Optimization of Various Machine Process Parameters on the Surface Roughness in EDM for an En21 Material using Anova

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Abstract— In manufacturing industries right selection of manufacturing condition is one of the most important aspects taken into consideration in the majority of processes and particularly in processes related to Electric Discharge Machining (EDM).The EDM is a non-traditional machining processes that involved a transient spark discharges through the fluid due to the difference between the electrode and the work piece. EN 21 materials has 3% nickel steel capable of being heat treated to produce an excellent resistance to shock combined with a tensile strength. It is obtained by water hardening and tempering for best combination of mechanical properties. The EDM process is finding out the effect of machining parameter such as discharge current, pulse on time and pulse off time of EN21 material. In this project we have determination surface roughness of EN21 material by changing machine process parameters of an EDM. We have used to Taguchi method and L27 orthogonal array are to reduce the number of experiment. We have got the 5.826 µm surface roughness value at current 14A, pulse on time 20µs and pulse off time 200µs. The ANOVA technique was used for identifying the most significant factor and interaction plot of process parameters on surface roughness. From ANOVA, it is observed that for Ra the discharge current and pulse on time was most significant factor.

Key words: EDM, Surface Roughness, Optimization, Analysis Of Variance (ANOVA), S/N Ratio

I. INTRODUCTION

Electrical Discharge Machining (EDM) is a non- traditional machining process which is more efficient than traditional machining process. The new concept of manufacturing non-conventional energy sources like as sound, light, mechanical, electrical, chemical, ions and electrons. Along with industrial and technological growth, complex to machine material and development of harder, huge application in aerospace, nuclear engineering, hardness and heat resistance qualities has been witnessed. with help of this machine difficult shapes and material removal mainly occurs due to thermal energy of the park The EDM process is huge employed for accurate parts, dies and tool making.

The effect of different input parameters over the surface roughness in EDM using the Grey-Taguchi method and also found that current had larger impact over the SR and also the experimental and predicted value was much closed to each other for an EN 41 material. In this paper finding the various surface roughness like R_a, R_q, R_{sk},R_{ku} and R_{sm}(Vikas at al,2014). The effect of pulse-on time, pulse-off time, discharge current and voltage on surface roughness of EDM with an EN19 material due to molybdenum and chromium. The experiment conducted as per L_{31} orthogonal array based on Response Surface Method (RSM). They observed that for Ra value of peak current and pulse-on time was most significant feature. R_a value decrease with a decrease in peak current as well as pulse on time (Shashikant at al, 2014). The mathematical modeling of EDM with AISI 4340 steel. The effect of MRR and SR with process parameters taken in to consideration were the pulse-on time, pulse-off time and peak current. The three level full factorial design was choosing. Finally the significant of the models were checked using the ANOVA. When the pulse-on time increase the roughness average values also increase so, batter surface roughness, the pulse-on time must be optimum. There is no change in Ra value when pulse-off time is increase(N.Annamalai at al, 2014). The effect of the EDM on such process parameters like as pulse-on time, pulse=off time, discharge current and voltage of MRR and SR of EN 31 steel tool. For a experimental plan central composite design (CCD) was used. Experiment result shows that with an increase in current and pulse–on time. Surface roughness value increase in the experimental regime(Milankumar Das at al, 2014). They have optimized the optimal process parameters of EDM a RENE 80 nickel steel alloy material. For current 60A, pulse on time 6µs and pulse off time value is 50µs. The surface finish is better than other value which shoes that in the fig. The SR value is increase with increases current and pulse on time but increase with increase in pulse off time(Chanramauli at al, 2014). The MRR, Tool Wear Rate and Surface Roughness for NiTi alloy. When the increase of pulse current in NiTi alloy, SR value increase. To obtain the least amount of SR, the least value of pulse current and pulse on time should be chosen and the off time between two pulses should be increase(Saeed Daneshmand at al, 2013).

II. SIGNAL TO NOISE RATIO

Taguchi used the signal-to-noise(S/N) ratio as the quality characteristic of choice. S/N ratio is used as a measurable value instead of standard deviation due to the fact that as the mean decreases, the standard deviation also decreases and vice versa. The category) the-higher-the-better was used to calculate the S/N ratio for both quality characteristics tensile strength and hardness, according to the equation:

$$\eta = -10\log_{10}\left(\frac{1}{n}\sum_{i-1}^{a} y_1^{\,2}\right)$$

Where: η = Signal to noise ratio
n = Number of repetitions of experiment
yi = Measured value of quality characteristic

III. EXPERIMENTAL SETUP

Fig.1 Toolcraft A25 EDM Machine

Experiments were conducted on die sinking EDM machine (TOOL CRAFT A25). The tool electrode (positive polarity) of electrolytic copper with 60 mm long and 12 mm diameter and work piece material EN21 with round cylinder of diameter 56 mm and 15 mm thick was used. EDM oil of commercial grade is used as die-electric fluid. With the help of DOE(Design of Experiment) [MINITAB Inc16] three levels, three parameters and 27 experiments were conducted. The process variables with their values on different levels are listed in table.

Variable	Level		
	1	2	3
Discharge current	14	28	22
Pulse on time	10	20	50
Pulse off time	500	200	100

Table.1 Design factor along with their levels

Analysis of variance (ANOVA) was performed on balanced data for wide variant of experience design. In ANOVA F-ratio calculates the, which is the ratio between the regression mean square and the mean square error. The analysis of variance is the statically treatment most commonly applied to the result of the experiment to determine the percent of contribution of each factors. Study of ANOVA table for given analysis help to determine which of the factors need control and which do not. These analysis were doing using MINITAB software specialized for the purpose.

