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"Experimental Investigation of MRR, TWR and Hole Enlargement on EDM of EN-31"

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Abstract -*EDM is a non-touching machining process that is utilized the machine hard materials that are hard to work by other customary procedures. Because of the progression underway, EDM is utilized generally in all ventures. The present research led on EN-31 utilizing copper as apparatus for setting up the connection between EDM parameters and execution measure. Peak- current, pulse on time..and voltage. were chosen as EDM parameters whose impact was surveyed on material removal rate, tool wear rate and hole enlargement. The results revealed that peak-current is the major affecting parameter for material removal hole enlargement while Ton is the most overpowering component for tool wear rate. Voltage is seen to be the base affecting parameter for all the execution measures.*

1.INTRODUCTION

EDM is accomplished by a release occurring between two nearest focuses device and work-piece The release makes extraordinary warmth close to the zone which dampen and deplete the materials. To potentiate the viability of the procedure, the setup work-piece and the apparatus are drenched in di-electric liquid (EDM oil). In the event that both the anodes are made with same material, the cathode cogitate with positive terminal dissolves at a speedier rate when contrasted with one associated with the negative anode. Subsequently the work-piece is made the anode. A reasonable hole, called start hole, is kept up between the instrument also work-piece surfaces. Start happens at the point at which the instrument and work-piece are the nearest and since the point changes after each start, the start voyages everywhere throughout a work-piece surface. Consequently uniform material expulsion everywhere throughout the surface is accomplished, lastly work-piece fits in with the state of hardware.

It has generally utilized, particularly to cut convoluted forms or sensitive holes that are difficult to create with regular machining strategies. Be that as it may, one basic confinement of EDM is that it just works with electrical-conductive system. Materials machined by utilizing EDM incorporate nickel-based compounds, (for example, aviation materials), hard instrument steels, High speed steels, conductive composites, conductive earthenware production.

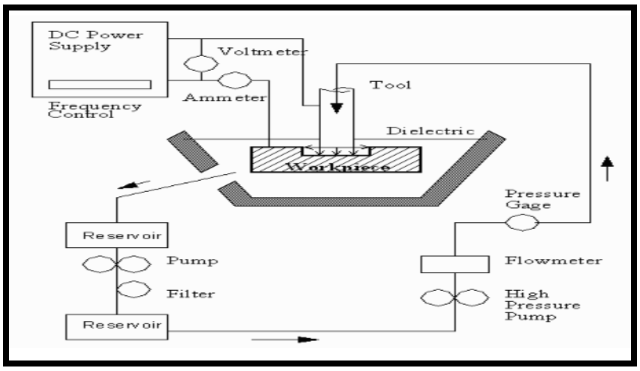
2. EDM PRINCIPLE

EDM is done along a liquid medium, the machine's automatic feed adjustment device to work-piece and the instrument cathode release hole between right, when the device is connected between anode to work-piece solid pulse voltage (up to the hole in the media breakdown voltage) when the most reduced breakdown quality of di-electric protection, as appeared.. The release region is little, the release time is short, so a high grouping of vitality, with the goal that the immediate temperature of the release region of up to 10000-12000 ℃, and instruments for surface incomplete dissolving the metal cathode surface, or even vaporized. Halfway liquefying and vaporization of metal under the activity of the dangerous tossed into the working liquid, little particles of metal was cooling, and after that immediately washed-away by the working liquid work zone, with the goal that the surface to shape a little pit.. One release, the medium dielectric quality recuperation sitting tight for the following release. This is rehashed ceaselessly with the goal that the surface removal, and duplicate the instrument anode on the work-piece shape, to accomplish the motivation behind framing. EDM metal removal is always releasing procedure. In spite of the fact that a heartbeat release time is short, yet it is electromagnetism, thermodynamics and liquid mechanics consolidated impacts of such a procedure is very perplexing. Taken together, the primary heartbeat release can be sporadic into the accompanying stages:

(1) Between the medium polar ionization, breakdown and formation of the discharge channel.

At the point when the beat voltage is connected to device anode and work-piece there is quick arrangement of an electric field mediate the two shafts.

