# OPTIMIZATION OF PROCESS PARAMETERS USING TAGUCHI METHOD WHILE MACHINING ALUMINIUM ALLOY (6082) MATERIAL ON DIE SINK EDM

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**ABSTRACT: -** Electrical Discharge Machining (EDM) is an unconventional machining process which is most successful and extensively recognized process for machining very hard materials, intricate profiles and small holes with high accuracy. Only electrically conductive materials can be machined by this process. In the present work, Aluminium alloy (6082) is machined using an Electrolytic Copper electrode on Spark Erosion Machine- SN35. The objective of the work is to experimentally study the influence of process parameters such as Current (I), Voltage (V), Pulse ON Time ($T_{ON}$), Pulse OFF Time ($T_{OFF}$) and magnetic field on Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness ($R_a$). The process parameters are optimized for maximum Material Removal Rate, minimum Tool Wear Rate and Surface Roughness based on experimental results by using Taguchi and ANOVA Method. The experimental response data of electric discharge machining process is analyzed and the optimal combinations of influential parameters are determined, and we got the optimal value of material removal rate 89.732, tool wear rate 0.0012 and surface roughness 11.127 respectively.

**KEYWORDS: -** Electrical Discharge machine, Aluminium alloy 6082, Current, Voltage, Taguchi method

## 1. Introduction:

Electrical Discharge Machine (EDM) has become the most widely adopted technology in the manufacturing industry. Electrical discharge machine (EDM) is a key "non-traditional manufacturing technology" that was created in the late 1940s and is now widely used to produce plastic mouldings, die castings, forging dies, and other forming tools. Novel material science breakthroughs have resulted in new engineered metallic materials, composite materials, and high-tech ceramics with good mechanical and thermal properties, as well as adequate electrical conductivity to allow for spark erosion machining. Electrical discharge machining (EDM) is a commonly used method in industry for high-precision machining of all types of conductive materials of any hardness, including metals, metal alloys, graphite, and even some ceramics. For machining heat-treated tool steels and sophisticated materials (super alloys, ceramics, and metal matrix composites) that demand high precision, complicated shapes, and high surface polish, EDM technology is rapidly gaining traction in the tool, die, and mould production sectors. Milling is a cost-effective alternative to traditional machining operations, which involve removing material with tooling that is harder than the work material. The eroding effect of an electric spark on both electrodes is used in electrical discharge machining (EDM). Electrical discharge machining (EDM) is a dielectric removal process that relies on the phenomenon of electrical discharge. As a result, the electrode has a significant impact on the rate at which material is removed and the tool's lifespan.

## 2. LITERATURE REVIEW AND OBJECTIVE:

A few studies on research publications linked to Electrical Discharge Machining [1] must be covered in this chapter. The readings in these papers and theses are largely focused with EDM settings like discharge current, applied voltage, pulse on time, pulse off time, duty cycle, and how these parameters will affect machining outputs like MRR, Ra, TWR, and so on. technique for doing a minimum number of runs using mixed level design and analysis

P. Balasubramanian and T. Senthilvelan [2] looked at two different workpiece materials produced in an Electrical discharge machine: EN8 and D3. The primary process parameters that have been chosen are peak current, pulse on time, die electric pressure, and tool diameter. Material removal rate (MRR), tool wear rate (TWR), and surface roughness are the three output responses (SR). Tool electrodes made of Cast Copper and Sintered Powder Metallurgy Copper (P/M Copper) were used to machine the above-mentioned work parts. The parameters were assessed using response surface methodology (RSM), and the important process parameters were discovered using analysis of variance (ANOVA). Interactions between parameters have been investigated as well. After machining on the work pieces, SEM pictures of both electrodes were taken to investigate the structure-property relationship. Maximum MRR, minimum TWR, and minimal SR were achieved by optimizing the input parameters. The MRR for EN-8 material is high when compared to Sintered electrode, whereas the TWR for Cast electrode is low. Furthermore, Sintered electrode has a lower SR value as compared to Cast electrode.

