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# Improve the Surface Characteristics of the Electric Discharge Machining Employing a Method Burnishing Process

**Shukry H. Aghdeab[a*], Ahmed G. Abdulameer[b], Ahmed B. Abdulwahhab [c], Majid H. Ismiel[d]**

[a] Department of Production Engineering and Metallurgy, University of Technology, Baghdad, Iraq, shukry_hammed@yahoo.com

[b] Center of Training and workshops, University of Technology, Baghdad, Iraq. ahmed.taku@yahoo.com

[c] Department of Production Engineering and Metallurgy, University of Technology, Baghdad, Iraq. ahmedbassil@yahoo.com

[d] Department of Production Engineering and Metallurgy, University of Technology, Baghdad, Iraq. eng_majid80@yahoo.com

*Corresponding author.

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KEYWORDS

Electrical Discharge Machining, Surface Roughness, pulse on time, pulse off time, burnishing.

ABSTRACT

*Electrical Discharge Machining (EDM) applies the concept of material eradication by utilizing electric spark erosion. The target of this exploration concentrates to examine the ideal procedure parameters of EDM on Aluminum 6061-T6as a workpiece with copper as a tool electrode. The effect of various process operators 'on machining rendering was examined. Internal factors with current (10, 20, 30) Ampere, pulse on time (50, 100, 150) µs was used after which takes pulse off time (25, 50, 75) µs. All parameters applied for empirical acts with influence on Ra (surface roughness ). The result showed that MRR" Material Removal Rate" is increment by expanding in current and pulse on time and it declines by expanding in pulse off time. Optimal condition are gained when using " Using current 30 Ampere, pulse on time is 150 µs and minimize assessment of pulse off time is 25 µs.*

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## 1. Introduction

The paper EDM is the operation by which metal is extracted with thebe of use to of spark generation through the workpiece and the tool. A spark is presented at the hole between electrode and workpiece when a DC supply with appropriate voltage and current is given. So, electrons released of the cathode, the hole was ionized and thousands sparks/sec occurs at the gap. The gap is maintained together with the help of a servo control mechanism. Due to the elevated temperature and high pressure generated by the spark, metal is eroded and flushed away by the dielectric fluid. Hence it also recognized as Spark Erosion Machining. When the voltage drops, the dielectric fluid gets deionized.

EDM is a spread method utilized in the industry sector to high accuracy delineation for all kinds of conductive matters like minerals, metallic alloys, graphite, others. Enough selection of industrialization situations is one from the most imperative perspectives to think about of conductive steel because this type is responsible to locate like significant Features: Ra, EW, and MRR. The matters applied to this research are tungsten carbide or hard metal [1].

EDM focus on different kinds of machining since its capacity to produce complex parts with a higher thoroughness. This task is profitable to tool solid materials, which would be hard to machining with different machining forms. The latest favorable position of EDM is the capacity to machine accessories a little scale [2].

In Daneshmande et al. [3] Concentrated on the influence of EDM parameters voltage (v), discharge current, pulses "on time and off time 'on the rate of MRR, surface roughness (Ra) also tool wear rate (TWR) using NiTi alloy". The results were the parameters of voltage, current and pulse on-time" which are effected directly on MRR when rise. Choudhary et al. [4] examined the influence of copper, brass and graphite electrodes on EDMON stainless steel 316 for studying surface roughness (SR) and MRR. They reported that brass supply a better surface quality than the copper electrode. Khan et al. [5] calculated the roof Silicon advantage of EDMed Ti-5Al-2.5Sn utilizing" graphite, copper and copper-tungsten’’ electrodes. This paper notified that copper tungsten electrode products the best surface goodness, while graphite gives the worst surface fineness at minimizing discharge power.

Kumar et al. [6] carried out the effect of cry treatment on the machining performance of Ti-5Al-2.5Sn titanium alloy and offered that surface finish enhanced by 19.58% for deep cryogenically treated alloy as compared to the untreated alloy. Chikalthankar et al. [7] calculated the effect of machining parameters as voltage (V), current (C), pulses (on time and off time) on (Ra) and MRR on the EDM of AISI D2 tool steel".

Chandramouli et al. [8] debated the optimal process parameters of EDM on RENE80 nickel super alloy material with aluminum as a tool electrode. The input parameters behold are current(C); pulse on-time(p) and pulse off time are used for experimental work and their effect on MRR, TWR and surface roughness. Resulting explains that appropriate determination of information parameters played a great base in EDM.

