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# Parameter Optimization on AISI M35 and AISI M42 in Electrical Discharge Machining

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## Abstract

**Electronic discharge machining(EDM) is very demanding process nowadays because of its accuracy and machining of complex shape.EDM is a type of non-traditional machining process. This paper aims to determine the material removal rate(MRR) and tool wear rate(TWR) on material high speed steel of grade M35 and M42 with using copper(cu) electrode of 6mm diameter. Taguchi L9 orthogonal array is used for the experimentation and analysis of the experimental result is done by using Analysis of variances(ANOVA).**

### Keywords

Electrical discharge machining, MRR, TWR.

## Introduction

Electrical discharge machining(EDM) is an extremely important machining process among newly developed non-conventional machining techniques for cutting hard material which is difficult to cut by other machining process.EDM is a thermi-electrical process in which material is eroded from the workpiece because off erosion effect of a series of sparks between workpiece and electrode or tool which is immersed in ionized dielectric fluid[1].In EDM there is no physical contact between workpiece and electrode, so there is no cutting force between workpiece and tool. Must condition forEDM is workpiece and tool both are electrically conductive in nature. EDM machine has an application like hole of small diameter, intricate or complex shape, die cavity and other precision part[2].

Machining of hard material is very difficult like high speed steel.So at this stage EDM proved workfull and this experimentation include the machining of high speed steel of grade M35 and M42 with copper electrode. Copper electrode gives good machining performance like better material removal rate and lower tool rate.

## Literature Review

Samesh S. Habib(2014) studied the effectiveor optimized parameters of EDM by using Taguchi approach.Author found that for best responses of mrr,twr and surface roughness the effective parameters play a vital role as in sequence like pulse on time, pulse off time, discharge current, and averahe machining voltage when using graphite electrodes[1]. Mehul et al.(2013) investigate the mrr, twr and surface roughness.They found that for high disharge current, copper electrodes show highest mrr,brass gives better surface finish and normal mrr[3]. Mannan et al.(2013) studied the surface characterization of high speed steel. Authors found that high pulse current and pulse on time has produce more surface roughness[4]. Amorim et al.(2013) studied the performance and surface integrity of Ti6AL4V using graphite electrodes. They found that best results come out of mrr,surface roughness with 10micrometer particle size and negative polarity of graphite electrode[5].

## Experimental setup

### Electric Discharge Machine

All the experiments were conducted on Sparkonix Die-sinking EDM machine which is died-sinking EDM machine and three important parameters were consider in this experimentation like like discharge current ,pulse on time and pulse off time.Commercial grade EDM oil was used.MRR and TWR are respones which are measured.

### Workpiece material

The workpiece material selected is high speed steel of grade AISI M35 and AISI M42.Mainly this material is used as cutting tool for traditional machining ,dies and moulds. This material belongs to Mgrade family, so it is molybendum riched or based type of high speed steel.Chemical composition of these material is shown in table 1.

Table1 :Chemical Composition of HSS M35 and M42..

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **AISI-M35** | **0.85-0.95** | **0.00-0.40** | **0.00-0.40** | **0.35** | **0.35** | **3.75-4.50** | **4.75-5.25** | **1.75-2.15** | **6.00-6.75** | **4.60-5.20** | **0.00-0.40** |
| **AISI-M42** | 1.05-1.15 | 0.15-0.65 | 0.15-0.40 | 0.35 | 0.35 | 3.50-4.25 | 9.00-10.00 | 0.95-1.35 | 1.15-1.85 | 7.75-8.75 | 0 |

### Electrode Material

The electrode selected for this experiment is electrolyte copper which is ductile as well as high electrical and thermal conductivity. In this experiment copper electrode of having 6mm diameter is used.

## Experimental Analysis

Taguchi L9 orthogonal array is used for creating expeimental table. Taguchi reduces the experimentation parameters. The experimentation result is analyzed by using Analysis of Variance(ANOVA).

