13th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2009, Hammamet, Tunisia, 16-21 October 2009

# SOME RESEARCHES REGARDING THE EDM PROCESS AND THE SURFACE QUALITY

**Popa S. Marcel**
**Technical University of Cluj-Napoca**
**103-105 Muncii Street, Cluj-Napoca**
**Romania**

**Tirla Andrei**
**Technical University of Cluj-Napoca**
**103-105 Muncii Street, Cluj-Napoca**
**Romania**

**Pop G. Marian**
**Technical University of Cluj-Napoca**
**103-105 Muncii Street, Cluj-Napoca**
**Romania**

**Contiu Glad**
**Technical University of Cluj-Napoca**
**103-105 Muncii Street, Cluj-Napoca**
**Romania**

**ABSTRACT**
*Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex forms or hard material parts that are extremely difficult-to-machine by conventional processes. The non-contact machining technique has been continuously evolving from a die and sinking tools process to a micro-scale application machining alternative attracting a significant amount of research interests. In recent years, EDM researchers have explored a number of ways to improve the sparking efficiency including some unique experimental concepts that depart from the EDM traditional sparking phenomenon. Despite a range of different approaches, this new research shares the same objectives of achieving more efficient metal removal coupled with a reduction in tool wear and improved surface quality. This paper reviews several researches in the EDM process concerning the quality of the surface and the dielectric used in the process.*
**Key words:** Electro-discharge machining, surface quality, optimization

## 1. INTRODUCTION

Electric discharge machining (EDM) is a non-traditional manufacturing process that uses electric spark discharges to machine electrically conducting materials. This process is typically used for materials such as tool- and die-steels, ceramics, etc., which are hard to machine using a more traditional approach. During the process, a voltage is applied between two electrodes—the tool and the workpiece—closely placed inside a liquid dielectric medium. When electrodes are very close to each other (gap distance) an electric spark discharge occurs between them forming a plasma channel between the cathode and the anode (Fig. 1 shows a close-up of the machining region). The spark generates enough heat to melt and even vaporize some of the work-piece material. As the spark collapses, some of the molten and vaporized workpiece material is removed from the rest of the workpiece and is carried away by the dielectric. Discharge duration is controlled by the process parameters used and can be anywhere from a few microseconds to hundreds of microseconds. Although quantity of material removed per discharge is miniscule, a large number of discharges occurring over time result in removal of the desired amount of material. As material is removed from the workpiece the tool slowly moves towards the workpiece surface (aided by servo-control mechanism) so that a constant gap between the two can do maintained. The liquid dielectric serves two purposes. It helps to keep the expanding plasma channel confined to a small diameter so that the intensity of the heat flux is very high over a small surface area of the electrodes. This ensures that melting, and even vaporization, can occur. A second use of the dielectric is to flush some of the particles that gather in the gap between the electrodes. EDM processes can be broadly classified into two categories, die-sinking EDM where the tool shape complements the final desired shape of the workpiece, and wire-EDM where the discharge takes place between a thin wire and the workpiece [3].

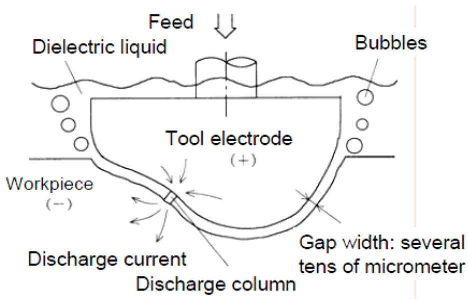


*Figure 1. EDM process.*

## 2. RESEARCHES ON THE SURFACE OF THE MACHINED WORK PIECE

Measurements of the surface were made both on the wire EDM and sinking EDM machined work pieces. The two processes are similar concerning the thermal and physical processes. The differences appear in the dielectric and in the material of the work tool. As a general characteristic in the two cases the material removal rate is created by successive craters as it appears in the figure 2.

