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"Experimental Investigation on EDM of EN-8 Using Copper Tools"

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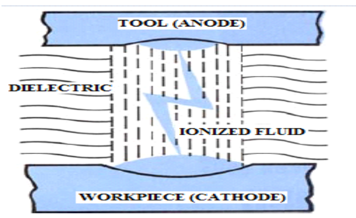
Abstract - EDM machine is a non-conventional machine which is used to cut alloy materials with high hardness, impact resistance and toughness. It can cut complex contours which are difficult to be machined by conventional cutting methods. The present investigation is conducted on EDM is performed on EN-8 with copper as electrode to establish the relationship between process parameters of EDM on material removal rate, tool wear rate and white layer thickness. The investigation concluded that material removal rate, tool wear rate and white layer thickness were majorly influenced by the peak current and pulse on time. Pulse off time was found to be the least dominating parameter for all the performance measures.

1.INTRODUCTION

Electrical Discharge Machining (EDM) is a controlled material removal technique used to remove metal by means of spark erosion. This process utilizes an electric spark as the cutting tool to machine the workpiece to produce the finished product to the desired size and shape. The material removal process is performed in dielectric medium to enhance the efficiency of the process and applies a pulsating (ON/OFF) electrical charge of high-frequency current by the electrode on to the workpiece. This removes a very tiny layer of metal from the workpiece at a controlled rate.



1.

1.2 EDM Process

EDM spark erosion is similar to have an electrical short which burns a hole in a piece of material it is in contacts. In the EDM process, both the work material and the electrode material must be electrically conductive.

The EDM process is used in two different ways:

1. A pre-shaped electrode or a too),usually graphite or copper, is in shape of a cavity to be produced on workpiece which is fed verticaaly downwards and erodes the workpiece into finished desired product.

2. A continuously travelling vertical electrode in form of wire of a diameter of about a small needle, controlled by the servomechanism which follow a programmed path to machine or cut a narrow slot into the workpiece and produces the required shape.

1.2.1 Conventional EDM

In the EDM process, continuous electric sparks are produced to machine the workpiece, which acquires the shape opposite to that of the cutting electrode. The electrode and the workpiece are both submerged in a dielectric fluid to make the process more effective. A servomechanism is used to maintains a gap of low thickness between the tool and the work, preventing them from contacting each other. This is called spark gap.

In EDM die-sink machining, a relatively soft copper or graphite electrode is used to machine hard material.The EDM process produces a cavity which is slightly larger than the size of electrode because of the overcut or enlargement.

1.2.2 Wire-Cut EDM

The wire-cut EDM is a electro discharge machine which uses electrode in form of wire to produce the desired contour or shape. It do not require a special shaped electrode, but it uses a continuously traveling vertical electrode in form of wire under tension as the electrode. The electrode in Wire-EDM is about a thickness as minimum as a diameter needle which produces the shape required..

7 TABLES FOR TAGUCHI DESIGN OF EXPERIMENT

Tables for Taguchi design of experiment are shown below:

Table 3.1: Process Parameters and their levels

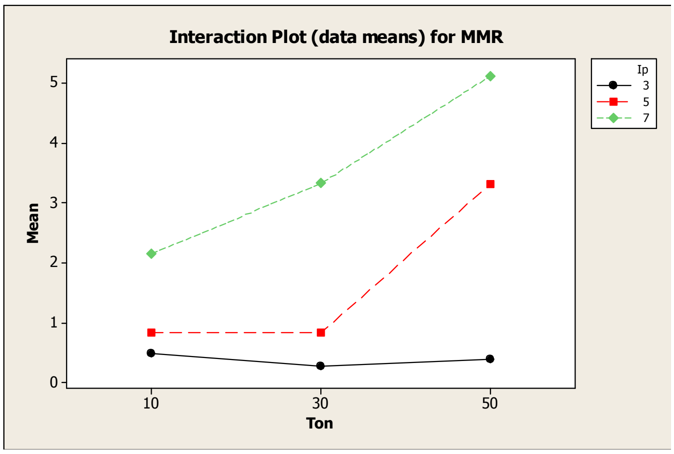
S.No.	Parameters	Units	Level 1	Level 2	Level 3
1	Current	A	3	5	7
2	Pulse-on-time	μsec	10	30	50
3	Pulse-off-time	μsec	10	30	50

