OPTIMIZATION OF PROCESS PARAMETERS IN EDM ON TITANIUM ALLOY GRADE 5 USING TAGUCHI ANALYSIS

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Abstract : In present work, the experiments were performed on NUMERICAL CONTROL EDM with COPPER ELECTRODE on TITANIUM ALLOY GRADE-5 material. Taguchi's L9 (3*3) Orthogonal Array (OA) has been used for experimentation. Three input parameters each with 3 levels, total 9 experiments are conducted to evaluate responses. MINITAB 18 software is used to analyze the experimental results for better surface roughness. A mathematical model is developed to establish relationship between control parameters and Output parameter (surface roughness).

Keywords: EDM, Orthogonal Array(OA), Taguchi Method, Surface Roughness.

1. INTRODUCTION

EDM is considered as a unique adoption of the conventional process, which uses an electrode to initialize the sparking process. With this process, any material can be machined irrespective to their hardness and toughness.

EDM, sparks jump from the electrode to the work piece. This causes material to be removed from the work piece In addition, EDM does not make direct contact between the electrode and the work piece eliminating mechanical stresses, chatter and vibration problems during machining.

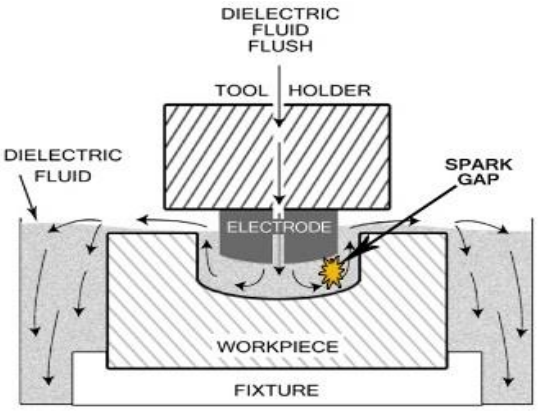

Figure: Schematic Representation of Ram EDM

2. LITERATURE REVIEW

For determining the better parametric settings, lot of work has been done in the engineering design. The EDM processes are having several performance characteristics like Metal Removal Rate, Surface roughness, Dimensional error etc. The optimal parametric settings with respect to different performance characteristics are different. Some of the research contributions to cite are:

Cao and Yang [1] carried out an experiment, and then they have used artificial neural network (ANN) and genetic algorithm (GA) together to establish the parameter optimization model.

Lee et al. [2] have done experiment and found that the results of MRR and surface roughness increases with the values of pulse current but after certain value SR and MRR reduce because of expansion of electric plasma.

Karthikeyan et al. [3] Experiment was done on EZNC EDM machine using 20 mm diameter copper electrode. Three level full factorial designs were used and its analysis is done.

Though many researchers have conducted experimentation on various materials still there is a lacuna in finding correct parameter setting to machine Titanium Alloy Grade 5 for better quality with reduced costs. With this above aim an attempt has been made in this paper.

3. DESIGN OF EXPERIMENTS

3.1 Selection of Orthogonal Array

The experiment designs were done based on the Taguchi Method. Genichi Taguchi a Japanese scientist developed a technique based on Orthogonal Array of experiments. This technique has been widely used in different fields of engineering to optimize the process parameters. The control factors considered for the study are Pulse-on, Pulse-off, and Current. Three levels for each control factor will be used. Based on number of control factors and their levels, L'9 orthogonal array (OA) was selected.Table-1 represents various levels of control factors and table-2 represents experimental plan with assigned values

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Table-1: Levels of various control factors

Control Factors		LEVELS		
		I	II	III
1	Pulse-on (µs)	15	25	30
2	Pulse-off (µs)	5	7	9
3	Discharge Current(A)	5	10	15

Table-2: Matrix of Experiments with assigned values

S.No	Pulse On (µs)	Pulse Off (µs)	Discharge Current (A)
1	15	5	5
2	15	7	10
3	15	9	15
4	25	5	10
5	25	7	15
6	25	9	5
7	30	5	15
8	30	7	5
9	30	9	10

3.2 Experimental Setup

The experiments were performed on NUMERICAL CONTROL EDM machine,

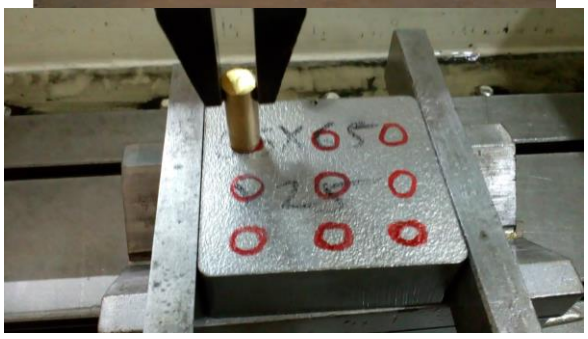

Figure: WORK PIECE SET UP IN EDM

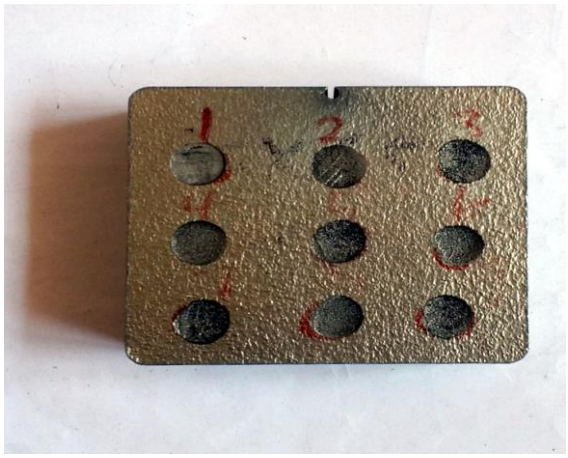

Figure: After machining the work piece

4. RESULTS AND DISCUSSION

The results obtained are analyzed using S/N Ratios, Response table and Response Graphs with the help of Minitab software.