Electric field quality and voltage related-to to the separation is contrarily relative to the voltage between with the separations between the expansion or reduction of electric field quality between the post with the expansion. Since the miniaturized scale device anode and work-piece-surface is uneven, removes between little, and consequently between the electric- field quality is exceptionally uneven, the closest between the shafts of the striking focuses or tip is by and large the most-extreme electric field quality. Cathode, positive particles are forward to the negative. Vitality changed over into motor vitality, dynamic vitality changed over into warm vitality through the impact and consequently in the channel, separately, as positive and negative surface warmth source achieves a high temperature.



3. LITERATURE REVIEW

The study of Pravin R. Kubade and V. S. Jadhav [1] investigated the influence of EDM parameters on EWR, MRR and ROC while machining of AISI D3 material with a copper electrode. The parameters considered were pulse-on time (Ton), peak current (Ip), duty factor (t) and gap voltage (Vg). It is concluded that the MRR is majorly influenced by peak current while the other factors have very less influence on material removal rate. Electrode wear rate is majorly dominated by peak current and pulse on time, whereas duty cycle and gap voltage has very less influence on electrode wear rate. Peak current is the most influencing parameter for radial overcut followed by duty cycle and pulse on time with almost negligible influence by gap voltage.

In an investigation conducted by Y. H. Guu [2] of surface characteristics of Fe-Mn-Al alloy analyzed by means of the atomic force microscopy (AFM) technique and concluded that the higher discharge energy caused more frequent melting expulsions, leads to deep and large crater formation on surface of work, resulting in a poor surface finish.

Another investigation conducted by George et al [3]optimized the machining parameters in the EDM machining of C-C composite using Taguchi method. The process parameters influence electrode wear rate and MRR, according to their relative significance, are selected as gap voltage, peak current and pulse on time respectively.

C.H. Cheron [4]machined XW42 tool steel and concluded that material removal rate with Cu electrode is greater than graphite electrode. He also concluded that Cu is suitable for roughing surface while graphite is suitable for finishing surface.

A similar study was conducted by Ahmet Hascalık and Ulas¸Caydas [5] using parameters such as pulse current and pulse duration and concluded that electrode material has an obvious effect on the white layer thickness, the material removal rate, surface roughness and electrode wear are increasing with process parameters.

Kumar Sandeep [6] investigated the aspects related to the surface quality and metal removal rate that are the most important parameters from the point of view for selecting the optimum level condition of processes and with the economical aspects. It reported the current research trends in EDM process.

Gill et al [7]on EN31with Cu-Cr-Ni Powder Metallurgy Tool found that current is the most contributing parameter towards surface roughness.

Malhotra et al [8] conducted experiments on EN-31 and found that surface roughness of EN-31 Die Steel was majorly influenced by the current and pulse on time. Lower the value of current better the surface finish and same effect in case of pulse on time.

Rajesha S et al [9] studied surface roughness on AL-7075 metal matrix composite and concluded that the Surface Roughness initially increases rapidly with an increase in pulse off-time and decreases at a slower pace with increase in level of pulse off time.

Singh [10] Investigating the Effect of Copper Chromium and Aluminum Electrodes on EN-31 Die Steel and concluded that Metal removal rate is better for copper chromium except at 6A current when compared to brass electrode. Maximum MRR was achieved at 12A for both brass and copper chromium.

4.1EXPERIMENTATAL SETUP

ELECTRONICA ZNC EDM machine was done machining the samples. The machine is as depicted in the figure below. EDM is 'non-customary' or 'non-traditional' gathering of machining techniques. In world, EDM is viewed as a progression of breakdown and after that rebuilding of the fluid dielectric in the middle of the apparatus and work-pieces. EDM utilizes start disintegration technique to evacuates the materials of the work-piece. The machine was available at Dilawar Engineering Works, Lucknow.