Calculation for Material RemovalRate

Exp. No	Ip	Ton	Toff	MRR(mm^3/min)
1	3	10	10	0.493
2	3	30	30	0.272
3	3	50	50	0.379
4	5	10	30	0.829
5	5	30	50	0.833
6	5	50	10	3.319
7	7	10	50	2.145
8	7	30	10	3.326
9	7	50	30	5.118

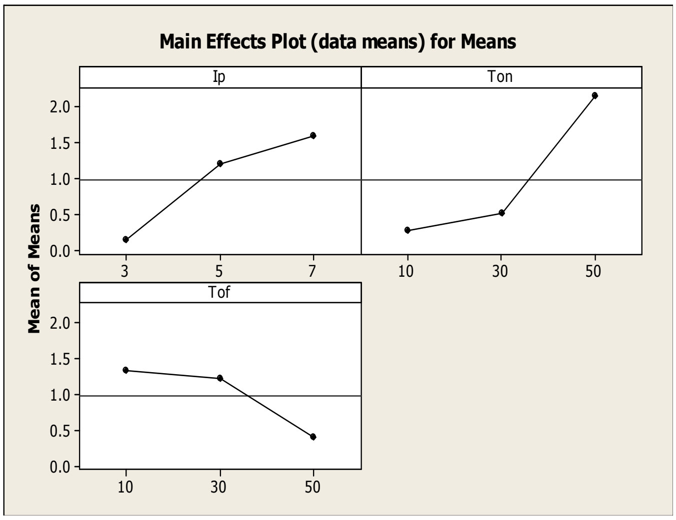
ANOVA of MRR

Source	DOF	SS	Adj MS	F Value	Contribution
Ip	2	15.0423	7.5511	24.20	63.53%
Ton	2	5.4188	2.7094	8.72	22.88%
Toff	2	2.5924	1.2962	4.17	10.94%
Error	2	0.6216	0.3108		2.62%
Total	8	23.6750			100%



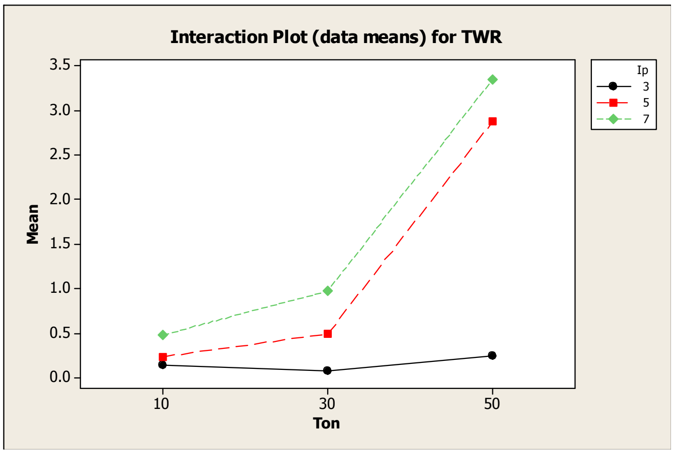
Calculation for Tool Wear Rate

Exp. No	Ip	Ton	Toff	TWR(mm^3/min)
1	3	10	10	0.134
2	3	30	30	0.075
3	3	50	50	0.238
4	5	10	30	0.233
5	5	30	50	0.490
6	5	50	10	2.870
7	7	10	50	0.479
8	7	30	10	0.972
9	7	50	30	3.345