### A. Calculations

Table2:For M35

| I | Ton | Toff | Depth | Wnet=Wi-Wf (gm) | Time (min.) | Density of M35 | MRR (mm3/min) | Wtnet | Density | TWR |
|---|---|---|---|---|---|---|---|---|---|---|
| **15** | 200 | 200 | 1 | 0.977 | 2.46 | 8.1 | 9.033 | 0.04 | 8.96 | 145.691 |
| **15** | 400 | 400 | 1 | 20.406 | 1.21 | 8.1 | 20.406 | 0.04 | 8.96 | 296.198 |
| **15** | 600 | 600 | 1 | 12.179 | 2.23 | 8.1 | 12.179 | 0.02 | 8.96 | 80.358 |
| **20** | 200 | 400 | 1 | 8.114 | 2.13 | 8.1 | 8.144 | 0.02 | 8.96 | 84.131 |
| **20** | 400 | 600 | 1 | 17.777 | 1.25 | 8.1 | 17.777 | 0.04 | 8.96 | 286.72 |
| **20** | 600 | 200 | 1 | 0.673 | 51.29 | 8.1 | 0.673 | 0.05 | 8.96 | 8.7 |
| **25** | 200 | 600 | 1 | 5.018 | 2.46 | 8.1 | 5.018 | 0.09 | 8.96 | 327.804 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **25** | 400 | 200 | 1 | 9.033 | 45.46 | 8.1 | 0.977 | 0.38 | 8.96 | 74.896 |
| **25** | 600 | 400 | 1 | 24.691 | 1.2 | 8.1 | 24.691 | 0.02 | 8.96 | 149.333 |

Analysis is done on Minitab

Main plots for MRR, TWR

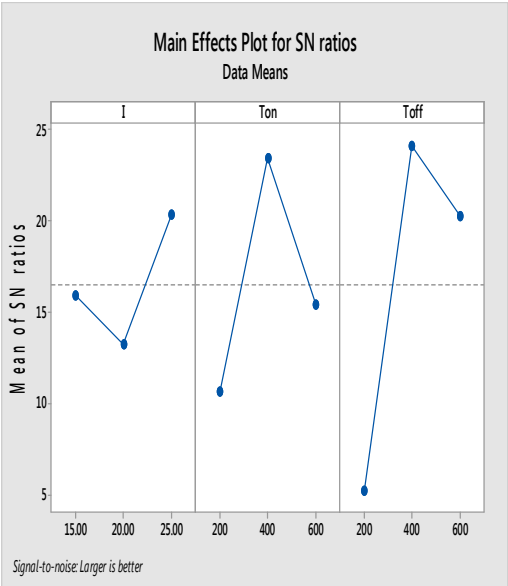


*Fig1. MRR*

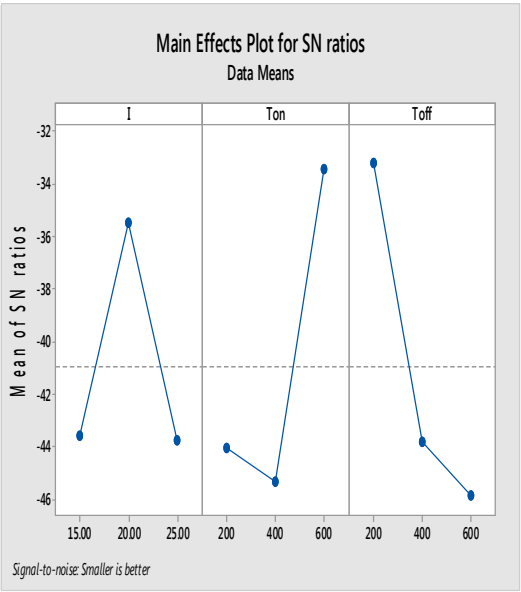


*Fig2. TWR*

FOR MRR

*Table 3: Anova for SN ratio*

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| **I** | 2 | 76.63 | 76.63 | 38.31 | 0.88 | 0.533 |
| **Ton** | 2 | 250.22 | 250.22 | 125.11 | 2.86 | 0.259 |
| **Toff** | 2 | 599.90 | 599.90 | 299.95 | 6.86 | 0.127 |
| **Residual err.** | 2 | 87.39 | 87.39 | 43.70 | | |
| **Total** | 8 | 1014.14 | | | | |