Table 4.1 Technical Specifications of EDM

Sr. No.	Specification	Value
1	Model	ZNC
2	Dielectric Fluid	EDM Oil
3	Input Power Supply	Three phase AC 415 V, 4 wire system,50 Hz
4	Electrode used	Copper
5	H X W X D machine size	1750 X 1060 X 525 mm
6	Maximum Load Lift	750 kg
7	Pulse on time	0.5 to 4000
8	Pulse frequency	0.1 to 500
9	Main Table Traverse (X,Y)	1100 X 650 mm

Density (g/cm^3)	Melting point (ºC)	Yeild strength (MPa)	Elastic modulus (GPa)	Possion's Ratio	Brinell Hardness
7.80	1540	450	210	0.3	65

Figure 4.1: EDM Machine

Table 4.3 Chemical composition of the work-piecematerial (EN-31) by weight

Material	Fe	Mn	Cr	C	Si
% Composition	95.7	0.52	1.30	1.50	0.22

Figure 4.4:work-pieceBars of EN-31

Figure 4.5: EN-31machined work- pieces

4.4TOOL MATERIAL

The tool material in-use work is 100% Copper (Cu). The tool was prepared of dimensions as 1 inches length and 5 mm. diameter. The density of pure copper used as tool is 8.96 g/cm^3.

5. RESULT AND DISCUSSION

Table 5.2 Calculation of S/N ratio for MRR

S.N.	MRR(mm^3/min)	Signal to noise ratio (db)
1	0.064	-23.8764
2	0.154	-16.2496
3	0.255	-11.8692
4	0.136	-17.3292
5	0.608	-4.3219
6	0.478	-6.4114
7	0.294	-10.6331
8	0.91	-0.8192
9	1.019	0.1635

Delta = (Highest mean S/N Ratio – Lowest mean S/N Ratio

CALCULATIONS OF ANOVA

Table 5.5 Values of MRR corresponding to different levels of Ip

Ip Levels	Value 1	Value 2	Value 3
1	0.064	0.154	0.255
3	0.136	0.608	0.478
5	0.294	0.910	1.019

Table 5.6: Calculation for Tool. Wear. Rate

Exp. No	Ip	Ton	V	TWR(mm^3/min)
1	1	10	100	0.018
2	1	15	125	0.045
3	1	20	150	0.166
4	3	10	125	0.04
5	3	15	150	0.353
6	3	20	100	0.416
7	5	10	150	0.064
8	5	15	100	0.28
9	5	20	125	0.67

	Ip	Ton	V	Hole enlargement (mm)
1	1	10	100	0.113
2	1	15	125	0.124
3	1	20	150	0.131
4	3	10	125	0.137
5	3	15	150	0.146
6	3	20	100	0.152
7	5	10	150	0.161
8	5	15	100	0.169
9	5	20	125	0.178

Exp. No	Ip	Ton	V	M/c Time	MRR(mm^3/min)
1	1	10	100	60	0.064
2	1	15	125	25	0.154
3	1	20	150	20	0.255
4	3	10	125	28	0.136
5	3	15	150	6	0.608
6	3	20	100	11	0.478
7	5	10	150	17	0.294
8	5	15	100	4	0.91
9	5	20	125	5	1.019

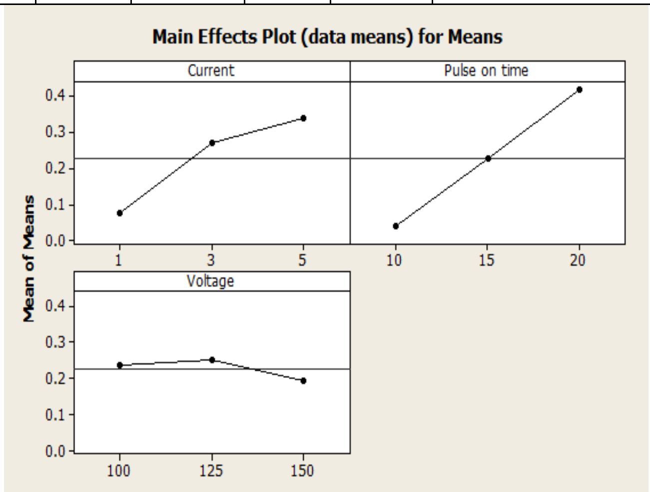


Figure 5.3:Main effect plot for TWR

5.3.2 Calculation of Mean S/N ratiofor Hole Enlargement

Table 5.12 Calculation of mean S/N ratio for Hole Enlargement

Level	Current	Ton	Voltage
1	18.24	17.36	16.91
2	16.78	16.76	16.80
3	15.43	16.34	16.74
Delta	2.81	1.02	0.17
Rank	1	2	3

