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Investigation of Optimum Process Parameters in Wire Cut EDM Process Using Regression Analysis

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ABSTRACT:

In this thesis, the effects of Pulse Time On, Pulse Tome Off, and Peak Current are investigated by determining quality of the machined surface. The optimization of the process parameters is done using Regression analysis taking L9 orthogonal array for minimal surface roughness values and maximum material removal rates. Experiments are conducted on the pieces by varying parameters. The material used for machining is Aluminum alloy and the process parameters varied are Pulse Time on 100μsec, 105μsec, 110 μsec, Pulse Time off 55μsec, 58μsec, 60μsec and Peak Current 160Amps, 170Amps, 180Amps. Wire Feed, Servo Voltage and Wire Tension are kept constant. Optimization is done using Minitab software.

Wire-cut EDM: The wire-cut type of machine arose in the 1960s for the purpose of making tools (dies) from hardened steel. The tool electrode in wire EDM is simply a wire. To avoid the erosion of material from the wire causing it to break, the wire is wound between two spools so that the active part of the wire is constantly changing. The earliest numerical controlled (NC) machines were conversions of punched-tape vertical milling machines. The first commercially available NC machine built as a wire-cut EDM machine was manufactured in the USSR in 1967. Machines that could optically follow lines on a master drawing were developed by David H. Dulebohn's group in the 1960s at Andrew Engineering Company for milling and grinding machines. Master drawings were later produced by computer numerical controlled (CNC) plotters for greater accuracy. A wire-cut EDM machine using the CNC drawing plotter and optical line follower techniques was produced in 1974. Dulebohn later used the same plotter CNC program to directly control the EDM machine, and the first CNC EDM machine was produced in 1976.

LITERATURE SURVEY

H. Singh and R. Garg et .al [1] 2009 evaluates the effects of various process parameters of WEDM like pulse on time (TON), pulse off time (TOFF), gap voltage (SV), peak current (IP), wire feed (WF) and wire tension (WT) have been investigated to reveal their impact on material removal rate of Hot die steel (H-11) using one variable at a time approach. The optimal set of process parameters has also been predicted to maximize the material removal rate & finally concluded that the wire feed and wire tension are neutral input parameters. The material removal rate (MRR) directly increases with increase in pulse on time (TON) and peak current (IP) while decreases with increase in pulse off time (TOFF) and servo voltage (SV). S. B. Prajapati and N. S. Patel et .al [2] 2013 evalutes the effect of process parameter like Pulse ON time, Pulse OFF time, Voltage, Wire Feed and Wire Tension on MRR, SR, Kerf and Gap current is studied by conducting an experiment. Response surface methodology is used to analyze the data for optimization and performance. The AISI A2 tool steel is used as work piece material in the form of square bar. & finally concluded that for cutting rate and surface roughness, the pulse ON and pulse OFF time is most significant. The spark gape set voltage is significant for kerf.

INTRODUCTION

EXPERIMENTAL SETUP AND PROCEDURE

Experiments have been performed in order to investigate the effects of one or more factors of the

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process parameters on the surface finish of the wire cut machined surface of Aluminum material. The main aim of the project is to determine the influence of time on, time off, wire feed and input power. The investigation is based on surface roughness during machining of Aluminum material.

EXPERIMENTAL PROCEDURE

The selected work piece materials for this research work are Aluminum alloy material. Experiments have been conducted on **wire cut edm**. The machine details are:

WIRE EDM CNC SPRINT CUT 734 (ELECTRANICA SPRINT CUT 734), Make: ELECTRIONCA LTD, PUNE

An electrolytic brass (Zinc coated) wire with a diameter of 2mm has been used as a tool electrode (positive polarity) and work piece materials used are Aluminum alloy and Copper materials rectangular plates of dimensions 80×30 *mm* and of thickness 6 *mm*. Commercial grades EDM oil will be used as dielectric fluid. Lateral flushing with a pressure of 7MPa will be used. The influence of time on, time off, wire feed and input power rate have been treated as controllable process factors. A collection tank is located at the bottom to collect the used wire erosions and then is discarded. The wires once used cannot be reused again, due to the variation in dimensional accuracy.

