.04% max
Phosphorus	0.035% max

Fig.2 Work Piece SAE-8620

3.3 Die-sinking EDM machine

The equipment used to perform the experiments was a die-sinking EDM machine of type SE-35 Electra plus 500x300. a jet flushing system in order to ensure the adequate flushing of the EDM process debris from the gap zone is employed. Pressure of the dielectric fluid is adjusted manually at the beginning of the experiment. The dielectric fluid used for the EDM machine was EDM oil-30, which is commercially available dielectric fluid. Polarity of the electrode is negative and that of the work piece is positive.

Fig.3 Electronica SE-35 EDM machine

4. EXPERIMENTAL DETAILS

This paper uses Taguchi method, which is very effective to deal with responses influenced by multi-variables. This method is a powerful Design of Experiments tool, which provides a simple, efficient and systematic approach to determine optimal machining parameters. Compared to the conventional approach to experimentation, this method reduces drastically the number of experiments that are required to model the response functions. Traditional experimentation involves one-factor-at-a-time experiments, wherein one variable is changed while the rest are held constant. The major disadvantage of this strategy is that it fails to consider any possible interactions between the parameters. Taguchi technique overcomes all these drawbacks. The main effect is the average value of the response function at a particular level of a parameter. The effect of a factor level is the deviation it causes from the overall mean response. The Taguchi method is devised for process optimization and identification of optimal combinations of factors for given responses. The steps involved are: 1. Identify the response functions and the process parameters to be evaluated. 2. Determine the number of levels for the process parameters and possible interaction between them. 3. Select the appropriate orthogonal array and assign the process parameters to the orthogonal array and conduct the experiments accordingly. 4. Analyze the experimental results and select the optimum level of process parameters. 5. Verify the optimal process parameters through a confirmation experiment. The process parameters chosen for the experiments are: (a) pulse-on time (T_{on}), (b) peak current (I_p), and (c) duty factor (τ) and three electrode Copper and brass. While the response functions are: (a) electrode wear rate (EWR) and (b) material removal rate (MRR).According to the capability of the commercial EDM machine available and general recommendations of machining conditions for SAE-8620 the range and the number of levels of the parameters are selected as given in

Table 3 –Level values of input Factors

Control factors	1	2
Peak Current(I_p),amp	5	10
Electrode	Copper	Brass
Spark on time (T_{on}) µsec.	500	1000
Duty cycle(τ)	10	11

A Taguchi design or an orthogonal array the method is designing the experimental procedure using different types of design like, two, three, four, five, and mixed level. In the study, a four factor mixed level setup is chosen with a total of eight numbers of experiments to be conducted and hence the OA L_8 was chosen. This design would enable the two factor interactions to be evaluated. As a few more factors are to be added for further study with the same type of material, it was decided to utilize the L_8 setup, which in turn would reduce the number of experiments at the later stage.

5. EXPERIMENTAL PROCEDURE

Experiments are performed, randomly, according to the L_8 orthogonal array, on A SAE-8620. For each experiment a separate electrode is used. The machining time is 15 minutes for all experiments. The machining time is noted from the timer of the machine. The electrode wear rate is calculated by weight difference of the electrodes using automatic weighing machine with 300 g capacity with a precision of 0.0001g. The experimental results for TWR, MRR based on L_8 orthogonal array is shown in table-4

TABLE 4 MRR AND TWR

EXP.NO	MRR(gm/m)	TWR(gm/m)
1	0.028	0.0011
2	0.019	0.0034
3	0.035	0.0074
4	0.038	0.0025
5	0.03	0.020
6	0.03	0.0022
7	0.05	0.0112
8	0.035	0.020

6. RESULTS AND DISCUSSION

After the experimental procedure, different response factors like MRR, TWR calculated from the observed data. Then a statistical analysis was performed on the calculated values.

6.1 Effect of input factors on MRR

The response table for MRR is shown in table 5 and corresponding analysis variances (ANOVA) table is shown in table 6for MRR, the calculation of S/N ratio follows "Larger the better model".

Table-5 Response table for signal-to- noise ratio for MRR

Level	Material	On Time	Current	Duty Cycle
1	-30.93	-29.31	-31.73	-30.84
2	-29.09	-30.71	-28.29	-29.18
Delta	1.84	1.4	3.44	1.66
Rank	2	4	1	3

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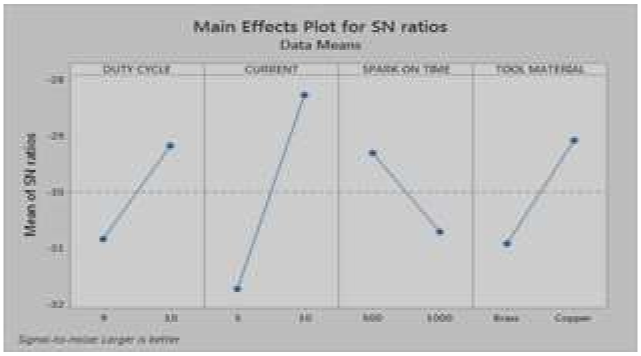

