Optimization of Electrical Discharge Machining Parameter using RSM Tool

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ABSTRACT

Over EDM Different systems are connected will move forward the material removal rate (MRR), surface roughness (SR) and tool wear rate (TWR) with distinctive cathode mix. However, the machining parameters need aid likewise successful same time machining. This worth of effort displays the effects of a scientific examination conveyed out to the impacts from claiming electrical discharge machining parameters for example, current, pulse on time, pulse off time and lift time with respect to material removal rate Furthermore surface roughness in electrical discharge machining of 17-4 PH steel toward utilizing copper cathode. Reaction surface technique ANOVA strategies would have utilized to information examination to unravel those multi-response streamlining. On accept those ideal levels of the parameter, affirmation run might have been performed by setting those parameters during ideal levels. Material removal rate throughout the methodology need been made concerning illustration profit estimate with the goal should amplify it. For a purposeful about minimizing surface roughness is been recognized concerning illustration the vast majority vital yield parameter. It will be found that the great concurred upon from claiming that current will be practically noteworthy parameter to material removal rate and lesquerella to surface roughness trailed toward pulse on time and lift time.

Keywords: *EDM, MRR, SR, Response Surface Methodology, ANOVA.*

1. INTRODUCTION

EDM may be currently turned the A large portion essential acknowledged advances done manufacturing commercial enterprises since huge numbers perplexing 3d shapes could make machined utilizing a straightforward formed apparatus cathode. EDM will be a critical 'non-traditional manufacturing method', created in the late 1940s Also need been acknowledged overall Likewise A standard preparing fabricate for framing devices to process plastics mouldings, kick the bucket castings, fashioning dies Furthermore and so forth. New developments in the field of material science need prompted new building metallic materials, composite materials, and high-tail ceramics, hosting great mechanical properties Also warm aspects and in addition electrical conductivity In this way that they might promptly make machined eventually perusing flash disintegration. In the exhibit time, electrical release machine (EDM) may be A broad strategy utilized within business for secondary precision machining of the greater part sorts for conductive materials for example, metals, metallic alloys, graphite, or Significantly A percentage ceramic materials, from claiming whatsoever hardness.

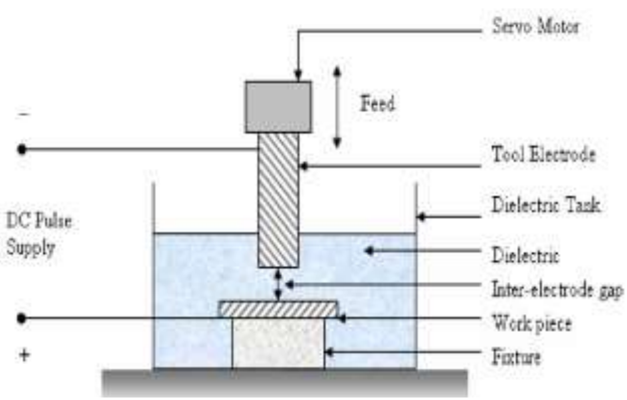

Figure 1. Schematic diagram of Electric discharge machine

2. PROBLEM IDENTIFICATION

Taguchi technique is normally used in linear interactions only. This is due to the fact that in Taguchi design, interactions between controls factors are aliased with their main effects. 3D surfaces generated by RSM can help in visualizing the effect of parameters on response in the entire range specified whereas Taguchi technique gives the average value of response at given level of parameters. Thus, RSM is a promising analytical tool to predict the response which suits the range of parameters studies.

The accuracy of the product happens due to the surface roughness (SR) is low or material removal rate (MRR) is not appropriate. Furthermore, electrode wear imposes high price on makers to substitute the worn difficult electrodes by new ones for die making. So, in order to improve the machining efficiency, erosion of the work piece must be maximized and that of the surface roughness minimized in EDM process. Therefore, learning the material removal rate, surface roughness and related vital factors would be effective to improve the machining productivity and process responsibility.

3. METHODOLOGY

To start optimization having discussion of present work designed earlier just before the implementation of machining. This one concerns by using design of experiments from response surface optimization method (RSM), preference of work piece, selection of tool, investigational set-up then by using the data of experiments (DOE) response made for Material Removal Rate (MRR) and Surface Roughness (SR).

