

# **To Analyse the Effects of Process Parameters on P-21 Mold Steel on WEDM Using Taguchi Approach**

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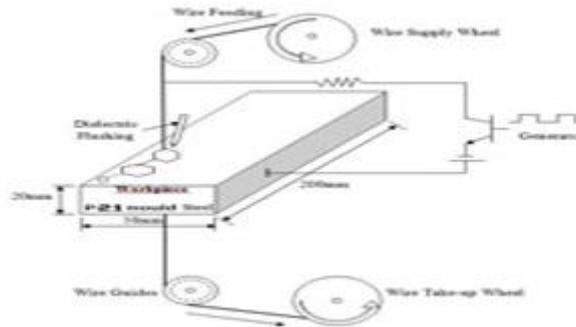
**ABSTRACT:** Wire Electric discharge machine is a specialized thermal machining process capable of accurately machining parts with varying hardness and complex shapes. The material P-21 used in the present work study finds out the application as mould steel. The main aim of this investigation is to optimize the various process parameters of WEDM for single response characteristics using L<sub>18</sub> orthogonal array to find out the performance characteristics from desired value. The present work was carried out on P-21 mould steel as work piece and zinc coated brass wire as tool electrode. Response characteristics are cutting speed and surface roughness. Three trial experiments were conducted and the average is chosen as the particular experimental condition. Experiment were performed by using different variables like input current, pulse-on, pulse-off, wire feed and wire tension. In the end confirmation experiment is carried out to validate the effectiveness of proposed optimal condition

**KEYWORDS:** P-21, WEDM, L<sub>18</sub> orthogonal array, S/N ratio, ANOVA

## **I. INTRODUCTION**

WEDM is a metal removing machine in which the electrode used is the continuous moving wire of Copper (Cu) and Brass. This is fed into the work-piece from the supply pool to take-up-pool. This continuous moving wire does not come in contact with the conductive work material. The material is eroded from the work-piece by discrete spark between the work-piece and electrode and these are separated by dielectric fluid. The gap between the work-piece and electrode is usually upto 0.0025-0.015mm and is maintained with the help of computer control WEDM. The important step is the selection of process parameter if improper process parameter are selected then it may result in problem i.e wire breakage, short circuiting of wire. No of studies has been carried out on various responses like material removal rate, surface roughness, cutting speed which depend upon various parameters like pulse-on, pulse-off, input current and many more.

In the present investigation we are using taguchi methodology for the optimal study of process parameter which is used in many places for optimization of single response and multi-response characteristics. The objective of this study into investigate the single response optimization of WEDM process for P-21 material so that we can achieve higher cutting speed and material removal rate and low surface finish. In the end Analysis of variances (ANOVA) and the confirmation experiment is conducted to validate the experimental result. Fig.1 Shows the systematic setup of WEDM



**II. EXPERIMENTAL SET-UP AND SELECTION OF PROCESS PARAMETERS**

The pulse generator capacity of the machine is 40A. The pulse generator supplies the electrical energy to the spark gap in the form of pulses. The machine tool unit comprises of a main worktable (called X-Y table) by which the work piece is clamped on auxiliary table (called U-V table) and wire drive mechanism. *Figure 2.* shows the stepwise procedure for Taguchi experimental design and analysis. *Figure 3.* shows the experiments are carried out in CNC sprint cut wire EDM of Electronic a Machine tool ltd. .

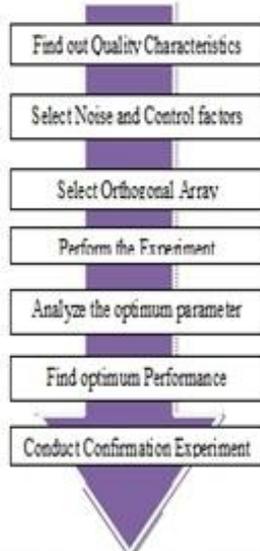


Figure. 2



Figure.3

**Work piece Electrode:** - The work piece material used in this investigation was steel P-21 Mould steel. Composition of P-21 Mould steel is C= 0.18-0.22% , Mn= 0.20-0.40% , Si ≤0.030% ,Cr= 0.50-0.30%, Ni=3.90-4.25%, Si= 0.20-0.40%, P≤ 0.030, V= 0.15-0.25, Al= 1.05-1.25. A P-21 die Mould steel plate of size 200x50x20 (l x b x w) is used.

**Tool Electrode:** Zinc coated copper wire having dia of 0.25mm is used in the present investigation as the electrode. Zinc coated Copper wire electrode can conduct high current as compare to simple copper wire.

**Selection of Process Parameters and their Ranges:**

In order to obtain high cutting speed, accurate dimension, better quality of surface roughness and the Good Material removal rate can be obtained by WEDM process. The optimal level of WEDM process parameters need to be determined. Based on the critical review of literature, process variables of the WEDM are selected according to transient state.