Figure 4 Main Effect Plot For SN Ratio of MRR

Table-6 Analysis of Variance for MRR

Source	Seq SS	Adj SS	F	P	% contribution
Tool	6.77	6.77	15.9	0.03	16.51
T_{on}	3.89	3.89	9.2	0.06	9.45
I_p	23.7	23.7	55.83	0.01	56.85
T	5.51	5.51	12.97	0.04	13.388
Error	1.27	1.27			3.09
Total	41.1				

Referring table 6 it is noticed that factor peak current (I_p) has largest contribution to the total sum of squares i.e. 56.85%. The factor Duty Cycle and material also have the considerable contribution in total sum of the squares which is 13.38% and 16.51% respectively. The factor Spark on Time has much less contribution of 9.45 %. The larger the contribution of any factor to the total sum of squares, the larger is the ability of that factor to influence material removal rate (MRR). So peak current (Ip) has maximum effect on material removal rate, Duty Cycle and material have considerable effect on material removal rate whereas Spark On Timehas very less effect on MRR shown in fig-4

5.3 Effect of input factors on TWR

The response table for TWR is shown in table 7and corresponding analysis variances (ANOVA) table is shown in table -8 for MRR, the calculation of S/N ratio follows "SMALLER the better model"

Table-7 response table for signal-to- noise ratio for TWR

Level	Duty Cycle	Current	Spark On Time	Tool Material
1	50.8	48.97	43.75	40.15
2	40.2	42.02	47.25	50.85
Delta	10.6	6.95	3.5	10.69
Rank	2	3	4	1

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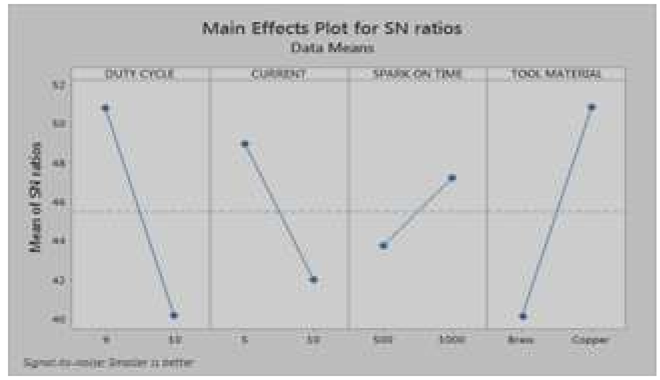

Figure 5 Main Effect Plot For SN Ratio of TWR

Table-8 Analysis of Variance for TWR

Source	Seq SS	Adj SS	F	P	% contribution
T	224.8	224.8	22.8	0.01	37.2
I_p	96.58	96.58	9.83	0.05	15.9
T_{ON}	24.45	24.45	2.49	0.21	4.04
Tool	228.7	228.6	23.2	0.01	37.8
Error	29.48	29.48			4.88
Total	604				

Referring table-8 it is noticed that material has largest contribution to the total sum of squares i.e. 37.8%. The factor duty cycle and current also have the considerable contribution in total sum of the squares which is 37.2% and 15.9 % respectively. The factor pulse on time (T_{on}) has much less contribution of 4.04 %. The larger the contribution of any factor to the total sum of squares, the larger is the ability of that factor to influence tool wear rate (TWR). So material has maximum effect on tool wear rate, duty cycle and current have considerable effect on tool rate whereas pulse on time (ton) has very less effect on TWR shown in fig-5

6. CONCLUSION

The present work shows the use of taguchi method to find out optimal machining parameter. The s/n ratio for the test results were found out using the taguchi method. Machining parameters namely material, peak current (I_p), duty cycle (τ) and pulse on time (T_{on}) is optimized to meet the objective. As

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a result of the study the following conclusions are drawn:-

1. The results reveal that the primary factor affecting the MRR is peak current subsequently followed by material, duty cycle and pulse on time.
2. In case of TWR the primary factor affecting TWR is material then duty cycle and current at last spark on time.
3. The optimized factor for MRR is cupper, duty cycle (τ) =10, pulse on time=500µs, peakcurrent=10amp
4. For TWR the optimized factors are brass, peak current=10amp, pulse on time (T_{on}) =500µs, duty cycle (τ) =10

So now it is found by this research how to use Taguchi parameter design to obtain optimum condition with lowest cost, minimum number of experiments and industrial engineer can use this method.

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