5.3.3 Analysis of Variance for Hole Enlargement

ANOVA for hole enlargement is given in the following table-

Table 5.13 ANOVA of Hole Enlargement

Source	DOF	SS	Adj MS	F Value	Contribution
Current	2	0.0023647	0.0011823	131.37	86.93%
Pulse on Time	2	0.0003247	0.0001623	18.04	11.93%
Voltage	2	0.0000127	0.0000063	0.70	0.50%
Error	2	0.0000180	0.0000090		0.64%
Total	8	0.0027200			100%

At least 95% confidence

Optimal Levels of Parameters for Hole Enlargement

- **Peak Current : 1A**
- **Pulse on Time : 10μsec**
- **Voltage: 100 V**

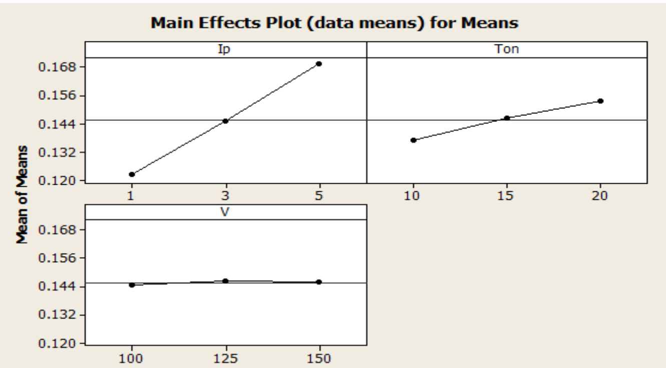


Figure 5.5 Main effect plot for Hole Enlargement

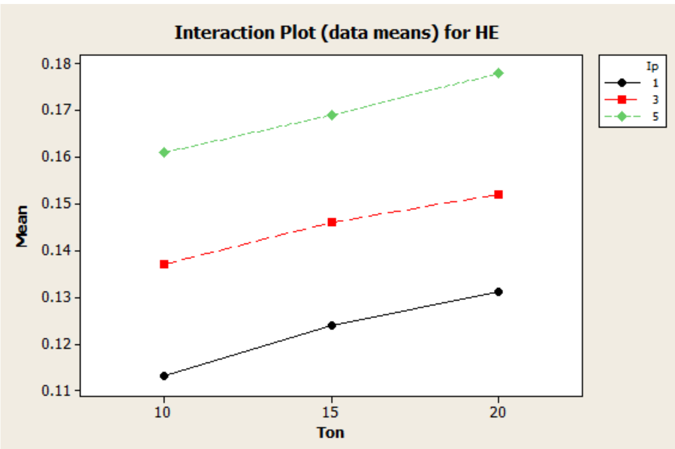


Figure 5.6: Interaction plot for parameters and Hole Enlargement

SEM FIGURES OF HOLE ENLARGEMENT

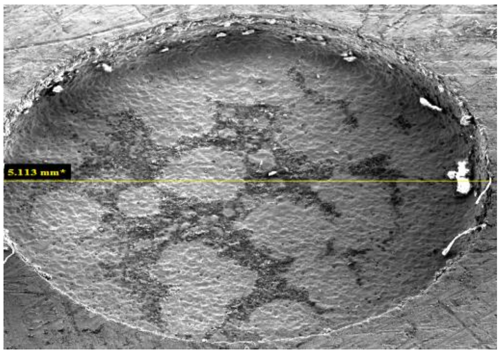


Figure 5.7: Hole Size of Sample 1

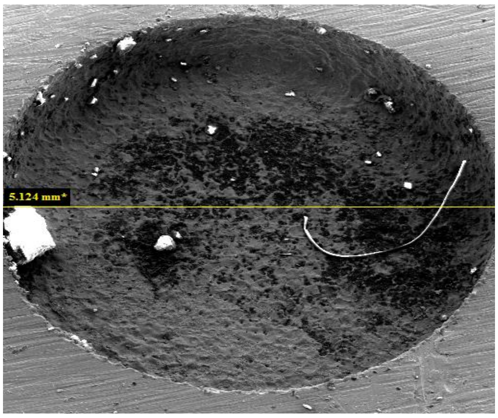


Figure 5.8: Hole Size of Sample 2

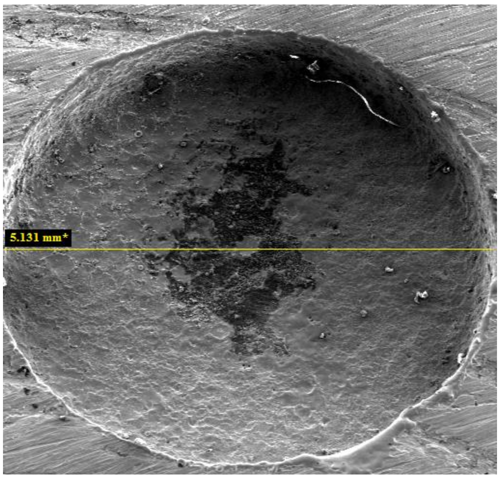


Figure 5.9: Hole Size of Sample 3

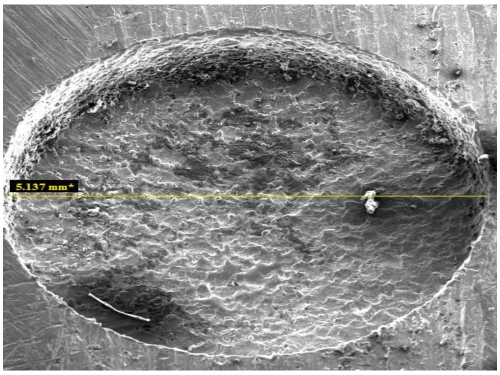


Figure 5.10: Hole Size of Sample 4

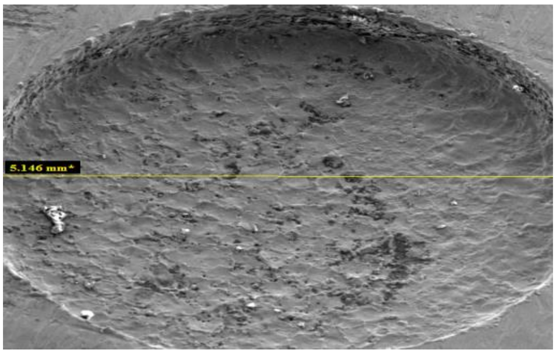


Figure 5.11: Hole Size of Sample 5

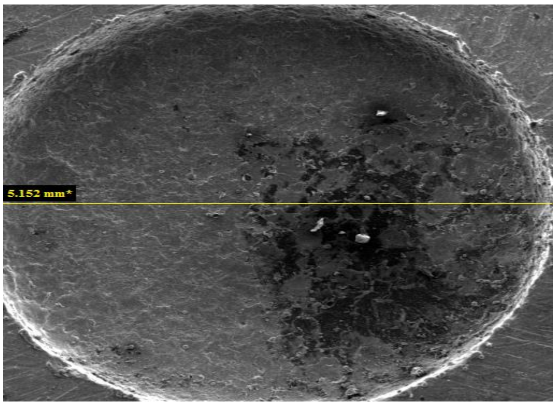


Figure 5.12: Hole Size of Sample 6

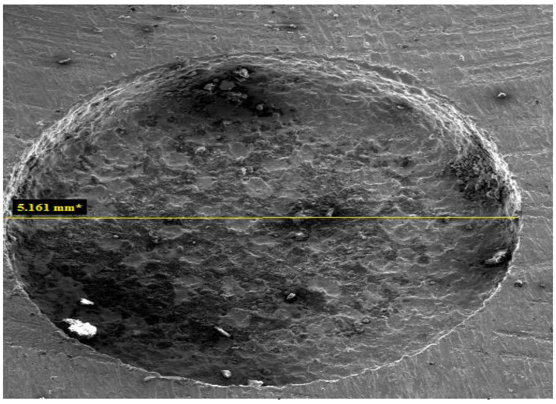


Figure 5.13: Hole Size of Sample 7

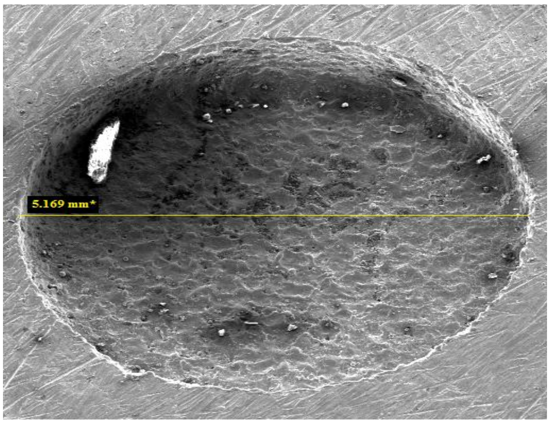


Figure 5.14: Hole Size of Sample 8

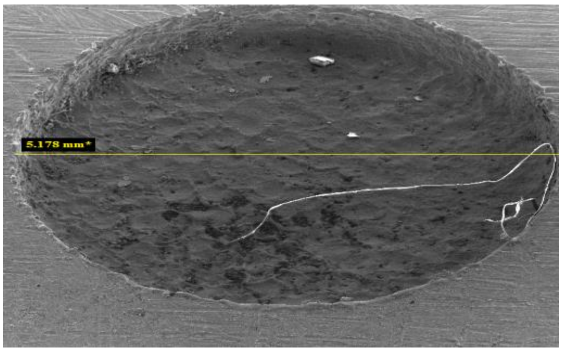