PROCESS PARAMETERS AND DESIGN

Input process parameters such as Pulse On time (TON), Pulse Off time (TOFF), Peak Current (Amp), used in this thesis are shown in Table. Each factor is investigated at three levels to determine the optimum settings for the WEDM process. All other parameters such as Wire Tension, Wire Tension and Servo Voltage are kept constant.

The selection of parameters for experimentation is done as per Regression analysis. An orthogonal array for three controllable parameters is used to construct the matrix of three levels of controllable factors. The L9 orthogonal array contains 9 experimental runs at various combinations of three input variables.

S.NO.	PROCESS PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
1	PULSE TIME ON (T_{ON}) µsec	100	105	110
2	PULSE TIME OFF (T_{OFF}) µsec	55	58	60
3	PEAK CURRENT (IP) Amps	160	170	180

Values for process parameters

The L9 orthogonal array for input parameters Pulse on time, pulse off time and peak current is shown in table below:

Exp no	**T on (µsec)**	**T off (µsec)**	**Ip (Amps)**
1	100	55	160
2	100	58	170
3	100	60	180
4	105	55	170
5	105	58	180
6	105	60	160
7	110	55	180
8	110	58	160
9	110	60	170

L9 parameters

RESULTS & DISCUSSIONS

In this project most important output performances in WEDM such as Surface Roughness (Ra) is considered for optimizing machining parameters. The surface finish value (in µm) was obtained by measuring the mean absolute deviation, Ra (surface roughness) from the average surface level using a Computer controlled surface roughness tester.

Surface Roughness Values with no. of trials

Exp no	T on (µsec)	T off (µsec)	Ip (Amps)	Surface Finish Values R_a
1	100	55	160	2.585
2	100	58	170	3.388
3	100	60	180	3.912
4	105	55	170	3.87
5	105	58	180	2.75
6	105	60	160	3.265
7	110	55	180	3.41
8	110	58	160	3.9
9	110	60	170	3.91

L9 parameters and Surface Roughness Results

MATERIAL REMOVAL RATE CALCULATIONS

$$MRR = \frac{W1 - W2}{\rho * t}$$

W_1 = Weight before machining (gms)
W_2 = Weight after machining (gms)
ρ = Density (gm/mm^3)
t = Time in min

Exp no	T on (µsec)	T off (µsec)	Ip (Amps)	MRR (mm^3/sec)
1	100	55	160	0.0658
2	100	58	170	0.1976
3	100	60	180	0.2045
4	105	55	170	0.2272
5	105	58	180	0.0946
6	105	60	160	0.3073
7	110	55	180	0.3246
8	110	58	160	0.3719
9	110	60	170	0.1515

L9 parameters and MRR Results

OPTIMIZATION USING REGRESSION ANALYSIS

DESIGN OF ORTHOGONAL ARRAY

Session

```
Factors:  3
Runs:     9

Columns of L9(3^4) Array

1 2 3
```

Worksheet 1 ***

↓	C1	C2	C3	C4
	PULSE TIME ON	PULSE TIME OFF	PEAK CURRENT	
1	100	55	160	
2	100	58	170	
3	100	60	180	
4	105	55	170	
5	105	58	180	
6	105	60	160	
7	110	55	180	
8	110	58	160	
9	110	60	170	

L9 orthogonal array of parameters

Enter Process Surface Roughness and MRR results in the table.

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	PULSE TIME ON	PULSE TIME OFF	PEAK CURRENT	SURFACE ROUGHNESS	MRR
1	100	55	160	2.585	0.0658
2	100	58	170	3.388	0.1976
3	100	60	180	3.912	0.2045
4	105	55	170	3.870	0.2272
5	105	58	180	2.750	0.0946
6	105	60	160	3.265	0.3073
7	110	55	180	3.410	0.3246
8	110	58	160	3.900	0.3719
9	110	60	170	3.910	0.1515

Parameters and Responses

SURFACE ROUGHNESS

Regression Analysis: SURFACE ROUGHNESS versus PULSE TIME ON, PULSE TIME OFF, PEAK CURRENT