The machining characteristics of austenitic stainless steel 304 were discovered by M.M. Rahman et al. [3]. MRR and surface roughness increase with increased current, according to the data. With peak current, the TWR climbs until the pulse on time exceeds 150 seconds. Copper electrodes had a long pulse on time with negligible tool wear when reverse polarized, according to the data.

Using a U-shaped copper electrode and an interior flushing technique, S. K. Dewangan [4] studied the influence of machining parameter settings such as pulse on time, discharge current, and tool diameter of AISI P20 tool steel material. The Taguchi method was used to conduct experiments with the L18 orthogonal array. Furthermore, the signal-to-noise ratios associated with the observed values in the tests were established by determining which factor is 5most affected by Material Removal Rate (MRR), Overcut (OC), and Tool Wear Rate Responses (TWR).

S. H. Tomadi et al. [5] investigated the impact of tungsten carbide machining settings on outputs such as TWR, MRR, and surface quality. In terms of machining characteristics, a confirmation test is used to assess the difference between projected values and experimental runs. Copper tungsten tool was discovered to be used for improved surface finishing of the work item.

They used complete factorial DOE for optimization and discovered that longer pulse off times resulted in decreased tungsten carbide tool wear, as did increasing current, voltage, and pulse on time.

AKM For the EDM milling operation of a stainless-steel work piece with copper tools, Asif Iqbal and Ahsan Ali Khan [6] adjusted the machining process parameters. The tool's RPM, feed rate, and voltage are input parameters, while MRR, TWR, and Ra are output parameters. To achieve better MRR, TWR, and Ra, the central composite design is used. The machining parameters for optimal condition are 1200 RPM, 120V, and 4m/sec, according to the results.

## 3. INTRODUCTION TO ELECTRICAL DISCHARGE MACHINING (EDM)

Electrical discharge machining (EDM), also known as spark machining, spark eroding, burning, die sinking, wire burning, and wire erosion, is a manufacturing process that involves the use of electrical discharges to achieve a desired shape (sparks). A series of quickly recurring current discharges between two electrodes separated by a dielectric liquid and exposed to an electric voltage remove material from the work piece. The tool electrode is one of the electrodes, while the work piece electrode is the other. The tool and the work item are not in direct contact throughout this process.

When the voltage between the two electrodes is increased, the intensity of the electric field in the volume between them exceeds (at least in some locations) the dielectric's strength, allowing current to flow between them. This occurrence is comparable to a capacitor failure (condenser). Material is removed from the electrodes as a result. When the current is turned off, a fresh liquid dielectric is injected into the inter-electrode compartment, allowing solid particles (debris) to be transported away and the insulating characteristics of the dielectric to be restored. Flushing is the process of infusing new liquid dielectric into the inter-electrode volume while also restoring the potential difference between the electrodes to its pre-breakdown condition, allowing for a new liquid dielectric breakdown.

### 3.1 PRINCIPLE OF EDM

In EDM, there may be a gap between the tool and the work piece. Both the tool and the work substance require electrical conductors. A dielectric medium surrounds the tool and the work material. Dielectric mediums such as kerosene or deionized water are routinely utilized. The tool is separated from the work item by a gap. An electric field is created based on the applied potential difference and the spacing between the tool and the work piece. The free ions on the tool and the work piece are exposed to electrostatic forces as the electric field between the tool and the work piece is created. When the electrode is pushed closer to the work piece, the dielectric breaks down. More positive ions and electrons would be created during the dielectric breakdown. The concentrations of electrons and ions in the dielectric medium between the tool and the job at the spark gap would increase as a result of this cyclic activity. The material in the channel is called "plasma" because of its extreme concentration. Such a plasma channel would have a very low electrical resistance. Electron avalanche motion is the name for this type of motion. A spark is a visual representation of such electron and ion mobility. As a result, the electrical energy of the spark is lost as heat energy. The temperature rise caused by such a strong localized heat flux would reach over 10,000°C in a matter of seconds. Material is lost as a result of such a localized substantial temperature rise. The quick evaporation and melting of the material results in the removal of components. The molten metal isn't totally eliminated; only a little portion of it is.

