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INVESTIGATION OF TWR OF EDM PROCESS ON MILD STEEL USING COPPER ELECTRODE

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ABSTRACT

Electrical discharge machining (**EDM**), is a thermal based machining process whereby a desired shape is obtained by using electrical discharges. In this process Material is removed from the workpiece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or "electrode," while the other is called the workpiece-electrode, or "workpiece." The process depends upon the tool and workpiece not making actual contact. When the voltage between the two electrodes is increased, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric (at least in some places), which breaks down, allowing current to flow between the two electrodes. As a result, material is removed from the electrodes. Once the current stops (or is stopped, depending on the type of generator), new liquid dielectric is usually conveyed into the inter-electrode volume, enabling the solid particles (debris) to be carried away and the insulating properties of the dielectric to be restored. In this study we will discuss the effect of different machining parameters like voltage, current, pulse on time, pulse off time on the response parameters mainly on tool wear rate. the study will be made with four different values of input parameters. The other parameters such as duty cycle, polarity, spark gap are kept constant. In this experiment mild steel is selected as work piece and copper rod with 10mm diameter is taken as tool electrode. The layout of design of experiment is based on Taguchi L_{16} orthogonal array and analysis of variance (ANOVA) is used to investigate the results obtained from Taguchi. From the result it is found that the tool wear rate is directly proportional to the current and pulse on time. As the range of current and pulse on time increases, the tool wear rate also increases. This is due to that as the current and pulse on time increases, the heat energy also increase which further results of more metal to be melt from work piece and tool. For the response parameter i.e. tool wear rate, the voltage and pulse off time have not much effect.

1.1 Electrical Discharge Machining

The history of Electrical Discharge Machining techniques goes as far back as the 1770s when it was discovered by an English Scientist. However, Electrical Discharge Machining was not fully taken advantage of until 1943 when Russian scientists learned how the erosive effects of the technique could be controlled and used for machining purposes. During research to eliminate erosive effects on electrical contacts, the soviet scientists decided to exploit the destructive effect of an electrical discharge and develop a controlled method of metal machining [3]. In 1943, soviet scientists announced the construction of the first spark erosion machining.Electrical Discharge Machining is a most basic nonconventional machining process, where material is removed from the work piece by thermal energy of repeated sequences of spark occurring between the small gap of an electrode and a work piece. Electrical Discharge Machining is mainly used for machining of electrically conductive hard metals, alloys and composites in aerospace, automotive and dies making industries. Electrical Discharge Machining process removes the undesirable material in the form of debris and produce shape of the tool surface as of a metal portion by means of a recurring electrical sparks stuck between tool and the work piece in the existence of dielectric fluid. Dielectric fluid may be EDM oil, kerosene oil, transformer oil and distilled water. The dielectric liquid acts as a de- ionizing medium between the tool and work piece.

1.2 Electrical Discharge Machining Types

Mainly, there are two kinds of Electrical Discharge Machining process

1.2.1 Sinking Electrical Discharge Machining Process

1.2.2 Wire Electrical Discharge Machining Process

1.2.1 Sinking Electrical Discharge Machining Process

Sinker EDM, uses an electrically charged electrode to produce a specific shape, which is generally shape of the tool electrode into a metal component. It is also called cavity type electric discharge machining or probe electric discharge machining or volume discharge machining. It sinks shape from the electrode part into the oil immersed work piece, not cutting all the way through the piece. The electrode discharges pulsed electrical sparks that jump to the work piece and tear out small particles. The materials most commonly used for the electrode are graphite, brass or copper ,tungsten. Graphite is used because of its machining capabilities and wearability, and copper for its fine finish requirements. This process can be used to form any type of intricate shapes on rigid materials. But only electric conductive materials can be worked out with this process. This machining consists of a tool and work piece submerged in a dielectric fluid such as EDM oil, kerosene oil; powder mixed EDM oil and de-ionized water. The tool and work piece are separated by a small gap known as arc gap. The arc gap generally ranges from 0.01mm – 0.5 mm [8].