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	0.53701	0.17900	0.58	0.653
PULSE TIME ON	1	0.29704	0.29704	0.96	0.372
PULSE TIME OFF	1	0.22269	0.22269	0.72	0.435
PEAK CURRENT	1	0.01728	0.01728	0.06	0.822
Error		5	1.54443	0.30889	
Total		8	2.08144		

Analysis of Variance

By observing P – value from above table, it can be found that the most important parameter is Pulse Time On.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.555775	25.80%	0.00%	0.00%

Model Summary

The optimization carried out is average as the R-Sq is 25.8%.

The goodness-of-fit of the model was checked by the determinationcoefficient (R^2 – 25.8%). The adjusted determination coefficient(adj. R^2=0.00%) was unsatisfactory for confirmingthe significance of the model.

Coded Coefficients

Term	Coeff	SE Coeff	T-Value	P-Value	VIF
Constant	3.431	0.186	18.46	0.000	
PULSE TIME ON	0.223	0.227	0.98	0.372	1.00
PULSE TIME OFF	0.191	0.225	0.85	0.435	1.00
PEAK CURRENT	0.054	0.227	0.24	0.822	1.00

Coded Coefficients

The probability (p) values were used as a tool to check the significance of each of the coefficients. A smaller p-value denotes greater significance of the corresponding coefficient.

Regression Equation in Uncoded Units

SURFACE ROUGHNESS = -6.56 + 0.0445 PULSE TIME ON+ 0.0766 PULSE TIME OFF+ 0.0054 PEAK CURRENT

The surface roughness considered should be minimum. The optimal parameters are selected at the minimal surface roughness values.

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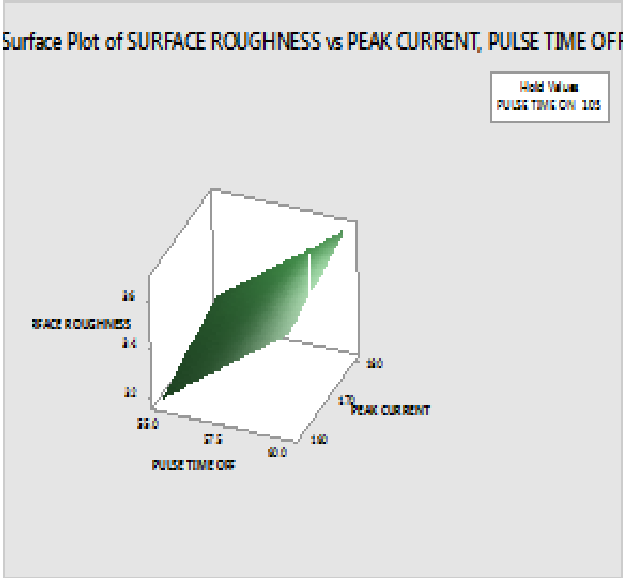
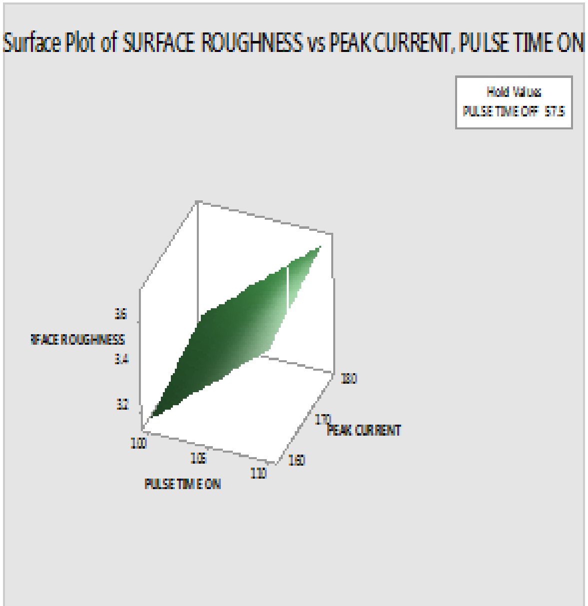