The plasma channel can no longer be produced when the potential difference decreases. As the plasma channel collapses, pressure or shock waves are generated, forcing the molten material to be evacuated and a crater of removed material to form around the spark source. To summarize, the principal source of material removal in EDM is the generation of shock waves caused by the collapse of the plasma channel due to the termination of the applied potential difference. The generator transfers voltage pulses from the tool to the workpiece in EDM. There isn't any consistent voltage. In EDM, just sparking is intended, not arcing. Localized arcing is the outcome of arcing. The tool surface is strewn with sparks, resulting in uniformly dispersed material removal beneath the tool.

## 4.EXPERIMENTATION

The dispute over whether graphite or copper is a better EDM electrode material has raged on for a long time. In any given geographical region, the choice is almost always the same. The preferred electrode material in North America has moved from copper to graphite. Many people in Europe and Asia feel that copper is the best material. Perhaps it's time to take a closer look at both materials to see what the differences are and which one would be best for your EDM applications.

**Figure.1. Sample work material (Aluminium Alloy 6082)**

**TABLE.I. Chemical Composition**

| Constituent | Percentage |
|---|---|
| Silicon | 0.7-1.3 |
| Ferrous | 0.0-0.5 |
| Copper | 0.0-0.1 |
| Manganese | 0.4-1.0 |
| Magnesium | 0.6-1.2 |
| Zinc | 0.0-0.2 |
| Titanium | 0.0-0.1 |
| Chromium | 0.0-0.25 |
| Aluminium | Balance |

**General properties:**

Density: 2.70 kg/m3
Machinability: Good
Thermal Conductivity: 180 W/m K
Melting Point: 555°C

### 4.1 Electrode material

Electrolytic copper was used as the electrode material in the studies. It can be generated or extruded, then shaped and dimensioned as needed. In both spearing and finishing processes, it has a low percentage of wear and can remove large amounts of material.

**Figure.2. Electrolytic Copper Electrode**

**Electrolytic Copper's chemical composition:**

Copper : 99.9% (min)
Oxygen : 0.02 to 0.04 %

**General properties:**

Density : 8.9 g/cm3
Brinell's hardness : 45
Melting Point : 1083 °C

### 4.2 EXPERIMENTAL SETUP

The workpiece must be placed on the EDM table first. The workpiece is clamped and positioned in the desired spot on the 'T' slot table by opening the tank door and clamping it. After clamping and precisely placing the workpiece, secure the electrode in the V block. Using X-Y coordinates and servo sliding motions, the electrode should be placed over the suitable cavity. Adjust the float switch so that the dielectric level is at least 5mm above the topmost sparking point. Then close the door securely using the clamps. The task of operating the machinery has been delegated. The ring magnet is set up for magnetic field tests so that the magnetic field line is perpendicular to the electrical field lines and parallel to the work piece surface.

**Figure.3. Experimental Setup with Magnet**

### 4.3 EXPERIMENTAL PROCESS

The tool is often connected to the generator's negative terminal, whereas the workpiece is connected to the positive terminal in EDM. The electrode position in reference to the workpiece is now modified in the DRO. By specifying the values of the reference point as the electrode's origin, DRO lets you to change units, choose between incremental and absolute origin, and cut depth.

Once the current (I), voltage (V), Pulse ON Time (TON), and Pulse OFF Time (TOFF) input parameters on the control panel are selected, an electric field is created depending on the applied potential difference and the spacing between the tool and the workpiece. The charged particles upon on tool were subjected to electromagnetic force as the electromotive force between both the tool and also the work was established. The workpiece and tool are machined when elevated electrons and ions collide with them. The flushing system is also engaged with such a pressure of 0.75 kg/cm2.