Lee and Li [9] showed the effect of the machining parameter in EDM of tungsten carbide on the machining characteristics. The EDM process with tungsten carbide best machining performances was obtaining generally with the electrode as the cathode and the workpiece as an anode. A tool with negative polarity gave the higher material removal rate, lower tool wear, and better surface finish.

This work was motivated by the problem of reducing the number of experiments to define the machining parameters of the electric discharge machining process. There are many existing approaches to finding these parameters. This work suggests using the Taguchi method to develop a mathematical description way to find the optimal machining parameters for this process. Experiments show that this approach is feasible as an optimization tool.

## 2. Experimentation

A few parameters pulse on time and pulse off time, current (C) effect on the (Ra). The CNC Machine CM 323Cis shown in Figure 1, the Electrode tool was a copper sheet with dimensions (70×30×6mm). The work material utilized in this examination is Aluminum 6061-T6 with twenty-seven specimen s dimensions (20×10×1.55 mm), as shown in Figure 2 (Specimens utilized in exploratory work). Table 1 shows the chemical composition of the work material (Aluminum 6061-T6) was obtained from chemical analysis in the laboratories of the state company for inspection and engineering Rehabilitation (S.I.E.R),while Table 2 shows the physical prosperities of Al 6061-T6 [10].

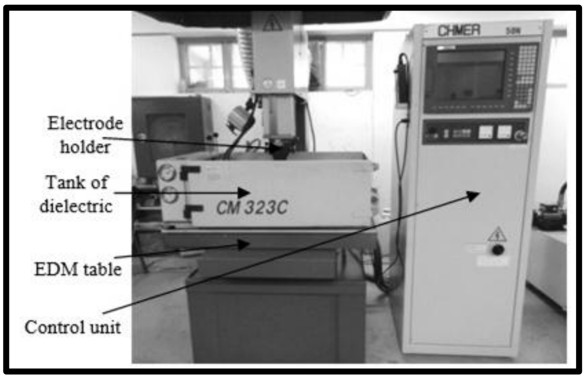


**Figure1: EDM CM323C CNC Machine used in this work**

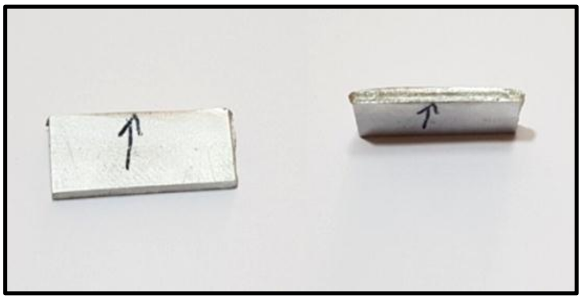

**Figure 2: Specimens utilized in exploratory work**

**Table 1: Chemical composition of Aluminum 6061-T6 work material**

| **Material** | **Al%** | **Si%** | **Mn %** | **Ti%** | **Zi%** | **Cr%** |
|---|---|---|---|---|---|---|
| % Weight | 96.43 | 0.48 | 0.13 | 0.13 | 0.24 | 0.32 |
| Material | Mg% | Ni% | Cu% | V% | W% | Fe% |
| % Weight | 0.11 | 8.60 | 0.33 | 0.064 | 0.059 | 0.65 |

**Table 2: Mechanical and physical properties of Al 6061-T6 [10]**

| Properties | Al 6061-T6 |
|---|---|
| Maximum Tensile Strength (MPa) | 310 |
| Yield Strength (MPa) | 276 |
| Elongation (1.6mm) | 12% |
| Thermal Conductivity (W/m-°K ) | 167 |
| MP ( melting point ) (°C) | 582-652 |
| Boiling point (°C) | 652 |
| E. Resistivity (ohm-cm) | 3.99x10-6 |
| Modulus of Elasticity (GPa) | 68.9 |
| Micro Hardness (HRB) | 40 |
| Poisson's Ratio | 0.33 |
| Fatigue Strength (MPa) | 96.5 |

The machine used for burnishing machining is a milling machine (Knuth MF1) as shown in Figure 3. The tool burnishing was used in the experimental study with a ball made of steel diameter (5 mm) as shown in Figure4.The working factors used in experimental work, as shown in Table 3. The experimental variables used in burnishing is (spindle speed is 350 rpm, depth of cut is 0.2 mm, the feed rate is 30 mm/min).The surface roughness (Ra) was measured by using (The Pocket Surf gauge) to measuring (Ra) of specimens after EDM machining then after burnishing machining gas shown in Figure 5. The level parameters of the investigation tests appeared in Table 4.