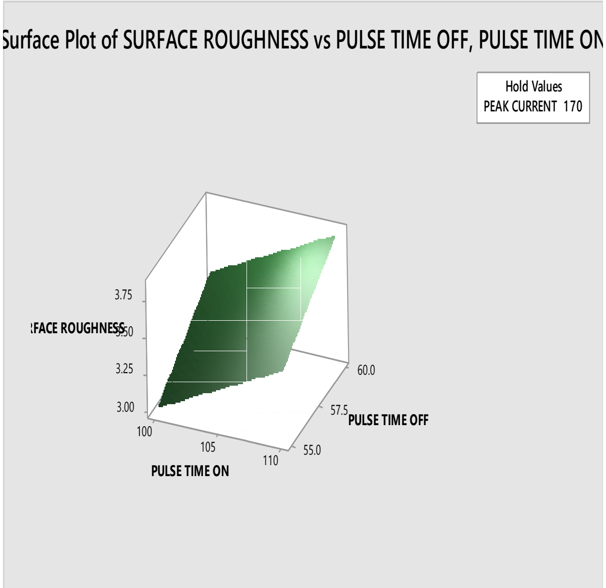
Surface Plot of Surface Roughness vs Peak Current, Pulse Time Off

By observing above graph, to minimize surface roughness, the Pulse Time Off should be set at 55 µsec and Peak Current at 160Amps.



Surface Plot of Surface Roughness vs Peak Current, Pulse Time On

By observing above graph, to minimize surface roughness, the Pulse Time On should be set at 100 µsec and Peak Current at 160Amps.

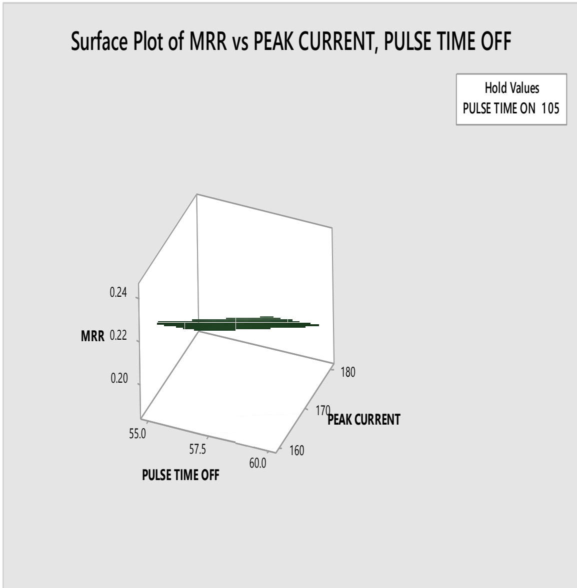


Surface Plot of Surface Roughness vs Pulse Time Off, Pulse Time On

By observing above graph, to minimize surface roughness, the Pulse Time On should be set at 100 µsec and Peak Current at 55 µsec.

MATERIAL REMOVAL RATE

The MRR considered should be maximum. The optimal parameters are selected at the maximum MRR values.