*Table 4:Response table for SN ratio*

| Level | I | Ton | Toff |
|---|---|---|---|
| 1 | 15.902 | 10.665 | 5.161 |
| 2 | 13.252 | 23.435 | 24.077 |
| 3 | 7.325 | 15.379 | 20.241 |
| Delta | 7.074 | 12.771 | 18.916 |
| Rank | 3 | 2 | 1 |

For TWR

*Table 5: Anova for SN ratio*

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| **I** | 2 | 134.19 | 134.19 | 67.09 | 1.52 | 0.397 |
| **Ton** | 2 | 254.53 | 254.53 | 127.26 | 2.88 | 0.258 |
| **Toff** | 2 | 277.05 | 277.05 | 138.53 | 3.13 | 0.242 |
| **Residual err.** | 2 | 88.47 | 88.47 | 44.23 | | |
| **Total** | 8 | 754.23 | | | | |

*Table 6:Response table for SN ratio*

| Level | I | Ton | Toff |
|---|---|---|---|
| 1 | -43.60 | -44.03 | -33.19 |
| 2 | -35.49 | -45.36 | -43.80 |
| 3 | -43.76 | -33.47 | -45.85 |
| Delta | 8.73 | 11.89 | 12.66 |
| Rank | 3 | 2 | 1 |

For M42

Table7. For M42

| I | Ton | Toff | Depth | Wnet= Wi-Wf (gm) | Time (min.) | Density of M35 | MRR (mm3/min) | Wtnet | Density | TWR |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 200 | 200 | 1 | 0.2 | 2.54 | 8 | 0.7045 | 0.02 | 8.96 | 70.551 |
| 15 | 400 | 400 | 1 | 0.15 | 1.12 | 8 | 16.741 | 0.04 | 8.96 | 320 |
| 15 | 600 | 600 | 1 | 0.2 | 1.42 | 8 | 17.605 | 0.03 | 8.96 | 189.29 |
| 20 | 200 | 400 | 1 | 0.15 | 1.47 | 8 | 12.755 | 0.59 | 8.96 | 3596.19 |
| 20 | 400 | 600 | 1 | 0.15 | 1.17 | 8 | 16.02 | 0.06 | 8.96 | 459.48 |
| 20 | 600 | 200 | 1 | 0.25 | 86.48 | 8 | 0.361 | 0.02 | 8.96 | 2.07 |
| 25 | 200 | 600 | 1 | 0.1 | 2.5 | 8 | 5 | 0.08 | 8.96 | 286 |
| 25 | 400 | 200 | 1 | 0.35 | 62.1 | 8 | 9.8400 | 0.02 | 8.96 | 2.88 |
| 25 | 600 | 400 | 1 | 0.3 | 1.2 | 8 | 31.25 | 0.02 | 8.96 | 149.33 |

Analysis is done on Minitab:

Main plots for MRR, TWR

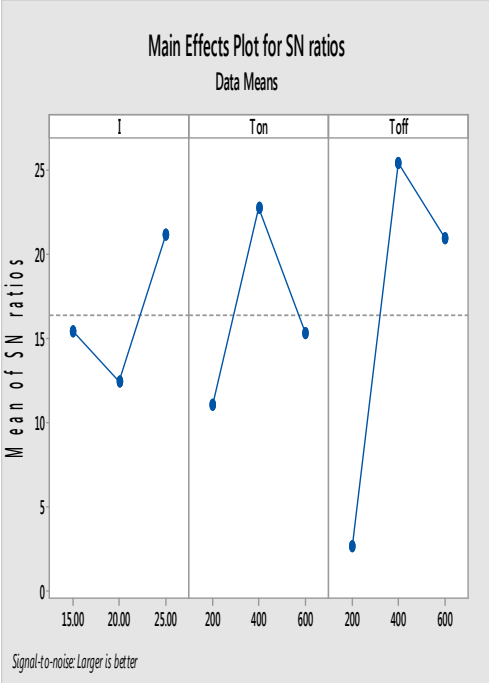


Fig3. MRR

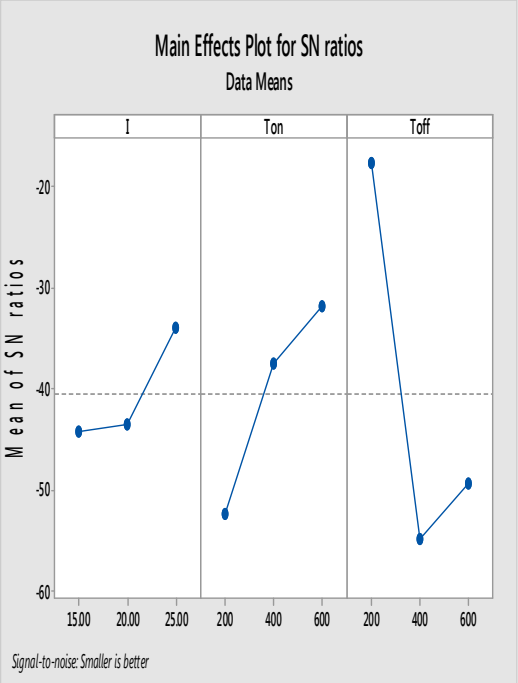


Fig4. TWR

For MRR

*Table 8: Anova for SN ratio*

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| **I** | 2 | 119.8 | 119.8 | 59.90 | 0.51 | 0.661 |
| **Ton** | 2 | 213.7 | 213.7 | 106.85 | 0.92 | 0.522 |
| **Toff** | 2 | 878.0 | 878.0 | 439.01 | 3.77 | 0.210 |
| **Residual err.** | 2 | 233.2 | 233.2 | 116.58 | | |
| **Total** | 8 | 1444.7 | | | | |

*Table 9:Response table for SN ratio*

| Level | I | Ton | Toff |
|---|---|---|---|
| 1 | 15.449 | 11.017 | 2.659 |
| 2 | 12.456 | 22.811 | 25.495 |
| 3 | 21.245 | 15.323 | 20.996 |
| Delta | 8.789 | 11.794 | 22.837 |
| Rank | 3 | 2 | 1 |

For TWR:

*Table10: Anova for SN ratio*

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| **I** | 2 | 198.2 | 198.2 | 99.09 | 1.41 | 0.415 |
| **Ton** | 2 | 680.2 | 680.2 | 340.09 | 4.85 | 171 |
| **Toff** | 2 | 2441.9 | 2441.9 | 1220.97 | 17.39 | 0.054 |
| **Residual err.** | 2 | 140.4 | 140.4 | 70.19 | | |
| **Total** | 8 | 3460.7 | | | | |

*Table11: Response table for SN ratio*

| Level | I | Ton | Toff |
|---|---|---|---|
| 1 | -44.21 | -52.41 | -17.50 |
| 2 | -43.56 | -37.52 | -54.90 |
| 3 | -33.95 | -31.78 | -49.31 |
| Delta | 10.26 | 20.63 | 37.40 |
| Rank | 3 | 2 | 1 |

## Result and Conclusion

From the experimental data, we clearly seen that discharge current have more effect than any others. Increase in pulse current leads to increase MRR and TWR.TWR is decreases by increase of pulse-on time.From the design of experiment we are able to find out effective paramets like Higher MRR is achieved when current 25amp,pulse on time 600 microsec. and pulse off time 400 microsec.But lower tool wear achieved when current 20amp,pulse on time 600 microsec. and pulse off time 200 microsec.

Now in case of M42 higher MRR is achieved when current 25amp,pulse on time 600 microsec. and pulse off time 400 microsec and lower tool wear rate is achieved when current 20amp,pulse on time 600 microsec. and pulse off time 200 microsec. Effective parameter are same for both of the material but higher MRR and lower TWR is achieved in material M42 as comparison than M35. So, machining of M42 by using copper electrode is more better than M35.

## Acknowledgements

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