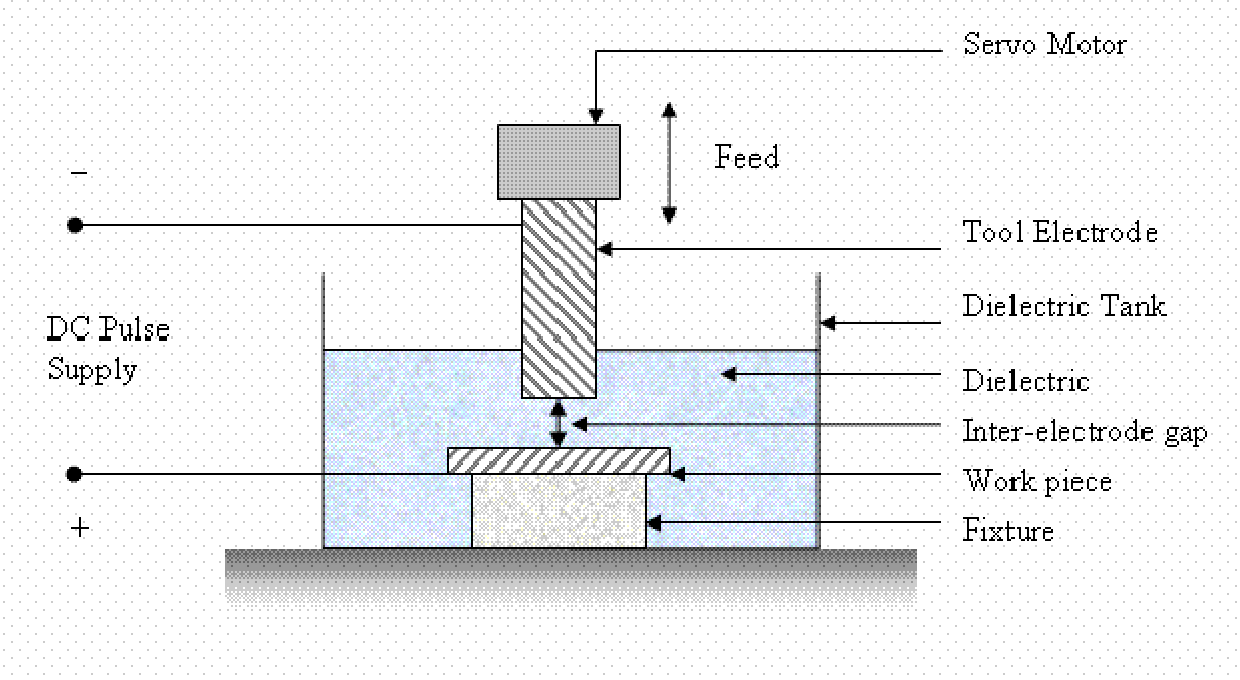


Fig. 1.1 Setup of Sinking Electrical Discharge Machining Process [6]

The dielectric fluid is allowed to flow through this arc gap to remove the debris from the machining surface. The tool and work piece are connected to a suitable power supply. The power supply produces an electrical potential between the tool and work piece. As the tool approaches the work piece, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps.

These sparks usually strike one at a time because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the work piece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterrupted.

1.2.1.1 Principle of Operation

In this machining process the material removal is done by a controlled erosion through a series of electric sparks. When a discharge takes place between two points of the anode (workpiece) and the cathode (tool), the intense heat generated near the zone metals and evaporates the material in the sparking zone. For improving the effectiveness the workpiece and tool are submersed in a dielectric fluid (hydrocarbon, mineral oils) and are separated by a small gap known as arc gap. Also for maintaing the predetermined spark gap, a servo control unit is generally used. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps. These sparks usually strike one at a time, because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the workpiece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterrupted. Several hundred thousand sparks occur per second The spark develops sufficiently high pressure between work and tool as a result of which a very high temperature is reached. This high temperature spark causes sufficiently compressive force developed between the tool and work piece as an outcome that minute amount of metallic particles are liquefied and eroded. Material removal occurs due to instant vaporization of the material as well as due to melting. [3]