The process parameters selected for this study are as following:

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- a. Current.
- b. Pulse- ON time.
- c. Pulse-OFF time.
- d. Wire Speed
- e. Wire Tension

In Sprint-cut WEDM, the value of current ranges b/w 10 to 230A, Pulse-ON time b/w 110 to 131, Pulse-OFF varies b/w 0-63, Wire speed 1-15m/min and Wire tension ranges between 1 to 15N.

### III. SELECTION OF ORTHOGONAL ARRAY (OA) AND PARAMETER ASSIGNMENT

Before selecting a particular OA to be used as a matrix for conducting the experiments, the following two points are first considered:

1. The number of parameters and interactions of interest.
2. The number of levels for the parameters of interest.

Degree of freedom (DOF) associated with each factor is equal to no. of level -1. Therefore, total degree of freedom for the five factors is (5+2+2+2+2) 11. As per Taguchi’s method, the total DOF of selected OA must be greater than or equal to the total DOF required for the experiment. So, L<sub>18</sub> OA having 17 (=18-1) degree of freedom is selected for the present analysis. The experiments are conducted at each trial conditions as given in *table 2*. For each trial, the experiments is repeated by three times.

Table 1. Levels for various control factors

Sr.NO	Level	Control Factors				
		A	B	C	D	E
1	1	170	120	48	4	6
2	2	180	124	52	5	7
3	3	190	128	56	6	8
4	4	200				
5	5	210				
6	6	220				

Table2. L<sub>18</sub> orthogonal array

Sr. No	Parametric Trial conditions				
	A	B	C	D	E
1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	2	1	1	2	2
5	2	2	2	3	3
6	2	3	3	1	1
7	3	1	2	1	3
8	3	2	3	2	1
9	3	3	1	3	2

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10	4	1	3	3	2
11	4	2	1	1	3
12	4	3	2	2	1
13	5	1	2	3	1
14	5	2	3	1	2
15	5	3	1	2	3
16	6	1	3	2	3
17	6	2	1	3	1
18	6	3	2	1	2

## IV. RESULT AND DISCUSSION

In this section, we are discussing the effect of WEDM process parameters( peak current, pulse on time, pulse off time, current, wire speed and wire tension) on the basis of response characteristics(cutting speed and surface roughness). The average value of response characteristics, mean data and S/N ratio for each parameter, at all levels, is calculated from table 3. These effects are plotted by using MINITAB 15 SOFTWARE.

### Effect Of Parameters On Cutting Speed

Average value of Cutting speed calculated from raw data is 3.71 mm/min. It is clear from the S/N plots. That the maximum S/N ratio occurs correspond to A6,B3,C1,D1,E3. Therefore, the optimum value will correspond to these factors but only the significant factor would be chosen. This factor will be chosen from the ANOVA table.

Table 3. Response Table for Signal to Noise Ratios (Larger is better)

Level	A	B	C	D	E
1	8.206	5.997	9.907	8.082	7.919
2	8.024	8.076	7.831	7.913	7.934
3	7.813	9.743	6.077	7.821	7.962
4	7.452				
5	7.943				
6	8.194				
Delta	<b>0.754</b>	<b>3.746</b>	<b>3.83</b>	<b>0.261</b>	<b>0.043</b>
Rank	<b>3</b>	<b>2</b>	<b>1</b>	<b>4</b>	<b>5</b>

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Table 4. Response Table for mean

Level	A	B	C	D	E
1	2.572	2.037	3.168	2.575	2.529
2	2.519	2.573	2.503	2.576	2.598
3	2.571	3.113	2.052	2.573	2.596
4	2.474				
5	2.621				
6	2.686				
<b>Delta</b>	<b>0.211</b>	<b>1.077</b>	<b>1.116</b>	<b>0.003</b>	<b>0.068</b>
<b>Rank</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>5</b>	<b>4</b>