Table 1. Chemical composition of materials [23]

Element	Concentration (% by weight)	Element	Concentration (% by weight)
Carbon	0.07 max	Chromium	15.00 – 17.05
Manganese	1.00 max	Nickel	3.00 – 5.00
Phosphorus	0.040 max	Copper	3.00 – 5.00
Sulphur	0.030 max	Columbium + Tantalum	0.15 – 0.45
Silicon	1.00 max	Iron	Balance

Table 1. Process parameters [23]

Input Parameters/Factors	Low	Intermediate	High
Discharge current (I) (A)	9	12	15
Pulse on time (T_{on}) (μs)	50	100	200
Pulse off time (T_{off}) (μs)	20	50	100
Lift Time (T) (μs)	10	20	50

Response Surface Methodology

Response Surface Methodology (RSM) was introduced by Box and Wilson in 1951 and later popularized by Montgomery. As per the introducer of the idea response-surface methodology can be defined as an empirical statistical technique employed for multiple regression analysis by using quantitative data obtained from properly designed experiments to solve multivariate equations simultaneously. The graphical representations of these equations are called response surfaces, which can be used to describe the individual and cumulative effect of the test variables on the response and to determine the mutual interactions between the test variables and their subsequent effect on the response.

$$Y_u = \beta_0 + \sum_{i=1}^{s} \beta_i X_i + \sum_{i=1}^{s} \beta_{ii} X_i^2 + \sum_{i>i}^{s} \beta_{ij} X_i X_j \ldots,$$

Table 2. Response values of MRR and SR [23]

S. No.	I	Ton	Toff	Lift time	MRR	SR
1	9	50	20	10	68.73	6.88
2	9	50	50	20	66.96	7.63
3	9	50	100	50	70.72	7.20
4	9	100	20	20	24.37	7.45
5	9	100	50	50	25.3	8.07
6	9	100	100	10	23.7	5.61
7	9	200	20	50	2.53	3.46
8	9	200	50	10	6.51	3.97
9	9	200	100	20	5.04	3.71
10	12	50	20	20	47.66	7.31
11	12	50	50	50	26.70	7.93
12	12	50	100	10	94.07	8.01
13	12	100	20	50	33.93	8.08
14	12	100	50	10	29.81	6.68
15	12	100	100	20	31.32	6.92
16	12	200	20	10	9.54	4.35
17	12	200	50	20	11.12	4.17
18	12	200	100	50	10.13	3.53
19	15	50	20	50	122.6	9.78
20	15	50	50	10	189.27	9.19
21	15	50	100	20	162.8	10.54
22	15	100	20	10	54.96	7.23
23	15	100	50	20	45.27	8.24
24	15	100	100	50	39.77	10.12
25	15	200	20	20	15.42	3.58
26	15	200	50	50	14.03	4.89
27	15	200	100	10	16.03	4.86

4. RESULT AND DISCUSSION

The Response surface optimization method is to identify the parameter settings which improve the quality of the product or process robust to unavoidable.

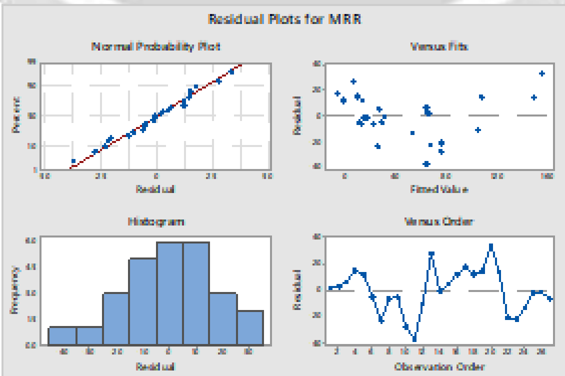

Figure 2. Residual plot for Material removal rate (MRR)