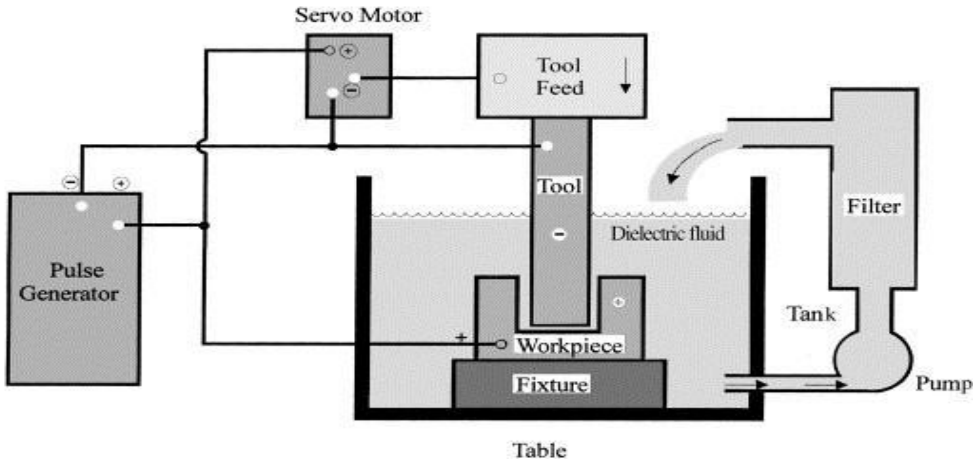
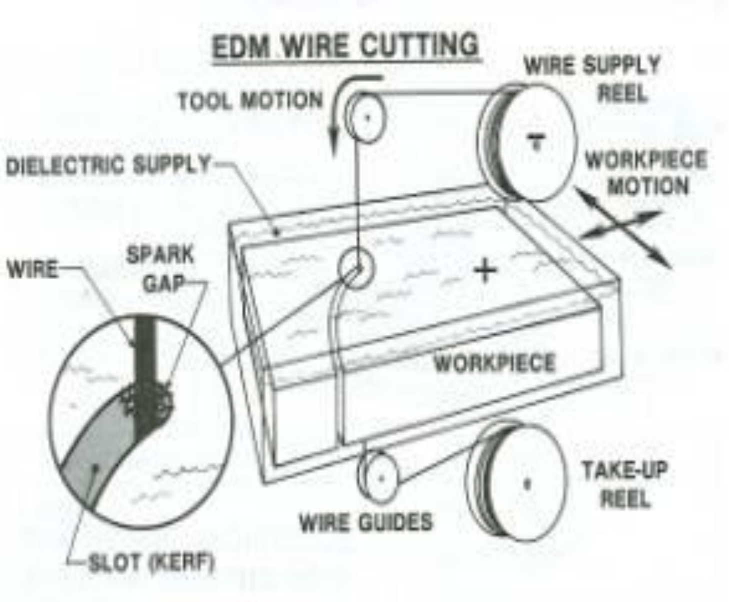


Fig. 1.2 Principle of Operation [19]

1.2.2 **Wire electric discharge machining process**

Wire EDM machine uses a metallic wire (electrode) to cut a programmed contour in a workpiece. Extrusion dies and blanking punches are very often machined by wire cutting. In the machining area, each discharge creates a crater in the workpiece (material removal) and an impact on the tool (wear of the tool/electrode). The wire can be inclined, thus making it possible to make parts with taper or with different profiles at the top and bottom. The wire is usually made of brass or stratified copper, and is between 0.02 and 0.33 mm diameter. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods. The wire, which is constantly fed from a spool, is held between upper and lower diamond guides. The guides, usually CNC-controlled, move in the *x*–*y* plane. On most machines, the upper guide can also move independently in the *z*–*u*–*v* axis, giving rise to the ability to cut tapered and transitioning shapes (circle on the bottom, square at the top for example).



Set up for EDM wire cutting machine

2.2 Literature Review

[1] Younis M. A. et. al. (2015), studied the effect of electrode material on surface roughness and to avoid residual stresses during electrical discharge machining. For this study two types of electrode material were chosen namely, Dura graphite 11 and Poco graphite EDMC-3. Two grades of tool steels DIN 1.2080 and DIN 1.2379 were chosen as a work piece material. To prepare the specimens for Electrical Discharge Machining process, the base specimens were machined by Electrical Discharge Machining to remove the unwanted material at various machining conditions i.e. rough, medium and soft according to the pulse on time and pulse off time. The scanning of specimen was done by scanning electron microscope (SEM) to study the effect of electrode of material upon the surface roughness and cracks. After that, the X- ray diffraction method was used to measure the residual stresses. From results, it was found that POCO graphite EDMC-3 electrode results higher residual stresses compared with Dura graphite electrode. Also the soft Electrical Discharge Machining exhibited higher residual stresses as a result of higher pulse on time.

[2] Abrol et. al. (2015), optimized the effect of chromium powder mixed with dielectric fluid on machining characteristics of AISI D_2 die steel. Cylindrical shaped rod of copper with 14 mm diameter was used as a tool with positive polarity. Peak current, pulse on time, pulse off time, concentration of powder were the machining parameters. The process performance characteristics were measured in terms of material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The design of experiment was based on Taguchi L_{27} orthogonal array and analysis of variance (ANOVA) was used to examine the percentage involvement of each process parameter for optimizing the performance characteristics of EDM. The authors establish that all the preferred parameters except pulse on time have a significant effect on material removal rate. Current was found to be the most significant parameter for material removal rate (MRR), tool wear rate (TWR). With increase in current, material removal rate (MRR), tool wear rate (TWR) also increases. The authors also concluded that, surface roughness increases with increase in pulse off time.