Ex No.	Current (A)	T_{on} (µs)	T_{off} (µs)	SR (µm)	S/N ratio (LB)
1	14	10	500	6.41	-16.137
2	14	10	500	8.6	-18.689
3	14	10	500	8.65	-18.74
4	14	20	200	5.49	-14.791
5	14	20	200	6.19	-15.833
6	14	20	200	5.8	-15.268
7	14	50	100	7.53	-17.535
8	14	50	100	7.71	-17.741
9	14	50	100	7.12	-17.049
10	18	10	200	11.2	-20.984
11	18	10	200	11.63	-21.311
12	18	10	200	11.58	-21.274
13	18	20	100	10.78	-20.652
14	18	20	100	11.57	-21.266
15	18	20	100	10.27	-20.231
16	18	50	500	12.58	-21.993
17	18	50	500	13.05	-22.312
18	18	50	500	12.9	-22.211
19	22	10	100	11.9	-21.511
20	22	10	100	12.23	-21.748
21	22	10	100	11.97	21.561
22	22	20	500	8.97	-19.055
23	22	20	500	8.17	-18.244
24	22	20	500	9.25	-19.322
25	22	50	100	10.51	-20.432
26	22	50	100	10.92	-20.764
27	22	50	100	11.26	-21.031

Table 2: Experiments results

IV. RESULT AND DISCUSSION

Experimental are carried out varying the process parameters like as discharge current, pulse on time and pulse off time in EDM of EN 21 material. The experimentals are conducted based on design of experiment consisting 27 numbers of experiments. Experimental results for surface roughness parameter Ra are presented in Table.2. The signal to noise ratios (S/N), which are log functions of desired output, serve as the objective functions for optimization, help in data analysis and the prediction of the optimum results. The ratio depends on the quality characteristics of the product/process to be optimized. Using the experimental results for Ra, ANOVA for the adequacy of the model is then performed in the subsequent step. The F ratio is calculated for 95% level of confidence. The value which are less than 0.05 are considered significant and the values greater than 0.05 are not significant and the model is adequate to represent the relationship between machining response and the machining parameters. It is observed from the adequecy test by ANOVA that linear term, discharge current, pulse on time and pulse off time.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
D C	2	106.682	106.682	53.341	103.20	0.000
T_{on}	2	22.407	22.407	11.204	21.67	0.000
T_{off}	2	2.389	2.389	1.194	2.31	0.125
Error	20	10.338	10.338	0.517	-	-
Total	26	141.816	-	-	-	-

Table.3 ANOVA table for surface roughness

Fig.2 depicts the main effect plot for Ra. From this figure, it is clear that the parameters peak current and pulse on time have highest inclination, so these are most significant factors affecting surface roughness.

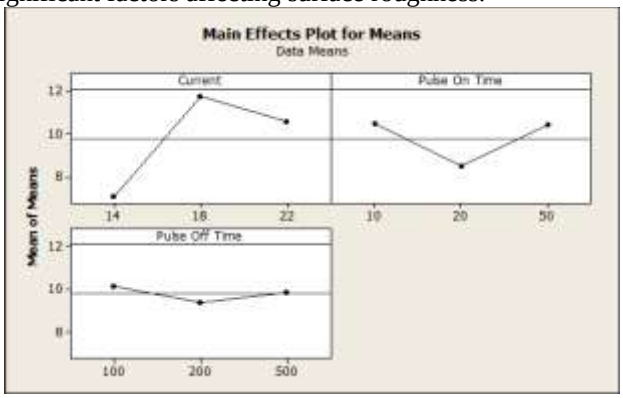

Fig. 2: Effect of Process Parameters on mean

A. Effect of Discharge current on surface roughness:

Fig.2 show that investigation on the effect of discharge current during the EDM process of EN21, it was found that initially when the current was increase the roughness of EN21 material increase up to current 18A. Then with further decrease in current more than 22A the surface roughness decrease.

B. Effect of Pulse on time on surface roughness:

Fig.2 show that surface roughness increase with the increase in pulse on time up to 20µs, and then start to increase under given working condition. When the pulse on time is low the SR of the successive traces will be small.

C. Effect of pulse off time on surface roughness:

From the curves in Fig.2, it can be seen that a reduction in surface in surface roughness in achieved up to the 200 µs in both figure, but beyond this number of pulse off time of surface roughness starts to increase. Similarly to the effect of SR, after a particular pulse off time, the surface becomes highly work-hardened, causing flaking to occur. This will lead to the effect of the surface and an increase in the surface roughness.

V. CONCLUSION

EDM Machine is widely utilized in industries. The EDM machining of EN21 material has been performed with the application of combination with design of experiment (DOE).The parameters studied were how to have setting for the parameter such as discharge current, pulse on time and pulse off time. The following conclusions have been derived.

- From ANOVA, it is observed that for Ra the discharge current and pulse on time was most significant factor.
- The surface roughness value in µm increase when there is increase discharge current. So the discharge current must be kept optimum for minimum Ra value.
- When the pulse on time increase the roughness average value also increase. So for batter surface finish, the pulse on time must be optimum.
- There is no change in Ra value when the pulse off time is increased.
- For optimum surface roughness obtain on A1B2C2.

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