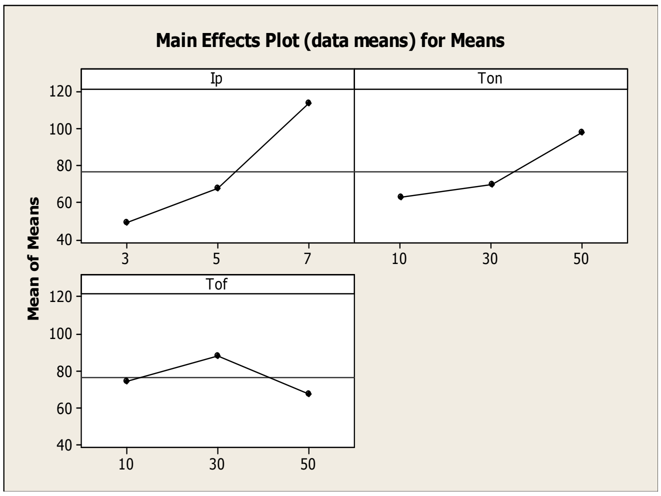
ANOVA of TWR

Source	DOF	SS	Adj MS	F Value	Contribution
Ip	2	3.3620	1.6810	2.85	27.33%
Ton	2	6.2314	3.1157	5.29	50.66%
Toff	2	1.5283	0.7641	1.30	12.42%
Error	2	1.1780	0.5890		9.57%
Total	8	12.2998			100%



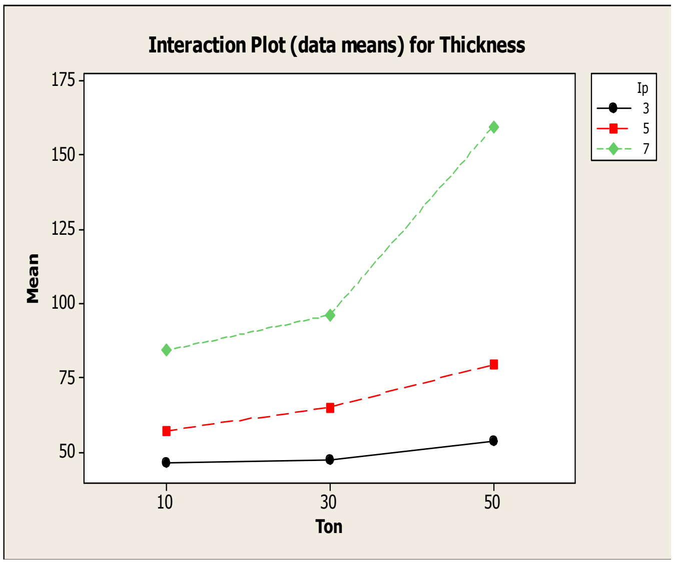
Calculation for Average White layer thickness

Exp. No	Ip	Ton	Toff	Average White Layer Thickness (µm)
1	3	10	10	46.30
2	3	30	30	47.10
3	3	50	50	53.51
4	5	10	30	57.20
5	5	30	50	65.00
6	5	50	10	79.70
7	7	10	50	84.25
8	7	30	10	96.25
9	7	50	30	159.80



ANOVA of White Layer Thickness

Source	DOF	SS	Adj MS	F Value	Contribution
Current	2	6619.8	3309.9	7.70	64.84%
Pulse on Time	2	2074.6	1037.3	2.41	20.32%
Pulse off Time	2	654.9	327.4	0.76	6.41%
Error	2	859.6	429.8		8.42%
Total	8	10208.9			100%



CONCLUSION

The present experimental study describes the optimization of input machining parameters in Electrical Discharge Machining of EN-8 with copper electrode using L9 orthogonal array of Taguchi method. Factors like Current, Pulse on Time and Pulse off timer and their interactions were found. These results show the performance of parameters at different levels to optimize the MRR, TWR and White Layer Thickness. Following conclusions are made:

- Material removal rate increases with peak current and pulse on time and both the parameters have major influence on MRR. MRR is observed to follow an increasing trend with increase in the level of peak current and pulse on time. It probably occurred because the intensity of spark is more at higher level of parameters and hence MRR increases.
- Peak Current is the major influencing parameter for mrr with a contribution of 63.53%.
- MRR is observed to be follow a decreasing trend with pulse off time and it is the least influencing parameter for MRR and has only 10.94% contribution.
- The same behavior of parameters is also notice for tool wear rate. Tool starts to degrade with increase in levels of peak current and pulse on time while with pulse off time reverse trend is followed.
- Pulse on time is the major influencing parameter for tool wear rate with a contribution of 50.66%.
- By increasing the peak current and pulse on time, the white layer thickness increases. Peak current is the most dominating factor for white layer thickness with a contribution of 64.84% and has major influence on it. It is usually due to higher intensity sparks generated at higher levels of peak current, hence influence of peak current is highest.
- White layer thickness increases due to sudden quenching with increase in the value of peak current.
- Pulse on time is found to be the second most dominating parameter for white layer thickness with a contribution of 20.32%.

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