[3] Santoki P. N. et. al. (2015), observed the effect of various process parameters of Electrical Discharge Machining on overcut. Current, pulse on time and pulse off time were the process parameters selected for this experiment. AISI 304 stainless steel was the work piece material and three electrodes namely graphite, copper and silver were used to investigate. The layout of experiment was based on Taguchi design approach. After investigation, it was found that the copper tool was more suitable. The experimental results indicated that the current was the most effective parameter followed by pulse on time and pulse off time. It was concluded that, for all the three electrodes, as the current and pulse on time increases, the overcut also increases. And as the pulse off time increases, the overcut decreases

[4] Gaikwad A. et. al. (2014), investigated the effect of process parameters of Electrical Discharge Machining on material removal rate and electrode wear rate. SS 316 is used as a work piece material and copper is used as an electrode. The process parameters selected for this experiment were pulse on time, pulse off time, current and dielectric pressure. Commercial grade kerosene oil was used as a dielectric fluid. Taguchi philosophy was used to design the experimental layout. Further ANOVA was used to analyze the optimum values of process parameters. Nine experiments were performed by varying the value of process parameters. From results it was observed that the pulse off time and current were the most effected parameters for both MRR and EWR followed by pulse on time and dielectric pressure. As the pulse off time and current increases, the MRR also increase. On the other hand as current increases, the EWR decreases. Further, the dielectric pressure has not much effect on MRR and EWR.

[5] Pandey et. al. (2014), investigated the effect of variable parameter on machining characteristics such as MRR, TWR and OC. Taguchi method used to create and L_{27} orthogonal array of input variable used for experiment design. AISI 304 stainless steel was selected as workpiece because of large industrial application. In result author found that current was the most significant parameter followed by pulse on time and least important was duty cycle for all three MRR, TWR and OC. With increase in duty cycle MRR also increases but pulse on time it increase only to 100µs and then started decrease. Surface roughness (SR) was directly related to the current, in case of duty cycle surface roughness (SR) increase up to 70% and then started decrease. Also founded that overcut (OC) increases with increase in current and pulse on time.

[6] Rani M.I. et. al. (2014), studied the various input parameters of Electrical Discharge Machining on AISI D2 tool steel using copper electrode. Grey relational analysis and Taguchi method was used to evaluate and estimate the effect of various process parameters on performance measures. The response parameters selected for this experiment were MRR and TWR and the corresponding input parameters considered were current, pulse on time, duty cycle and voltage. Taguchi L9 orthogonal array was used to design the layout of experiment. It was observed that, current was the most significant parameter for MRR followed by pulse on time, duty cycle and voltage. The results indicated that, as the current increased, the MRR and TWR also increased. When the pulse on time increased, the MRR increased and TWR decreased. Further, with the increase in duty cycle and voltage, the value of MRR and TWR first increased and then decreased.

[7] Raghuraman et. al. (2013), optimized the EDM machining parameters using Taguchi design approach and grey relational analysis. Mild steel was used as a work piece material for this experiment even as copper was selected as a tool material. The experimental design procedure was based on Taguchi L_9 orthogonal array and analysis has been carried out by using grey relational analysis. Pulse on time, pulse off time and current were elected as a machining parameters for this experiment. MRR, TWR and surface roughness were the performance parameters. The experiments were performed on EDM machine of ELECTRONICA. Commercial grade EDM oil was used as dielectric fluid. The authors observed that, as the current and pulse on time increases, both the MRR and TWR also increases. The authors also concluded that, current was the most effectual parameter for MRR and TWR while pulse off time was the most significant parameter for SR. As the pulse off time increase, the SR decrease

[8] Sengottuvel P. et. al. (2013), investigated the effect of various control parameters of Electrical Discharge Machining and influence of different tool geometry on MRR, TWR and surface roughness on machining of inconel 718 using copper electrode. Five control parameters namely pulse on time, pulse off time, peak current, flushing pressure and electrode geometry. The electrode geometries were circle, square, rectangle and triangle. Four different levels of five control parameters were planned as per the L16 OA. The parameters were optimized using multi objective optimization technique and significance of each parameter was analyzed using ANOVA. In addition, fuzzy logical model was used to better understand the input and output responses. It was observed that, with the increase in pulse on time and peak current, the material removal rate also increase. On the other hand as the pulse off time increase, the MRR decrease. Whereas, the tool wear rate and surface roughness decreased with the increase in pulse off time. It was also observed that, the rectangular tool has obtained the best results as compared to other tool geometries.