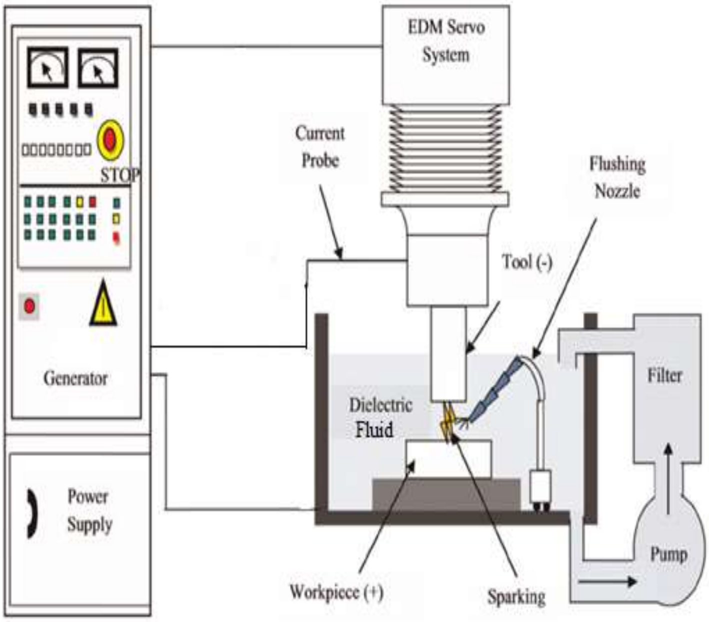

**Figure.4. Block diagram of EDM**

The tool and work piece weights before and after each machining experiment, as well as surface roughness data, are all recorded. The following is how the Material Removal Rate (MRR) and Tool Wear Rate (TWR) are calculated:

MRR= (weight before machining-weight after machining) / (Time × density of material)

Where weight is measured in grams, time is measured in minutes, and density is measured in kg/mm3.

TWR= (Tool weight before machining-Tool weight after machining)/time

Where weight is measured in grams and time is measured in minutes

**Fig.5. Aluminium Alloy 6082 before machining**

**Fig.6.Aluminium Alloy 6082 after machining**

## 5.STATISTICAL ANALYSIS

The Taguchi technique and the S/N ratio are used in this chapter to improve the Material removal rate, Tool ware rate, and Surface roughness. A Taguchi design, also known as an orthogonal array [OA] approach, is a method of designing an experimental technique that includes two, three, four, five, and mixed level designs. Because it is a four-factor mixed level design with a total of sixteen trials, the orthogonal array L16 was chosen for this study. The L16 arrangement was chosen since a few more factors will be added for future research with the same type of material, lowering the number of trials at a later time. It would also be much easier to compare the outcomes.

**TABLE. II. Levels of Machining parameters**

| Machining parameter | Symbol | Units | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| Discharge current | I | A | 15 | 20 | 25 | 30 |
| Voltage | V | V | 40 | 50 | 60 | 70 |
| Pulse on time | TON | msec | 7 | 8 | 9 | 10 |
| Pulse off time | TOFF | msec | 7 | 8 | 9 | 10 |

**TABLE.III. Observation table**

| S.NO | Current (I) | Voltage (V) | $T_{on}$ (msec) | $T_{off}$ (m sec) | M.R.R ($mm^3$/min) | T.W.R (gms/min) | $R_a$ (µm) |
|---|---|---|---|---|---|---|---|
| 1. | 15 | 40 | 7 | 7 | 39.527 | 0.00259 | 8.0172 |
| 2. | 15 | 50 | 8 | 8 | 43.326 | 0.00262 | 8.5831 |
| 3. | 15 | 60 | 9 | 9 | 42.012 | 0.00203 | 8.7342 |
| 4. | 15 | 70 | 10 | 10 | 40.034 | 0.00167 | 9.2132 |
| 5. | 20 | 40 | 8 | 9 | 67.238 | 0.00318 | 9.1932 |
| 6. | 20 | 50 | 7 | 10 | 35.134 | 0.00289 | 7.823 |
| 7. | 20 | 60 | 10 | 7 | 38.037 | 0.00201 | 8.8327 |
| 8. | 20 | 70 | 9 | 8 | 62.079 | 0.001201 | 11.0572 |
| 9. | 25 | 40 | 9 | 10 | 67.345 | 0.00463 | 9.4321 |
| 10. | 25 | 50 | 10 | 9 | 88.213 | 0.00249 | 11.1271 |
| 11. | 25 | 60 | 7 | 8 | 68.123 | 0.00623 | 8.3682 |
| 12. | 25 | 70 | 8 | 7 | 46.028 | 0.00144 | 10.4624 |
| 13. | 30 | 40 | 10 | 8 | 69.876 | 0.00293 | 10.3962 |
| 14. | 30 | 50 | 9 | 7 | 86.026 | 0.00317 | 10.5273 |
| 15. | 30 | 60 | 8 | 10 | 89.732 | 0.00232 | 10.6231 |
| 16. | 30 | 70 | 7 | 9 | 68.327 | 0.00201 | 9.243 |