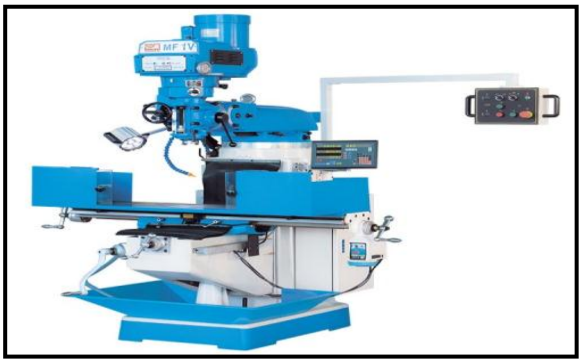


**Figure 3: Milling machine (Knuth MF1)**

**Figure 4: Tool burnishing used in the experimental study**

**Table 3: Working factors**

| Working Factors | Description |
|---|---|
| Work material | AISI 304 (40×30×1.7 mm) |
| Tool-electrode material | copper (5mm diameter) |
| Tool-electrode polarity | Negative (-) |
| Workpiece polarity | Positive (+) |
| Dielectric | Kerosene |
| Dielectric temperature | 40-80°C |
| Input voltage | 380V (three phase) AC |
| Output voltage | 140V (two phase) DC |
| Current | 10-30A |
| Pulse on time | 50-70 μs |
| Pulse off time | 35-55 μs |


**Figure 5: Pocket Surf gauge**

**Table 4:Layout of experiment**

| Factors of consideration | Symbols | Levels | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Current | I | 10 | 20 | 30 |
| Pulse (µs) | $P_{on}$ | 50 | 100 | 150 |
| Pulse (µs) | $P_{off}$ | 25 | 50 | 75 |

## 3. Resulting and Discussion

The result of the experimental tests shown in Table 5, dependent on the layout of Taguchi method used in the Minitab software. Figure 6 explains the effect of test parameters current, pulses(on time and off time) on (Ra) by (response of mean)after EDM machining, from figures, the Ra decreased to (3 µm) with increased current to (20 A) then Ra increase to (4.02 µm) with increased current to (30 A) that's due to the increasing the current leads to erosion of the material, Ra reached to (3.97µm) by increased pulse on time to (100 µs),then Ra decreased to (3.58 µm) with raising pulse on time (150µs), the Ra reached to (3.84 µm) with value pulse off time (50 µs) then Ra reached to (3.34 µm) with pulse off time become (75 µs)because increasing the spark impulses leads to increased removal of the material and reducing of impulses leads to decreased it, the protected value of surface roughness by using Taguchi method with Minitab program is (4.04815 µm).

Figure7 explains the effect of testing guides (current, pulse on time and off time) on the (Ra) by (response of mean) after burnishing machining, from this figure, the Ra decreased to (1.18 µm) with increased current to (20 A) then Ra increase to (1.20 µm) with increased current to (30 A), Ra reached to (1.41 µm) by increased pulse on time at reach (100 µs) then Ra decreased to (1.09 µm) with a rising pulse on time at reach (150 µs), the Ra reached to (1.28 µm) with value pulse off time (50 µs) then Ra reached to same value (1.28 µm) with increasing of pulse off time to (75 µs), the protected value of surface roughness is (0.952222 µm). This is because tool burnishing crushes the sharp edges on the surface of the operator, which improves the surface specifications and reduce surface roughness.