[9] Nipanikar S.R. (2012), investigated the control parameters for Electrical discharge machining on AISI D3 steel material using copper tool. Taguchi method was used to formulate the experimental layout and to analyze the effect of each parameter on the machining characteristics. For this experiment current, voltage, duty cycle and pulse on time were the control parameters. The machining characteristics selected were material removal rate, tool wear rate and radial overcut. The analysis by using Taguchi method revealed that, the peak current significantly affects the MRR, EWR and OC. It was also concluded that, the voltage has least effect on TWR and OC.

3.1 Objectives of the Present Work

The objectives of this dissertation are as:

1. To experimentally investigate the tool wear rate for Sinker EDM on mild steel using copper electrode.
2. To experimentally find out the influence of current, pulse on time, pulse off time and voltage on the tool wear rate of Sinker EDM.
3. To find the optimum value of machining influence of current, pulse on time, pulse off time and voltage for lower tool wear rate.

3.2 Selection of Machining Parameters

Process parameters are the variables within the process that affects the performance characteristics. Determination of the process parameters which affects the performance is an important task for any design of experiment to achieve better quality characteristics. The machining parameters selected for this experiment are current, pulse on time, pulse off time and voltage.

Table 3.1 Machining Parameters

Machining Parameters	Symbol	Unit	Levels			
			Level 1	Level 2	Level 3	Level 4
Current	I	Amp	8	10	12	14
Voltage	V	Volt	35	40	45	50
Pulse on Time	Ton	µs	50	100	150	200
Pulse off Time	Toff	µs	5	7	9	11

3.3 Response Data

For this experiment the response data is:

1. Tool Wear Rate (TWR)

The objective of this experiment is to maximize the material removal rate and minimize the tool wear rate.

3.4 Calculation of Tool Wear Rate

It is the amount of material removed in gram from the tool per minute. The tool wear rate (TWR) is expressed as the difference of weight of the tool before and after machining to the machining time.

$$TWR\ (g/min) = \frac{\mathrm{Wt\,b - Wta}}{\mathrm{T}} \text{…………………………} \quad (3.4)$$

Where, Wtb = Weight of the work piece before machining

Wta = Weight of the work piece after machining
T = machining time

3.5Selection of Orthogonal Array

The selection of an orthogonal array for an experiment depends upon the following two factors: i.e. number of parameters and number of levels for each parameter. In this experiment four machining parameters namely current, pulse on time, pulse off time and voltage and each at four levels have been selected and hence the L_{16} orthogonal array is chosen. Responses are obtained by running the experiments according to the L_{16} orthogonal array. The L_{16} orthogonal array in terms of actual parameters is shown in table 3.2.

Table 3.2 L16 Orthogonal Array

Column	**1**	**2**	**3**	**4**	**Response data**
Run	**I**	**V**	**Ton**	**Toff**	**TWR**
1	8	35	50	5	-
2	8	40	100	7	-
3	8	45	150	9	-
4	8	50	200	11	-
5	10	35	100	9	-
6	10	40	50	11	-
7	10	45	200	5	-
8	10	50	150	7	-
9	12	35	150	11	-
10	12	40	200	9	-
11	12	45	50	7	-
12	12	50	100	5	-
13	14	35	200	7	-
14	14	40	150	5	-
15	14	45	100	11	-
16	14	50	50	9	-

3.6 Conduct of Experiment

The experiment is done on ELEKTRA EMS 5535 Die-sinking type of EDM machine using copper electrode having 10 mm in diameter and mild steel as a work piece. Commercial grade EDM oil is used as a dielectric fluid with external pressure flushing. Experiments are conducted with negative polarity of electrode. Pressure flushing is used to flush the EDM oil between the spark gap. The design of experiment is based on Taguchi L_{16} orthogonal array. In this experiment flushing pressure, duty cycle and spark gap are kept constant i.e, 0.25 kgf/cm^2, 8% and 0.05 mm respectively. A constant spark gap can be maintained with the help of a servo control system. The total sixteen numbers of experiments are performed on die sinking type electrical discharge machine. The tool wear rate is calculated by using equations 3.5. The calculated values of tool wear rate is shown in table 3.8 as:

Table 3.8 Calculated Values of TWR

Run	I (Amp)	V (Volt)	Ton (µs)	Toff (µs)	TWR (g/min)
1	8	35	50	5	0.00150
2	8	40	100	7	0.00164
3	8	45	150	9	0.00173
4	8	50	200	11	0.00186
5	10	35	100	9	0.00192
6	10	40	50	11	0.00184
7	10	45	200	5	0.00202
8	10	50	150	7	0.00190
9	12	35	150	11	0.00199
10	12	40	200	9	0.00213
11	12	45	50	7	0.00189
12	12	50	100	5	0.00206
13	14	35	200	7	0.00232
14	14	40	150	5	0.00221
15	14	45	100	11	0.00212
16	14	50	50	9	0.00201

RESULTS AND DISCUSSION

4.1 Signal to Noise Ratio: The signal-to-noise (S/N) ratio indicates how the response characteristics varies relative to the target value under different noise factors. We can choose from different S/N ratios, depending on the objective of experiment. The equations for calculating S/N ratios for larger is better (LB), smaller is better (SB) and nominal is best (NB) are as follows:

1. Larger is Better

$$\mathrm{SN_i} = -10\log\frac{1}{\mathrm{N_i}}\sum_{\mathrm{u}=1}^{\mathrm{N_i}}\frac{1}{\mathrm{y}^2}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4.1)$$

2. Smaller is Better

$$\mathrm{SN_i} = -10\log\sum_{\mathrm{u}=1}^{\mathrm{N_i}}\frac{\mathrm{y}^2}{\mathrm{N_i}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4.2)$$

3. Nominal is Best

$$\mathrm{SN_i} = 10\log\frac{\mathrm{y}^2}{\mathrm{s}^2}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4.3)$$

Where, i= Experiment number
u= Trial number
N_i= Number of trials for experiment I
S= Variance
y= Performance Parameter

Table 4.2 S/N Ratio for TWR

Run	I (Amp)	V (Volt)	Ton (µs)	Toff (µs)	TWR (g/min)	S/N Ratio
1	8	35	50	5	0.00150	56.4782
2	8	40	100	7	0.00164	55.7031
3	8	45	150	9	0.00173	55.2391
4	8	50	200	11	0.00186	54.6097
5	10	35	100	9	0.00192	54.3340
6	10	40	50	11	0.00184	54.7036
7	10	45	200	5	0.00202	53.8930

8	10	50	150	7	0.00190	54.4249
9	12	35	150	11	0.00199	54.0229
10	12	40	200	9	0.00213	53.4324
11	12	45	50	7	0.00189	54.4708
12	12	50	100	5	0.00206	53.7227
13	14	35	200	7	0.00232	52.6902
14	14	40	150	5	0.00221	53.1122
15	14	45	100	11	0.00212	53.4733
16	14	50	50	9	0.00201	53.9361

4.2 Influences on TWR

The response tables for means and S/N ratio are shown in table 4.6 and table 4.7. The delta values for each process parameter i.e. current (I), voltage (V), pulse on time (Ton) and pulse off time (Toff) are 0.000482, 0.000025, 0.000273 and 0.000015 and ranks 1, 3, 2, 4 respectively, in response table for means shown in table 4.6.

Table 4.6 Response Table for Means (TWR)

Level	I	V	Ton	Toff
1	0.001683	0.001933	0.001810	0.001948
2	0.001920	0.001955	0.001935	0.001938
3	0.002018	0.001940	0.001958	0.001948
4	0.002165	0.001958	0.002083	0.001953
Delta	0.000482	0.000025	0.000273	0.000015
Rank	1	3	2	4

Similarly from response table for S/N ratio shown in table 4.7 the delta values and ranks for machining parameters are 2.20, 0.21, 1.24 and 0.12 and 1, 3, 2 and 4 respectively. The current gets rank 1 followed by pulse on time, voltage and pulse off time. The ranks and delta values show that the current has the greatest effect on the tool wear rate followed by the pulse on time, voltage and pulse off time.

Table 4.7 Response Table for S/N Ratio (TWR)

Level	I	V	Ton	Toff
1	55.51	54.38	54.90	54.30
2	54.34	54.24	54.31	54.32
3	53.91	54.27	54.20	54.24
4	53.30	54.17	53.66	54.20
Delta	2.20	0.21	1.24	0.12
Rank	1	3	2	4

4.3 Main Effect Plot For TWR

The main effect plot for means and S/N ratio are shown in figure 4.3 and 4.4 clearly shows that, the current has the influencing parameter for tool wear rate and the next one is pulse on time.