Surface Plot of MRR vs Peak Current, Pulse Time Off

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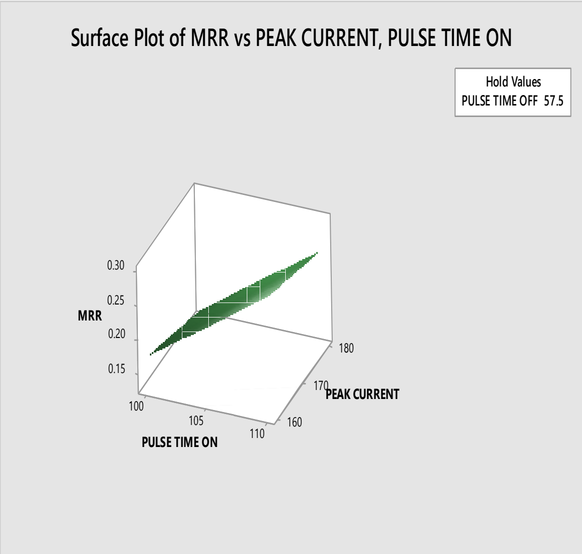
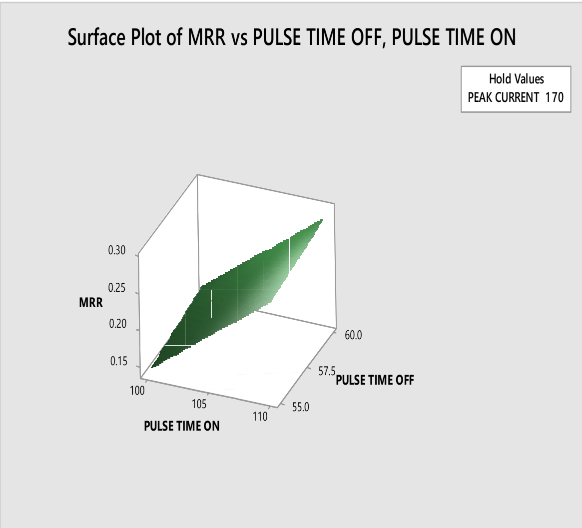
By observing above graph, to maximize MRR, the Pulse Time Off should be set at 60 µsec and Peak Current at 160Amps.



Surface Plot of MRR vs Peak Current, Pulse Time On

By observing above graph, to maximize MRR, the Pulse Time On should be set at 110 µsec and Peak Current at 160Amps.



Surface Plot of MRR vs Pulse Time Off, Pulse Time On

By observing above graph, to maximize MRR, the Pulse Time On should be set at 110 µsec and Peak Current at 60 µsec.

CONCLUSION

By observing the experimental results and by optimizing the parameters using Regression Analysis, the following conclusions can be made:

- To get better surface finish the optimized parameters are pulse time on - 100µsec, pulse time off is 55µsec and Peak current is 160Amps.
- To get high MRR the optimized parameters are pulse time on - 110µsec, pulse time off is 60µsec and Peak current is 160Amps.

REFERENCES

1. Evaluation of Optimal Parameters for machining with Wire cut EDM Using Grey-Taguchi Method by S V Subrahmanyam, M. M. M. Sarcar
2. Performance Analysis of Wire Electric Discharge Machining (W-EDM) by Atul Kumar, DR.D.K.Singh
3. Analysis of Process Parameters in Wire EDM with Stainless Steel Using Single Objective Taguchi Method and Multi Objective Grey Relational Grade by M. Durairaja, D. Sudharsunb, N. Swamynathan
4. Optimization of process parameters of micro wire EDM by Ricky Agarwal
5. A Study to Achieve a Fine Surface Finish in Wire-EDM by J.T. Huang, Y.S. Liao and Y.H. Chen
6. Rajurkar K.P., Scott D, Boyina S., "Analysis and Optimization of Parameter Combination in Wire Electrical Discharge Machining", International Journal of Production Research, Vol. 29, No. 11, 1991, PP 2189- 2207.
7. Y. S. Tarng., Ma S.C., Chung L.K., "Determination of Optimal Cutting Parameters in Wire Electrical Discharge Machining", International Journal of Machine Tools and Manufacture, Vol. 35, No. 12, 1995, PP. 1693-1701.
8. J.Prohaszka, A.G. Mamalis and N.M.Vaxevanidis, "The effect of electrode material on machinability in wire electro-

discharge machining", Journal of Materials Processing technology, 69, 1997, PP 233-237.

9. (A) Y.S. Liao, Y.Y. Chu and M.T. Yan, Study of wire breaking process and monitoring of WEDM, International Journal of Machine Tools & Manufacture, 37 (1997) pp. 555-567. (B) Y.S Liao , J.T.Huang, A study on the machining parameter optimization of WEDM, Journal of Material Processing Technology,71(1997) pp. 487-493
10. Jose Marafona, Catherine Wykes., "A new method of optimizing MRR using EDM with Copper–tungsten electrodes". International journal of Machine tools and manufacturing. Vol. 40, 22 June 1999, PP 153-164.

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