**Table 5: Experimental results of machining parameters**

| No. | Current (A) | Pulse on (µs) | Pulse off (µs) | $Ra_1$ (µm) | $Ra_2$ (µm) |
|---|---|---|---|---|---|
| 1 | 10 | 50 | 25 | 4.71 | 1.17 |
| 2 | 10 | 50 | 50 | 4.32 | 0.54 |
| 3 | 10 | 50 | 75 | 3.12 | 1.36 |
| 4 | 10 | 100 | 25 | 2.70 | 1.62 |
| 5 | 10 | 100 | 50 | 6.04 | 1.58 |
| 6 | 10 | 100 | 75 | 4.05 | 1.13 |
| 7 | 10 | 150 | 25 | 4.57 | 0.55 |
| 8 | 10 | 150 | 50 | 2.64 | 1.70 |
| 9 | 10 | 150 | 75 | 2.49 | 1.70 |
| 10 | 20 | 50 | 25 | 2.76 | 1.42 |
| 11 | 20 | 50 | 50 | 2.95 | 0.60 |
| 12 | 20 | 50 | 75 | 2.89 | 1.03 |
| 13 | 20 | 100 | 25 | 2.35 | 1.76 |
| 14 | 20 | 100 | 50 | 3.33 | 1.37 |
| 15 | 20 | 100 | 75 | 2.77 | 1.51 |
| 16 | 20 | 150 | 25 | 2.42 | 0.28 |
| 17 | 20 | 150 | 50 | 3.71 | 1.52 |
| 18 | 20 | 150 | 75 | 3.90 | 1.15 |
| 19 | 30 | 50 | 25 | 4.92 | 0.85 |
| 20 | 30 | 50 | 50 | 2.95 | 1.67 |
| 21 | 30 | 50 | 75 | 1.37 | 1.67 |
| 22 | 30 | 100 | 25 | 4.29 | 1.16 |
| 23 | 30 | 100 | 50 | 5.00 | 1.96 |
| 24 | 30 | 100 | 75 | 5.21 | 0.61 |
| 25 | 30 | 150 | 25 | 4.55 | 0.96 |
| 26 | 30 | 150 | 50 | 3.63 | 0.61 |
| 27 | 30 | 150 | 75 | 4.32 | 1.37 |

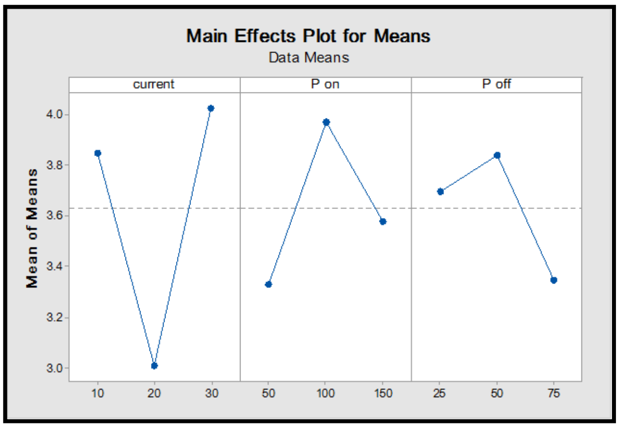


**Figure 6: Relationships of current, pulses (on time and off time) with the (Ra) after machining**

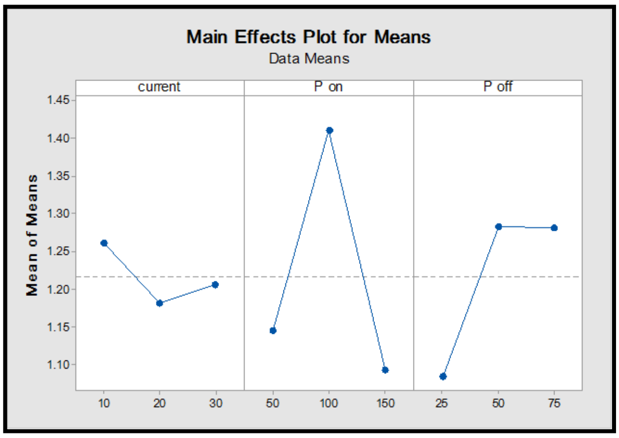


**Figure 7: Relationships of pulses (on time and off time),current with (Ra) after burnishing machining**

## 4. Conclusion

According to the experimental result, the conclusions can be as the following:

- The parameters (current, pulses on time and pulses off time)on Ra have important effecting in the EDM machining.
- Surface roughness (Ra) increased (34%) with increasing current and decrease (9.82%) with an increasing pulse on time then Ra decreased to (13.02%) with increasing pulse off time.
- Surface roughness is significantly reduced by the burnishing process and obtaining the minimum value of (0.28µm) current (20 A), pulse on time (150 µs) and pulse off time (25 µs).
- Using of software computer with Taguchi approach to analyze the results of experiments and optimize the operation then to obtaining the charts for the relationships between input and output parameters.

## 5. Acknowledgment

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