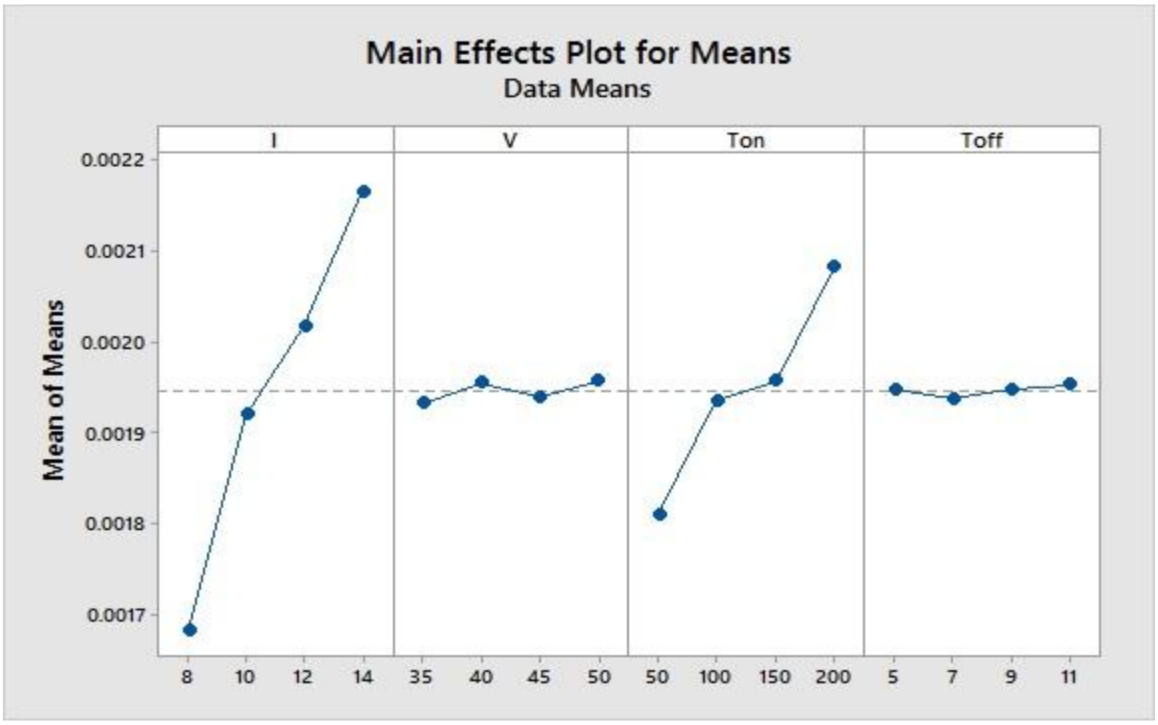


Fig. 4.3 Main Effect Plot for Means (TWR)

Both these machining parameters are directly linked with tool wear rate i.e. as we increase the value of current from 8 amp to 14 amp and the value of pulse on time increases from 50 μs to 200 μs the tool wear rate also increases. Further, the other two parameters namely voltage and pulse off time have very small effect on tool wear rate. So for lower tool wear rate the value of current and pulse on time should be low