**TABLE. IV.S/N ratios of mechanical properties**

| EX.NO | M.R.R (mm3/min) | S/N Ratio | T.W.R (mm3/min) | S/N Ratio | S. R | S/N Ratio |
|---|---|---|---|---|---|---|
| 1. | 39.527 | 31.937 | 0.00259 | 51.734 | 8.017 | -18.08 |
| 2. | 43.326 | 32.734 | 0.00262 | 51.633 | 8.583 | -18.672 |
| 3. | 42.012 | 32.467 | 0.00203 | 53.845 | 8.734 | -18.824 |
| 4. | 40.034 | 32.048 | 0.00167 | 55.54 | 9.213 | -19.288 |
| 5. | 67.238 | 36.552 | 0.00318 | 49.943 | 9.193 | -19.269 |
| 6. | 35.134 | 30.914 | 0.00289 | 50.761 | 7.823 | -17.867 |
| 7. | 38.037 | 31.604 | 0.00201 | 53.93 | 8.832 | -18.921 |
| 8. | 62.079 | 35.858 | 0.0012 | 58.406 | 11.057 | -20.872 |
| 9. | 67.345 | 36.566 | 0.00463 | 46.688 | 9.432 | -19.492 |
| 10. | 88.213 | 38.91 | 0.00249 | 52.076 | 11.127 | -20.927 |
| 11. | 68.123 | 36.665 | 0.00623 | 44.11 | 8.368 | -18.452 |
| 12. | 46.028 | 33.26 | 0.00144 | 56.79 | 10.462 | -20.392 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. | 69.876 | 36.886 | 0.00293 | 50.641 | 10.396 | -20.337 |
| 14. | 86.026 | 38.692 | 0.00317 | 49.973 | 10.527 | -20.446 |
| 15. | 89.732 | 39.058 | 0.00232 | 52.69 | 10.623 | -20.525 |
| 16. | 68.327 | 36.691 | 0.00201 | 53.905 | 9.243 | -19.316 |

### 5.1 S/N Ratio

The Taguchi method highlights the need of assessing response fluctuation using the signal-to-noise (S/N) ratio, which lowers variance in quality characteristics due to uncontrollable parameters.
A higher S/N value indicates better performance irrespective of performance characteristic category. As a result, the best level of machining parameters is the one with the largest S/N value. With the notion of "larger-is-better," smaller is better, quality criteria such as material removal rate, tool wear rate, and surface roughness were examined, with the S/N ratio used for this kind of response being supplied by.

**TABLE.V. S/N ratio values for material removal rate**

| Level | Current(I) | Voltage (V) | TON | TOFF |
|---|---|---|---|---|
| 1 | 32.296 | 35.485 | 34.051 | 33.873 |
| 2 | 33.732 | 35.312 | 35.401 | 35.535 |
| 3 | 36.35 | 34.948 | 35.895 | 36.155 |
| 4 | 37.831 | 34.464 | 34.862 | 34.646 |
| Delta | 5.535 | 1.021 | 1.844 | 2.282 |
| Rank | 1 | 4 | 3 | 2 |

The optimal machining performance for MRR on current at 30(level 4), voltage at 40(level 1), pulse on time at 9(level 3), pulse off time at 9(level 3) is based on the analysis of the S/N ratio from Table. III Based on the MRR results, we conclude that the current is the most significant or influencing factor, followed by Toff, and finally voltage on the given input.