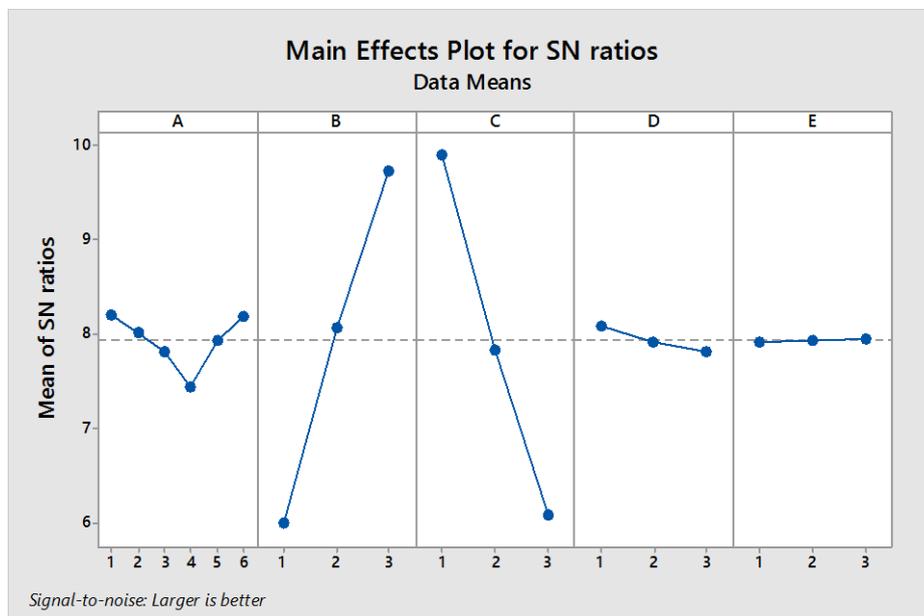




Figure.1 Main Effect Plot for S/N ratio and MEAN for cutting speed

**Effect of Parameters On Surface Roughness**

Surface roughness is a key factor in die making and depends upon the energy drop across the electrodes. Surface roughness is a “smaller is better” type characteristics. So, the optimum value of surface roughness should be low so that depth of recast layer remains minimum or equal to zero. Average value of surface roughness is 2.83µm. Main effects of each parameter are calculated from response table 5 and 6 as shown in fig 2. These effects are plotted by using MINITAB 15.

Table 5 Response Table for S/N Ratios (Smaller is better)

Level	A	B	C	D	E
1	-9.042	-8.625	-9.404	-9.025	-9.101
2	-9.14	-8.983	-8.965	-8.905	-9.108
3	-8.319	-9.365	-8.604	-9.043	-8.765
4	-8.605				
5	-9.321				
6	-9.52				
<b>Delta</b>	<b>1.201</b>	<b>0.74</b>	<b>0.8</b>	<b>0.139</b>	<b>0.343</b>
<b>Rank</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>5</b>	<b>4</b>

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Table. 6 Response Table for Mean

Level	A	B	C	D	E
1	2.832	2.708	2.955	2.834	2.861
2	2.866	2.822	2.814	2.794	2.863
3	2.619	2.941	2.702	2.843	2.748
4	2.702				
5	2.924				
6	2.999				
<b>Delta</b>	<b>0.38</b>	<b>0.232</b>	<b>0.253</b>	<b>0.049</b>	<b>0.115</b>
<b>Rank</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>5</b>	<b>4</b>

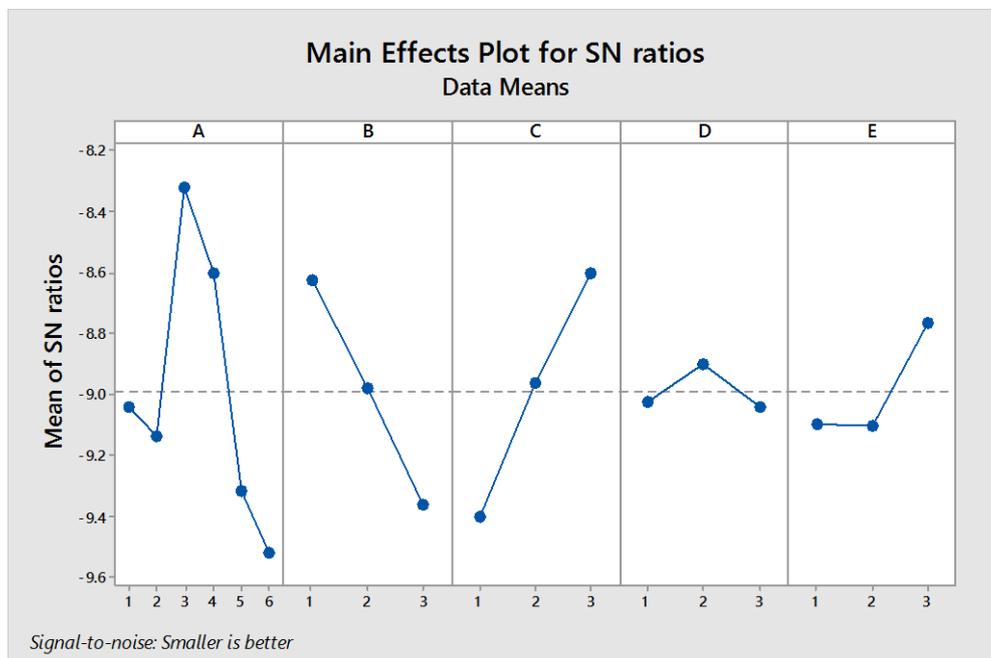




Figure. 2 Main Effect Plot for S/N ratio and MEAN for surface roughness

#### Confirmation Experiment:

It is conducted for the cutting speed, die width and for surface roughness. The experimental value obtained at the optimal setting of parameter is:

Cutting speed = 3.56 mm/min

Surface roughness = 3.13 $\mu$ m.

#### V. CONCLUSION

On the basis of above studied experiments, it can be safely concluding that:- .

- Cutting Speed is affected by Pulse-on and Pulse-off time
- Surface roughness does not have any significant factor

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