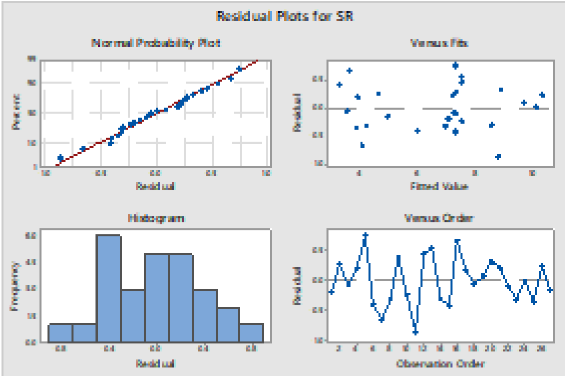

Figure 3. Residual plot for Surface roughness (SR)

In Figure 2 and Figure 3, shows the normal probability model is adequate as represented by the points falling on a straight-line plot. It mentioned that the errors are normally distributed. Also, the plot of the residual's vs predicted response is structure less i.e. containing no obvious pattern.

4.1 Empirical Models

Regression Equation for MRR and SR is

MRR = 294 - 35.4 A - 1.299 B + 0.43 C - 0.92 D + 2.26 A*A + 0.00640 B*B- 0.00056 C*C+ 0.0170 D*D - 0.0775 A*B - 0.0064 A*C- 0.094 A*D - 0.00143 B*C + 0.00555 B*D - 0.00053 C*D

SR = 11.72 - 1.131 A+ 0.0407 B- 0.0402 C+ 0.0381 D+ 0.0522 A*A- 0.000146 B*B - 0.000130 C*C- 0.000444 D*D- 0.001963 A*B+ 0.00530 A*C+ 0.00283 A*D- 0.000040 B*C - 0.000241 B*D+ 0.000002 C*D

Where, A= I
B= Ton
C= Toff
D= Lift Time

4.2 Optimization

The optimizations plot for material removal rate (MRR) and surface roughness (SR) is shown in Figure 4. The main objective of this work was to maximize the material removal rate (MRR) and minimize the surface roughness (SR). The desirability approach was used for determining out the optimum values of material removal rate (MRR) and surface roughness (SR).

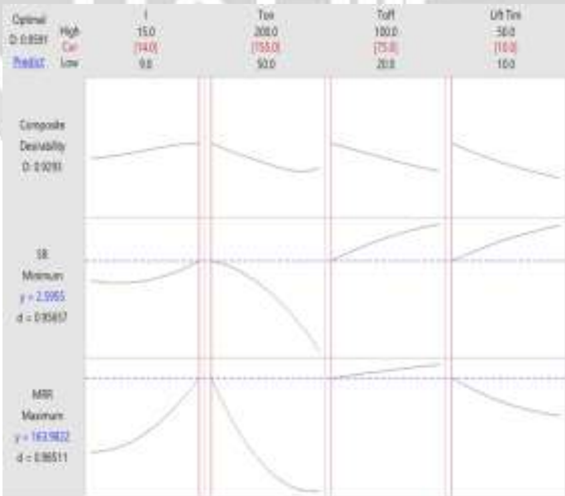

Figure 4. Optimization plot for material removal rate and surface roughness

Table 3. Comparison of results with present work and previous work [23]

Response	Chandramouli and Eswaraiah [23]	DOE RSM (Proposed Work)	% Improvement
MRR (mg/min)	134.19	**163.98**	**22.19%**
SR (µm)	2.89	**2.59**	**10.38%**

5. CONCLUSION

- From above discussion, it was concluded or observed that the response surface methodology has been quite robust and allowed for this work to find the contribution of each machining parameters and their interaction.
- Material removal rate increases as the current and pulse on time increases while pulse off time and lift time has been decreasing.
- Surface roughness are increasing with increase in current and pulse on time but decreasing with an increase in pulse off time and lift time.
- The main objective of the future work is to maximize the Material Removal Rate (MRR) and minimize the Surface Roughness (SR) value.
- The present predicted results were compared with literature [23] and the good agreement and improvement was found approx. 10-17% for MRR and SR value.
- It is Also concluded that the Taguchi technique is normally used in linear interactions only but RSM can help in visualizing the effect of parameters on response in the entire range specified. Taguchi technique gives the average value of response at given level of parameters but RSM is a promising analytical tool to predict the response which suits the range of parameters.

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