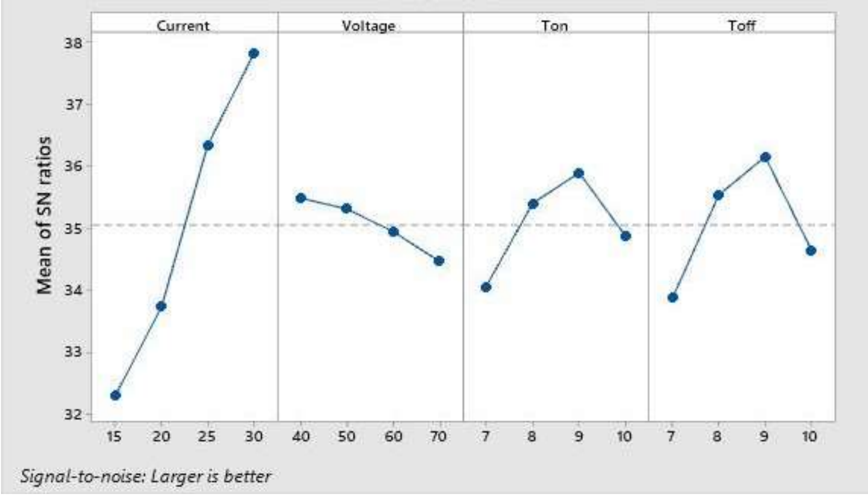

**Fig.7. Main Effects Plot for SN ratios to M.R.R**

**TABLE.VI. S/N ratio values for tool ware rate**

| Level | Current (I) | Voltage (V) | TON | TOFF |
|---|---|---|---|---|
| 1 | 53.188 | 49.751 | 50.127 | 53.106 |
| 2 | 53.26 | 51.11 | 52.764 | 51.197 |
| 3 | 49.916 | 51.143 | 52.228 | 52.442 |
| 4 | 51.802 | 56.16 | 53.046 | 51.419 |
| Delta | 3.344 | 6.409 | 2.919 | 1.909 |
| Rank | 2 | 1 | 3 | 4 |

The optimal machining performance for TWR on the current at 20 (level 2), voltage at 70 (level 4), pulse on time at 10 (level 4), pulse off time at 7 (level 1) was determined by analysing the S/N ratio from Table. III From the TWR results, we concluded that the voltage is the most significant or influencing factor, followed by current and ton, and finally Toff on the given input.

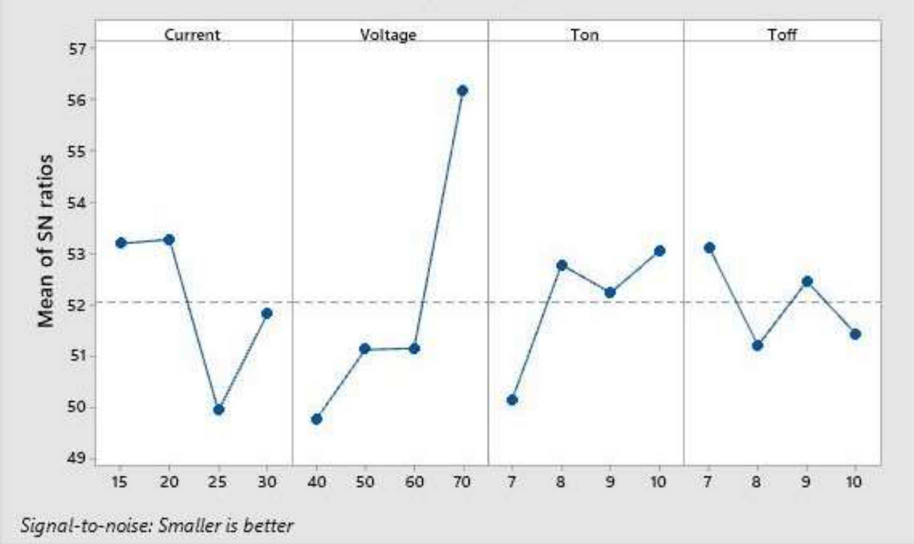

**Fig.8.Main Effects Plot for SN ratios to T.W.R**

**TABLE.VII. S/N ratio values of surface roughness**

| **Level** | **Current (I)** | **Voltage (V)** | **TON** | **TOFF** |
|---|---|---|---|---|
| 1 | -18.716 | -19.294 | -18.428 | -19.459 |
| 2 | -19.232 | -19.478 | -19.714 | -19.583 |
| 3 | -19.815 | -19.1805 | -19.908 | -19.584 |
| 4 | -20.156 | -19.967 | -19.868 | -19.293 |
| Delta | 1.44 | 0.7865 | 1.48 | 0.291 |
| Rank | 2 | 3 | 1 | 4 |

The optimal machining performance for SR on the current at 15(level 1), voltage at 60(level 3), pulse on time7(level 1), and pulse off time at 10(level 4) is based on the analysis of the S/N ratio from Table. III In the case of surface roughness, the pulse on time is the effective parameter, followed by current, voltage, and pulse off time on the given input.