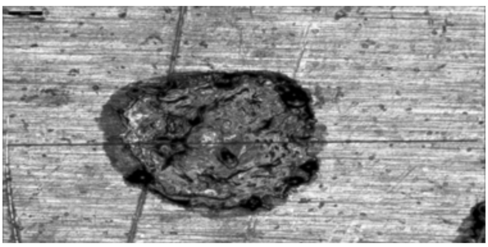

*Figure 2. Crater measurements with microscope*

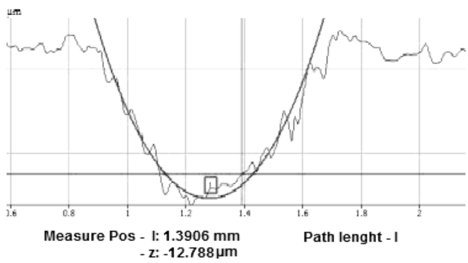


*Figure 3. Dimension of the crater radius measured*

Crater measurements were made with Alicona microscope and the crater radius dimension was measured with the InfiniteFocus software. The measurements were made thanks to the support of the ETH Zurich.

### 2.1. Measurements of the surface roughness.

Some measurements were made on machined work pieces that were obtained by Wire EDM. Some experiments were made by the collective to improve the knowledge that is necessary to obtain prescribed quality of the surface in a short time and with low costs.

For a higher hardness, the test pieces were thermal treated. (Table 1.)

The dimensions of the test pieces are:

- length L = 80mm;
- width l = 20mm;
- height h = 10÷50mm;

The roughness of the surface was measured on the middle of the height. For the same thickness of the work pieces the value of the roughness are oscillating between 1, 85 µm and 2, 70 µm as it can be seen in the figure 4.

*Table 1. Values of the hardness of the metal.*

| Material | OLC45 | 42MoCr11 | OSC7 |
|---|---|---|---|
| Obtained hardness | 241 HB (21,2 HRC) | 263 HB (24,7 HRC) | 640 HB (61,9 HRC) |

The roughness of the surface was measured on the middle of the height. For the same thickness of the work pieces the value of the roughness are oscillating between 1, 85 µm and 2, 70 µm as it can be seen in the figure 4.
For the work pieces that have thicknesses over 70 mm, it can be observed the difference between the roughness from the bottom and the middle of the work piece.
On a work piece with a thickness of 110 mm, the measurements were made from the bottom to the middle of the work piece and the roughness grows from 2, 7 µm up to 5, 5 µm as it can be seen in fig. 5.
This phenomenon takes place because the nozzles for dielectric are placed at the top and at the bottom of the work piece and the pressure is not big enough to be able to wash all the particles.

In the industry the roughness that is obtained is very important. On this parameter depends the quality and the aspect of the product.

Today the new machines with the command and control system that assist the process make the work of the operator easier. Some of the machines have the capability to estimate the time that remains for the process, material removal rate and the roughness. Usually these parameters are not real. The roughness can modify concerning dielectric and the washing possibility of the machine as it is shown in the figure 5.

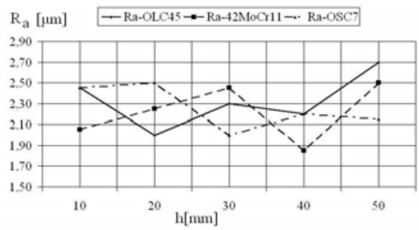


*Figure 4. Roughness variation depending on the material*

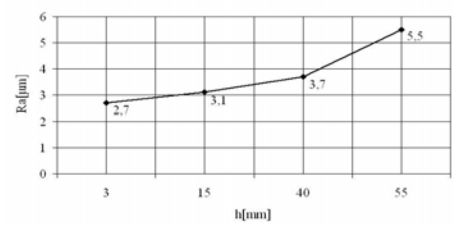


*Figure 5. Roughness variation*

**2.2 Powder additives**

Fine abrasive powder is mixed into the dielectric fluid. The hybrid material removal process is called powder mixed EDM (PMEDM) where it works steadily at low pulse energy [5] and it significantly affects the performance of EDM process. Electrically conductive powder reduces the insulating strength of the dielectric fluid and increase the spark gap between the tool and the work piece. EDM process becomes more stable and improves machining efficiency, material removal rate (MRR) and surface quality (SQ). However, most studies were conducted to evaluate the surface finish since the process can provide mirror surface finish which is a challenging issue in EDM. The characteristics of the powder such as the size, type and concentration influence the dielectric performance [6].

