Process Parameter Optimization in EDM using Heat Treated Al Tool and without Heat Treated Al Tool

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Abstract: In this experimental work, we investigated optimization of process parameters in EDM using Taguchi method by taking Low carbon steel as work piece. Process parameters chosen were Pulse on-time (Ton), Flushing pressure (P) and Pulse Current (Ip). Here we have chosen L9 orthogonal array to study the effect of main factors and interaction between factors on the response variable i.e. Surface Roughness (SR), Material removal Rate (MRR) and Tool Wear Rate (TWR). The contribution of the main factors and interaction were determined here. The MR, TWR and surface integrity are some of the important performance attributes of EDM process. The objective of EDM is to get high MRR along with achieving reasonably good surface quality of machined component with reduced tool wear rate for Low carbon steel material.

Keywords: SR, MRR, TWR, EDM, Taguchi etc.

I. INTRODUCTION

There are different ways of machining, Some are conventional machining where cutting tool is directly comes to contact with the work piece whereas some are non-conventional machining for which there is no physical contact of tool and work piece. Here our focus is limited to EDM machining process, where electrically conductive materials is machined by using precisely controlled sparks that occur between an electrode and a work-piece in the presence of a dielectric fluid.

Different types of EDM-
1. Die sinking EDM
2. WEDM

In this experiment we have used Die sinking EDM.

II. SET UP OF EDM

Electrode, Servo System, Power Supply, Dielectric system.

III. EDM PROCESS PARAMETERS

Spark On-time (pulse time or Ton), Over cut , Voltage (V), Duty cycle (τ), Spark Off-time (T_off) Arc gap (or gap), Discharge current (Ip)

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IV. DIELECTRIC FLUID

There are various types of dielectric fluids are used in EDM such as EDM oil, Kerosene, Transformer oil, Distilled water etc. Here we have used the Fresh EDM oil Grade-II.

V. EDM SPECIFICATIONS

Table-1 EDM machine Specifications

| Model                  | ZNC25 |
|------------------------|-------|
| Operating platform (mm)| 28X450|
| Operating groove(mm)   | 820X500X280 |
| X-axis range           | 250mm |
| Y-axis range           | 200mm |
| Z-axis Range           | 200mm |
| Electric pole carrying capacity | 30Kg |
| Maximum capacity of the operating platform | 205Kg |
| Maximum dimensions (mm)| 1390X1480X2010 |
| Weight of the machine tool | 1010Kg |
| Motor                  | 3phase, ½ hp, 50hz |

VI. ELECTRODE AND WORK PIECE

Low carbon steel specimen has been chosen as work piece. The composition of Low carbon steel is - Carbon -0.10-0.25%, Si - 0 to 0.30%, Mn - 0.30 to 0.70%, P - 0 to 0.04%, S - 0 to 0.05%

VII. HEAT TREATMENT

Here, we have used two Aluminum tools out of which one is heat treated and other is without heat treated. One tool is heat treated in an electric arc furnace for 1 hour and temperature range was 300-500°C

VIII. VARIABLES

Design parameters-Material removal rate(MRR), Tool wear rate (TWR), Surface roughness(SR)
Machining parameter- Pulse current (Ip), pulse on time, pulse (T_on), flushing Pressure (P).
IX. EXPERIMENTAL WORK

| Machining parameter | Symbol | Unit | Level 1 | Level 2 | Level 3 |
|---------------------|--------|------|---------|---------|---------|
| Pulse on Time       | T_{ON} | µs   | 30      | 150     | 300     |
| Pulse Current       | I_p    | A    | 2       | 6       | 9       |
| Flushing Pressure   | P      | Kg/cm^2 | 0.3 | 1 | 1.1     |

Table 2 process parameters

Target is 2mm for machining the work piece. Time is not constant. TWR and MRR have been calculated by measuring the electrode and work piece respectively with the help of semi micro balance.
Table 4 Response table for S/N ratio of MRR for Without Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | -22.59        | -36.16        | -21.51           |
| 2     | -24.21        | -19.99        | -22.92           |
| 3     | -22.10        | -12.75        | -24.47           |
| Delta | 2.11          | 23.41         | 2.96             |
| Rank  | 3             | 1             | 2                |