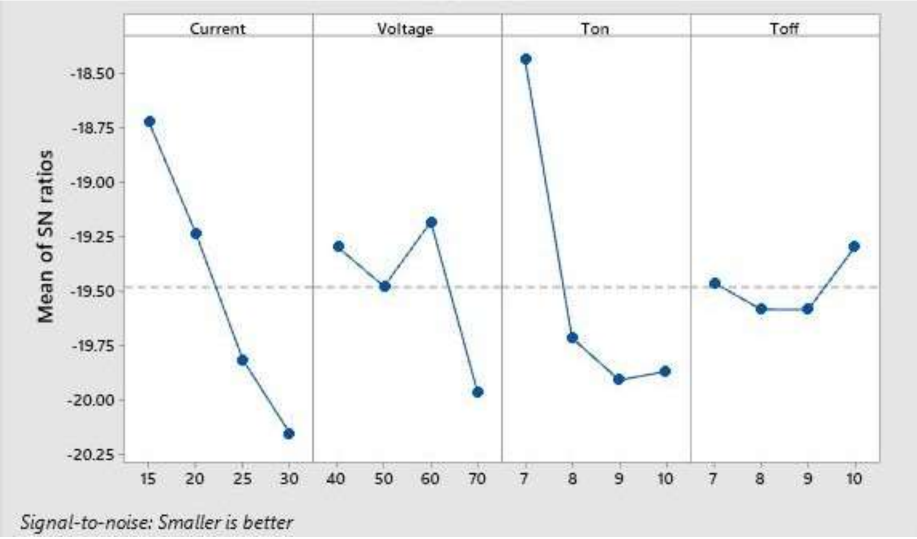

**Fig.9.Main Effects Plot for SN ratios to S.R**

### 5.1Analysis of variance (Anova)

ANOVA is a hypothesis-testing approach that analyses the variances of data to determine whether two or more population (or treatment) means are equal. ANOVA can be used to assess whether the differences between the samples are due to random error (sampling mistakes) or if there are systematic treatment effects that cause the mean of one group to differ from the mean of the other. ANOVA is often used to assess the equality of three or more means, however comparing the means of two samples with ANOVA is the same as comparing the means of independent samples with attest. If the among variation is much bigger than the within variation, the means of different samples will not be equal; if the between then within variations are nearly the same magnitude, no significant difference among sample means will exist. ANOVA was used to calculate degrees of freedom for four parameters under one of two levels and three of three levels.

**TABLE. VIII. ANOVA results for MRR**

| Factor | D.O. F | S. S | Variance | F-ratio | % Of Contribution |
|---|---|---|---|---|---|
| Current(A) | 3 | 74.981 | 24.993 | 3.1105 | 61.95 |
| Voltage(V) | 3 | 2.44 | 0.8133 | 0.1012 | 2.01 |
| Pulse on Time ($T_{On}$) | 3 | 7.481 | 2.4936 | 0.3103 | 6.18 |
| Pulse off Time ($T_{Off}$) | 3 | 12.0189 | 4.0063 | 0.4986 | 9.93 |
| Error | 3 | 24.1051 | 8.0350 | | 19.91 |
| Total | 15 | 121.026 | | | 100 |

Current has a 61.95 percent contribution, followed by pulse off time 9.93 percent, pulse on time 6.18 percent, and voltage 2.01 percent, according to the aforementioned experimental results of ANOVA on MRR.