Figure 5.15: Hole Size of Sample 9

5.4 CONFIRMATION TEST

Table 5.14: Confirmation of expectable and effective values of MRR

Experiment No.	**Optimum Machining Parameters**			**MRR (gm/min)**	
	Current (A)	Pulse on Time (µsec)	Voltage	Effective	Expectable
1	**5**	**20**	**100**	**0.957**	**0.983**
				Error (%)	**2.71%**

Table 5.15: Confirmation of expectable and effective values of TWR

Experiment No.	**Optimum Machining Parameters**			**TWR**	
	Current	Pulse on	Voltage	Effective	Expectable

	(A)	Time (µsec)			
1	**1**	**10**	**150**	**0.031**	**0.028**
				Error (%)	**9.67%**

Table 5.16: Confirmation of expectable and effective values of Hole Enlargement

Experiment No.	**Optimum Machining Parameters**			**Hole Enlargement**	
	Current (A)	**Pulse on Time (µsec)**	**Voltage**	**Effective**	**Expectable**
1	**1**	**10**	**100**	**0.113**	**0.116**
				Error (%)	**2.65%**

6. CONCLUSIONS

This test contemplate was led to upgrade the information m/cinvariable in EDM of EN-31 utilizing copper cathode with L9-orthogonal exhibit of Taguchi strategy. Current, Ton and Voltage were chosen as information machine parameters which are fluctuated to discover their collaborations with execution measures. The outcomes demonstrate the execution of parameters at assorted levels for streamlining the MRR, TWR and Hole Enlargement of EN-31. Following conclusions are produced using the examination:

- Material Removal Rate increments with both Ip and Ton. Both these parameters have significant blow on MRR like that got by Kubade [1]. In addition, with increment in the level of peak-current and Ton, the MRR is seen to take after an expanding pattern. This is because of the way that the force of start is more at more elevated amount of parameters and thus MRR increments.

- Voltage is the slightest commanding parameter for material removal rate and has just a commitment of 1.52%. MRR tends to diminish with increment in voltage.

- The device begins to corrupt with increment in levels of Ip and Ton. Since Ton and Ip- are the to-the-highest-degree impacting parameters like Kubade [1], subsequently the plot acquired for them are direct line that are indicating expanding pattern.

- For voltage, the bend got is level. On expanding the estimation of voltage, a declining pattern is taken after [1].

- Ton contributes significantly for tool wear rate with a commitment of 54.20%.

- The Ton and Ton are major impacting factors for Hole Enlargement and it increments with the expansion in the level of parameters.

- Peak-current is the major ruling component for Hole Enlargement same as that acquired by Kubade [1] with a commitment of 86.93% and has real effect on it. Higher power sparkles are created at more elevated amounts of Ip, subsequently impact of Ip is most astounding and Hole Enlargement increments with increment in the estimation of Ip.

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