Table-3: Surface Roughness Values

S. No	Pulse On (µs)	Pulse Off (µs)	DC (A)	Surface Roughness (µm)
1	15	5	5	2.52
2	15	7	10	2.35
3	15	9	15	3.21
4	25	5	10	3.41
5	25	7	15	3.5
6	25	9	5	4.1
7	30	5	15	2.16
8	30	7	5	3.47
9	30	9	10	3.97

4.1 Selection of Best Parameter Combination

Table-4: Response Table for Means

LEVEL	P ON	P OFF	CURRENT
1	2.693	2.697	3.363
2	3.670	3.107	3.243
3	3.200	3.760	2.957
DELTA	0.977	1.063	0.407
RANK	**2**	**1**	**3**

Table-5: Response Table for Signal to Noise Ratios (Smaller Is Better)

LEVEL	P ON	P OFF	CURRENT
1	-8.526	-8.457	-10.363
2	-11.264	-9.703	-10.017
3	-9.824	-11.454	-9.234
DELTA	2.738	2.996	1.130
RANK	2	1	3

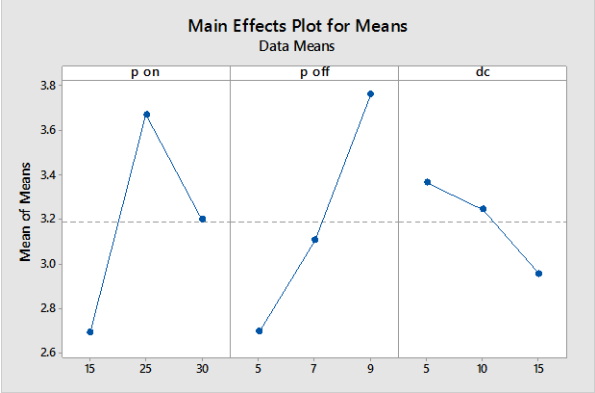

Figure: Response Graphs for Means (surface roughness)

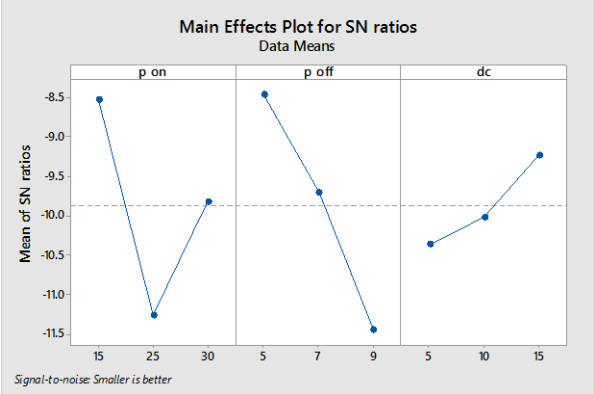

Figure: Response Graphs for S/N ratio (surface roughness)

Table-6: Optimum level combination for surface roughness

Control Factors	Optimum Level
Pulse ON	15
Pulse OFF	5
Discharge current	15

4.2 Development of Regression Equation

The objective of multiple regression analysis is to construct a model that explains as much as possible, the variability in a dependent variable, using several independent variables.

Ra =0.73+0.0429 P ON+0.266P OFF-0.0407DC

With the help of Regression equations the predicted values of surface roughness is calculated, and compared with experimental values to find the deviation for each experiment and is shown in the Table- 7.

Table-7: Comparison of Experimental and Predicted values

S.NO	Theoretical Values	Experimental Values
1.	2.5	2.52
2.	2.8285	2.35
3.	3.157	3.21
4.	2.7255	3.41
5.	3.054	3.5
6.	3.993	4.1
7.	2.7365	2.16
8.	3.6755	3.47
9.	4.004	3.97

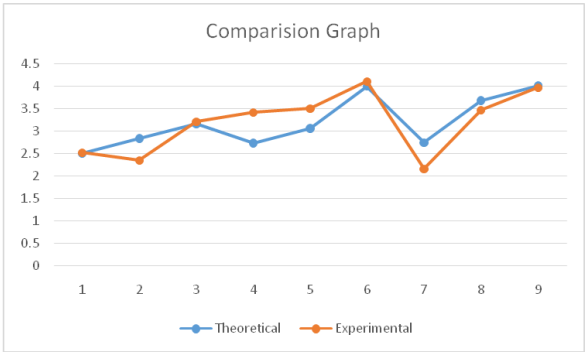

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Figure: Graph for predicted and experimental values of surface roughness

4.3 Validation Of Surface Roughness

Table-8: Validation of optimized values of MRR with experimental values

Response	Optimal Parameter	Predicted Value
Surface roughness	Pulse-On - 15 Pulse-Off - 5 Discharge Current - 15	2.093

5. CONCLUSION

Based on the results and discussion the following conclusions are drawn.

- It is observed that the effect of pulse-off is maximum on surface roughness followed by Pulse on and Discharge current has least effect on surface roughness.
- The optimal parameter setting for better surface roughness is obtained at Pulse-On 15 µs, Pulse-Off 5 µs, discharge current 15A.

6. FUTURE WORK

- The work can be extended by considering the other parameters like flush rate, measuring the initial electrode weight and final electrode weight, electrode tension, dielectric medium used and inter electrode gap etc.
- The work may be continued, for machining different materials for finding optimal combination of parameters and also by varying the electrode materials to find out the best material of the electrode.
- During the experiment, some noise factors were ignored like electrode vibrations, electrode speed, impurities present in the dielectric medium which can be included.

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