Table 5 Response table for S/N ratio of TWR for Without Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | 42.14         | 74.95         | 53.02            |
| 2     | 68.14         | 58.35         | 63.23            |
| 3     | 74.63         | 51.60         | 68.66            |
| Delta | 32.49         | 23.35         | 15.65            |
| Rank  | 1             | 2             | 3                |

Table 6 Response table for S/N ratio of SR for Without Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | -7.780        | -3.404        | -8.896           |
| 2     | -9.083        | -9.083        | -7.604           |
| 3     | -6.548        | -10.925       | -6.911           |
| Delta | 2.535         | 7.521         | 1.985            |
| Rank  | 2             | 1             | 3                |
Table 7  Response table for S/N ratio of TWR for Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | -22.20        | -35.92        | -19.91           |
| 2     | -22.49        | -19.00        | -22.61           |
| 3     | -21.74        | -11.51        | -23.91           |
| Delta | 0.75          | 24.40         | 4.00             |
| Rank  | 3             | 1             | 2                |

Table 8  Response table for S/N ratio of TWR for Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | 42.97         | 69.00         | 64.79            |
| 2     | 70.18         | 63.63         | 60.15            |
| 3     | 74.44         | 54.96         | 62.65            |
| Delta | 31.47         | 14.04         | 4.64             |
| Rank  | 1             | 2             | 3                |

Table 9  Response table for S/N ratio of SR for Heat treated tool

| Level | Pulse on time | Pulse current | Flushing pressure |
|-------|---------------|---------------|------------------|
| 1     | -6.625        | -1.889        | -8.787           |
| 2     | -9.729        | -9.591        | -7.584           |
| 3     | -7.540        | -12.414       | -7.523           |
| Delta | 3.105         | 10.526        | 1.264            |
| Rank  | 2             | 1             | 3                |

X. RESULTS

Referring to the different response tables, we found that pulse current is the main parameter for increasing the MRR, whereas the effect of Pulse on time and flushing pressure are equal. The MRR gives highest value in case of run no 8 and lowest value in case of run no 6.

Referring to the table 5, it was observed that pulse on time is the main parameter for reducing the TWR and pulse current and flushing pressure are also playing as main effective parameters for TWR. The TWR gives highest value in case of runs no 2 and lowest value in case of run no6.

Referring to the table 6, we found that pulse current is the main parameter for reducing the SR and whereas the effect of Pulse on time and flushing pressure are equal. The SR gives highest value in case of run no. 5 and lowest value in case of run no 6. For Heat treated tool, the response table for S/N ratios for MRR, TWR and SR are shown in tables 7, 8 and 9 respectively with graphical representation of the three control factors i.e. T_{on}, I_{p}, and P on MRR, TWR and SR.

Referring to the table7, it was observed that pulse current is the main parameter for increasing the MRR, Pulse on time also gives average effect whereas flushing pressure gives least effect. The MRR gives highest value in case of run no 8 and lowest value in case of run no 6.

Referring to the table 8, it was observed that pulse on time is the main parameter for reducing the TWR and pulse current and flushing pressure are also playing as main effective parameters for TWR. The TWR gives highest value for run number 3 and lowest value for run number 7.

XI. CONCLUSIONS

1. For MRR, the most significant factors were found to be pulse current and flushing pressure followed by pulse on time.
2. For TWR, the most significant factor was Pulse on time, pulse current.
3. For SR, the most significant factor was pulse current.
4. Increase in pulse current and pulse on time, the MRR, SR and TWR were increased.
5. TWR can be reduced by heat treatment process and it gives better surface finish as compare to without heat treated tool.
6. The best condition for minimize the SR for both Heat Treated and without heat treated tool is 2A pulse current, 300µs of pulse on time and 1.2kg/cm².

7. The best condition for minimize the TWR for both Heat Treated and without heat treated tool is 2A pulse current, 300µs of pulse on time and 1.2kg/cm².

8. The best condition for MRR for both Heat Treated and without heat treated tool is 9A pulse current, 300µs of pulse on time and 1.0kg/cm².

From confirmation test it has been observed that the experimental values give better result as compare to predicted values. So the Taguchi Method is most effective technique for better solution of single objective optimization process.

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