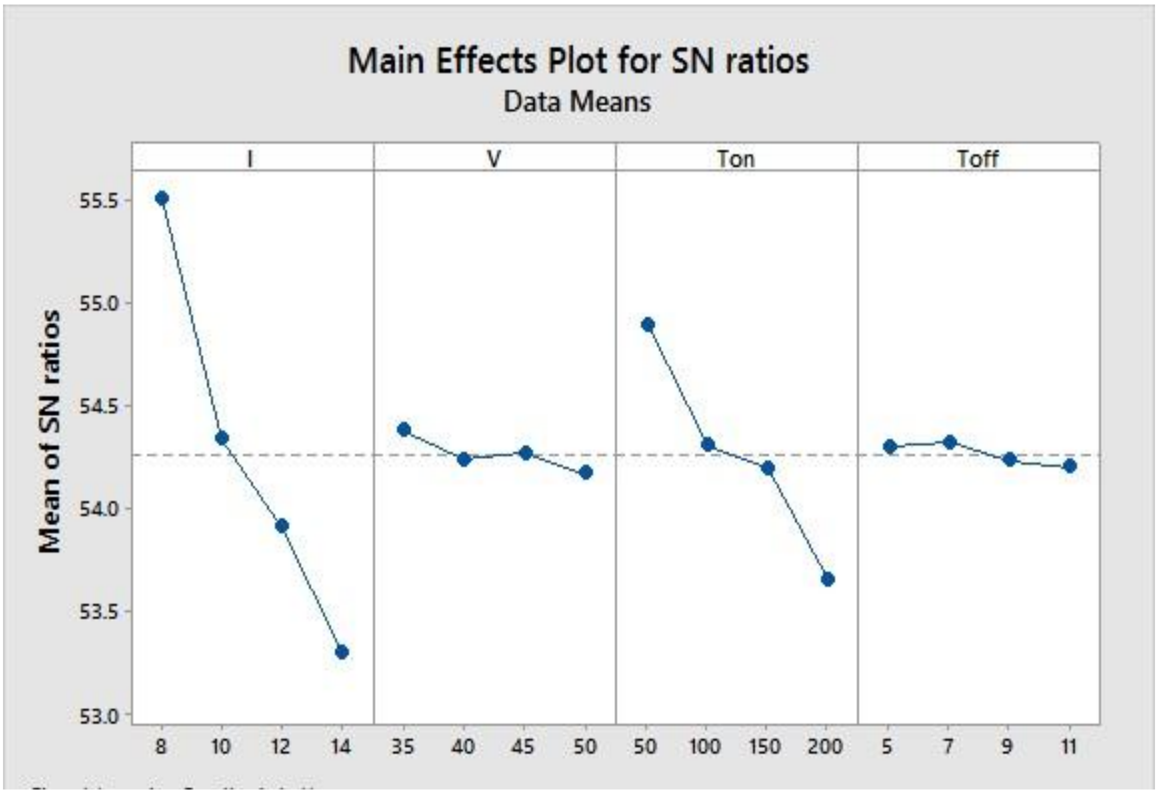


Fig. 4.4 Main Effect Plot for S/N Ratio (TWR)

4.4 Analysis of Variance For TWR

The analysis of variance (ANOVA) for tool wear rate is shown in table 4.8. Analysis of variance is a statistical method to determine the significance of each machining parameter towards the response. The parameters whose P value less than or equal to 0.05 will be the most significant parameter. The machining parameter whict attains higest F value gets lowest P value.

The F value for the machining parameters i.e. current, voltage, pulse on time and pulse off time are 26.22, 0.23, 7.83 and 0.09 and the corresponding P values of above mentioned parameters are 0.012, 0.871, 0.062 and 0.958 respectively as shown in table 4.8, analysis of variance table for tool wear rate.

Table 4.8 Analysis of Variance for TWR

Source	DF	Seq SS	Adj MS	F	P	% Contribution
I	3	10.3975	3.46583	26.22	0.012	74.12
V	3	0.09070	0.03025	0.23	0.871	0.65
Ton	3	3.10490	1.03497	7.83	0.062	22.13
Toff	3	0.03760	0.01253	0.09	0.958	0.27
Error	3	0.39660	0.13220			
Total	15	14.0274				

From results of analysis of variance tables, it is clear that out of all machining parameters, current and pulse on time have most significant effect on tool wear rate. From these results, it is also clears that current is the most effective parameter for tool wear rate followed by pulse on time, voltage and pulse off time.

CONCLUSIONS AND FUTURE SCOPE

5.1 Conclusions

The main aim of this work is to determine the most significant values of different machining parameters like current, voltage, pulse on time and pulse off time to minimize the tool wear rate with maximum machining rate. For this experiment, the work is done on mild steel work piece by using a cylindrical shaped copper rod is used as a work piece and 8 pieces of cylindrical shaped copper tool having 10 mm in diameter and 6 cm in length each is used as an electrode. The complete work is done by an ELEKTRA- EMS 5535 die-sinking type electric discharge machine. Taguchi L_{16} orthogonal array is employed to design the experimental layout. From the results obtained for this experiment, the following conclusions have been drawn: -

1. The response parameters i.e. tool wear rate is significantly influencing by the machining parameters.
2. Current is the most significant parameter for tool wear rate followed by pulse on time, voltage and pulse off time.
3. The tool wear rate is directly proportional to the current and pulse on time.
4. As the range of current and pulse on time increases, the tool wear rate also increases. This is due to that as the current and pulse on time increases, the heat energy also increase which further results of more metal to be melt from work piece and tool.
5. For the response parameter i.e. tool wear rate, the voltage and pulse off time have not much effect.
6. To minimize the tool wear rate, the optimal value of machining parameters are current (14 amp), pulse on time (200 µs), voltage (50 volt) and pulse off time (11 µs) respectively.

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