**TABLE. IX. ANOVA results for TWR**

| Factor | D.O. F | S. S | Variance | F-ratio | % Of Contribution |
|---|---|---|---|---|---|
| Current(A) | 3 | 29.495 | 9.831 | 0.852 | 15.51 |
| Voltage(V) | 3 | 95.521 | 31.840 | 2.760 | 50.24 |
| Pulse on Time ($T_{On}$) | 3 | 20.922 | 6.974 | 0.604 | 11.00 |
| Pulse off Time ($T_{Off}$) | 3 | 9.575 | 3.191 | 0.276 | 5.03 |
| Error | 3 | 34.606 | 11.535 | | 18.20 |
| Total | 15 | 190.119 | | | 100 |

Voltage has a 50.24 percent contribution, followed by current at 15.51 percent, pulse on time at 11.00 percent, and pulse off time at 5.03 percent, according to the aforementioned ANOVA results on TWR.

**TABLE.X. ANOVA results for SR**

| Factor | D.O. F | S. S | Variance | F-ratio | % Of contribution |
|---|---|---|---|---|---|
| Current(A) | 3 | 4.855 | 1.618 | 2.169 | 32.93 |
| Voltage(V) | 3 | 1.443 | 0.481 | 0.644 | 9.78 |
| Pulse on Time ($T_{On}$) | 3 | 5.979 | 1.993 | 2.671 | 40.55 |
| Pulse off Time ($T_{Off}$) | 3 | 0.227 | 0.075 | 0.101 | 1.54 |
| Error | 3 | 2.237 | 0.745 | | 15.17 |
| Total | 15 | 14.742 | | | 100 |

From the aforementioned ANOVA results on SR, it was discovered that pulse on time accounts for 40.55 percent, contribution is 32.93 percent, voltage is 9.78 percent, and pulse off time is 1.54 percent.

## 6.CONCLUSION

The best parameter setting of tool wear rate, material removal rate, & surface roughness was identified by using Taguchi approach in this investigation, as indicated in the table below.

**Table 6.1 Optimum Mechanical Properties**

| **Mechanical properties** | **Optimal value** | **Current(I)** | **Voltage(V)** | **Pulse on time(msec)** | **Pulse off time(msec)** |
|---|---|---|---|---|---|
| **MRR ($mm^3$/min)** | 89.732 | 30 | 60 | 8 | 10 |
| **TWR ($mm^3$/min)** | 0.0012 | 20 | 70 | 9 | 8 |
| **SR** | 11.127 | 25 | 50 | 10 | 9 |

•The ANOVA analysis was applied on to the results obtained from testing to determine the most influential process parameters.
•The most important or influencing factor on MRR was current, which was followed by pulse off time, pulse on time, and finally voltage on the given input.
• On the supplied input, the voltage was the most significant or influencing factor, followed by current, pulse on time, and finally pulse off time.
• On the given input, the pulse on time was the most significant or influencing factor on SR, followed by current, voltage, and pulse off time.

## 7.BIBLIOGRAPHY

[1]http://www.docstoc.com/docs/135847346/ELECTRICAL-DISCHARGE MACHINING
[2] P. Balasubramanian and T. Senthilvelan, Optimization of Machining Parameters in EDM process using Cast and Sintered Copper Electrodes, Procedia Materials Science, Volume 6, 2014, Pages 1292-1302
[3] Rahman M.M., Khan M.A.R., Kadirgama K., Noor M.M. and Bakar R.A., Experimental Investigation into Electrical Discharge Machining of Stainless Steel 304, Journal of Applied Sciences, 11(3) (2011): pp. 549-554.
[4] Dewangan S.K., Experimental Investigation of Machining parameters for EDM using U-shaped Electrode of AISI P20 tool steel, M-Tech Thesis (2010), http://ethesis.nitrkl.ac.in/2071/1/Thesis_EDM.pdf
[5] Tomadi S.H., Hassan M.A. and Hamedon Z., Analysis of the influence of EDM parameters on surface quality, material removal rate and electrode wear of tungsten carbide, Proceedings of the International Multi Conference of Engineers and Computer Scientists, Vol II (2009).
[6] Iqbal AKM A. and Khan A.A., Optimization of process parameters on EDM milling of stainless steel AISI 304, Advanced Materials Research, 264-265 (2011): pp. 979-984.