**2.3. Surface quality (SQ)**

Ming and He [7] indicated that some conductive powder and lipophilic surface agents can lower the surface roughness and the tendency of cracks in middle finish and finish machining but the inorganic oxide additive does not have such effect. Wong et al. compares the near mirror- finish phenomenon using graphite, silicon (Si), aluminum (Al), crushed glass, silicon carbide (SiC) and molybdenum sulphide with different grain size. Al powder has been reported to give mirror finish for SKH-51(high-speed steel) work pieces, but not on SKH-54 work pieces. They suggested that it is important to have the correct combination of powder and work piece materials and an understanding of the fundamental mechanisms affecting such combinations will promote the applications of PMEDM to feasibly produce superior surface finish and properties of components using EDM. When investigating the surface modification of SKD 61with PMEDM, Yan et al. revealed that the corrosion resistance and surface hardness were improved by adding the proper powder into dielectric. Silicon powder was used by Pecas and Henriques [6] to assess improvement through quality surface indicators and process time management over a set of different processing area. The result shows that 2 g/l of Si concentration, smooth and high reflective craters were achieved with average surface roughness (Ra) depends on the area and varies between 0.09 mm for 1 cm2 and 0.57 mm for 64 cm2 electrode. The polishing time has a greater effect on decreasing the surface roughness. Furutani et al. studied a deposition method of lubricant during finishing EDM to produce parts for ultrahigh vacuum such as space environment using PMEDM. Smoother surface can be obtained by adding aluminum powder to the mixture of molybdenum disulfide (MoS2) powder and working oil and it has smaller friction coefficient than that with normal working oil. Yih-fong and Fu-chen investigates the effect of powder properties on SQ of SKD-11 work piece using Al, chromium (Cr), copper (Cu), and SiC powders. The smallest particle (70–80 nm) generates best surface finish and Al powder produces the best surface finish [7].

## 3. CONCLUSIONS

Our researches want to show the importance of all parameters that can influence the quality of the process. For the industry it would be important to prepare a library with specified parameters for machining different materials. For example for the same kind of machining (roughing or finishing), in the tables of the machine-tools, the parameters are optimized but it is not specified the quality of the surface that can be obtained. The dimensions of the crater influence directly the roughness of the surface. Also a mathematical model will improve the knowledge of the phenomena and it will open the possibilities of using the process in different applications.

The effect of adding powder in dielectric was studied and many researchers have shown that it improves surface finish to a great extent. Addition of about 4 g/l of fine graphite powder in kerosene increases MRR by 60% and tool wear by 15%. The dielectric with suspended electrically conductive powder can enlarge the gap distance and can improve the energy dispersion, surface roughness, and material removal rate. Using Al with 40 g/l and 10 mm granularity, machining efficiency is improved with an increasing rate of 70% [7]. The machining efficiency can be highly increased by selecting proper discharge parameter (increasing peak current and reducing pulse width) with better surface finish in comparison with conventional EDM machining.

## 4. REFERENCES


[1] Nichici, Al., Achimescu, N.: – Prelucrarea pin eroziune electrică în construcția de mașini, Editura Facla, Timişoara, 1983.

[2] Dudun O.:Tehnologii neconvenționale. Prelucrari cu scule Materializate, Edirura Tehnica-Info, Chişinău, 2001.

[3] DiBitonto D.D., Eubank P.T., Patel M.R., Barrufet M.A., Theoretical models of the electrical discharge machining process. I. A simple cathode erosion model, J. Appl. Phys. 66 (9) (1989).

[4] Popa M., et, al.: Surface quality of the EDM processed materials, XIX Imeko World Congress Fundamental and Applied Metrology September 6-11, Lisbon, Portugal, 2009.

[5] Zhao F.-L., Lu Z.-Z., Wang H., Qian Z.-Q., Research on effecting mechanism of particles in powder-mixed EDM, Dalian Ligong Daxue Xuebao/Journal of Dalian University of Technology 45 (2005).

[6] Pecas P., Henriques E., Influence of silicon powder-mixed dielectric on conventional electrical discharge machining, International Journal of Machine Tools & Manufacture 43 (2003).

[7] Norliana Mohd Abbas, et al.: A review on current research trends in electrical discharge machining (EDM), International Journal of Machine Tools & Manufacture 47 (2007).