Electrical Discharge Machining in Dielectric-Powder Media

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ABSTRACT The paper reports investigations of EDM using powder suspended working fluid instead pure dielectric. The EDM characteristics obtained using hydrocarbon dielectric (kerosene) and mixture deionized water with abrasive powder have been compared. The relationship between surface roughness parameters, material removal rate and operating parameters of EDM have been determined for different kind of powder and its concentration in kerosene/water.The investigation results show that there are chances for replacing the conventional dielectric with water and that would imply considerable economic and ecology advantages.

1. INDRODUCTION

During the last decades, EDM has nearly obtained a first position in some important areas due to its capability of machining any material with electrical conductivity more than 0.01 S/cm with high cutting speed, high precision and satisfactory surface finish. Conventional EDM surface is generally matt, since it is generated by network of individual craters as result of discharges. Therefore, hand smoothing has been usually used for finishing plastic molds, dies and casting molds.

Mohri, et al. [1, 2, 3] found that an EDM finishing process using dielectric mixed with silicon powder provides a mirror surface of up to 500 cm^2, area. Recently this machining method has been introduced in commercial machine tools and practically applied in industry.

The effect of silicon and others kind of powders mixed with the dielectric on the surface generation mechanism was investigated [4, 5]. According to investigations carried out in Japan, positive influence of electrical conductive or nonconductive particles on AEDM performance is the effect of better dispersion of sparks over a workpiece [1 - 4]. This dispersion is much related with gap distance between the electrode and workpiece which becomes bigger by mixing powder into dielectric. In order to estimate the effect of powder suspension on the gap distance, when sparks are occurs, the maximal electrical field intensity in the gap with grains was determined [6]. Estimation of distribution of electric field in dielectric with spherical particles shows that electrical breakdown in the gap with conductive or nonconductive particle should be at 3 or 1.5 times larger distance than in the case EDM in pure dielectric, respectively. The experiments described in the paper [4], confirm the

conclusion that the conductive particle enlarges the working gap significantly more compared to that of nonconductive particles.

Bigger gap distance makes more uniform flushing conditions, sparks stable, and consequently they disperse over wider area of a workpiece. Moreover, when the gap distance is bigger, the stray capacitance inserted in the gap is smaller, which affects the surface quality [1, 4].

Simultaneously, environmental and work protection legislation, which is constantly becoming more and more stringent, leads to considerable obligations in the operation of erosion systems and the handling of operating materials, particularly working media and filtration aids. A possible solution lies in replacing the oil-based dielectrics, which are used as standard for EDM-sinking by water-based fluids. Extended investigations carried out in Germany show high efficiency application of mixture water and glycerin for reducing disadvantages in EDM-sinking using pure water [7, 8].

This paper reports investigation on EDM sinking using mixture deionized water and abrasive powders. For comparison, results using powder suspended oil-based dielectric is also presented.

2. EXPERIMENTAL PROCEDURE

Experimental investigations have been performed on modified EDM machine tool FORM 2LC CNC by incorporating developed dielectric system for deionized water and mixture powder/dielectric (Figure 1).

As working fluids were used:

- kerosene FLUXELF 2 with resistivity 7.4×10^{10} Ωcm;
- deionized water with conductivity 15 μS/m.
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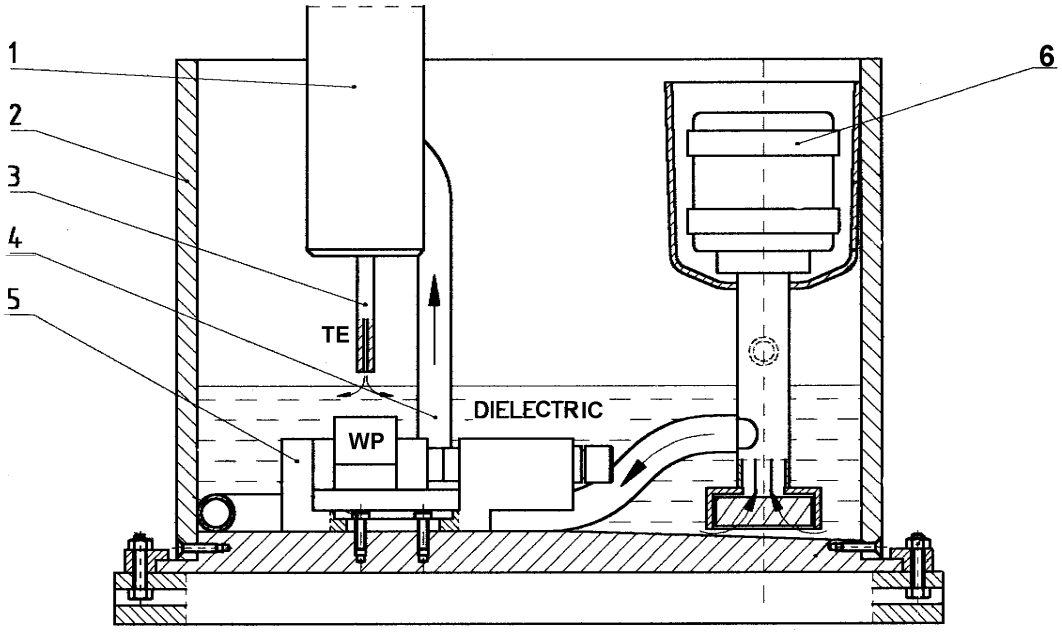

Figure 1. Schematic diagram of dielectric/powder supply system: 1- tool electrode holder,2 - container, 3 - tool-electrode TE, WP-workpiece, 4 - pipe for dielectric delivering to TE, 5 - workpiece holder, 6 - pomp

These fluids were mixed with powder:

- silicon carbide SiC with 180 grade;
- Al_2O_3 with 600, 800 and 1200 grade;
- Al with 180 grade.

A copper cylinder of 20 mm in diameter has been used as a tool electrode; the hole has been made in the cylinder in order to pump dielectric into to area of machining. The tool steel NC6, in compliance with Polish Standard, was used as a workpiece.

To determine of basic EDM relationships between input parameters such as pulse current, on-time, duty factor, and output parameters namely material removal rate (MRR) and surface roughness (Ra, Rz), factorial design and multiple regression analysis have been used.

First series of experiments were carried out using kerosene and kerosene/powder mixture as dielectric and second series with using deionized water and deionized water/powder mixture.

During machining negative and positive polarity of tool electrode was used for investigation of polarity effect, it is an especially important when water-based dielectric is used.

3. EXPERIMENTAL RESULTS FOR EDM USING POWDER SUSPENDED KEROSENE

The experiments confirmed of previous investigations presented in papers [1 - 6], that application of powder suspended fluids reduces roughness of EDM-ed surfaces. The relations between the surface roughness obtained with EDM process carried out in pure kerosene (Ra and Rz) and in SiC powder suspension Ra(0.2) and Rz(0.2) of two different concentration (0.2 % and 2 %) and various current values is illustrated in Fig. 2 and 3.

The largest differences have been obtained for low pulse current, which is advantageous as the EDM finishing is carried out for low current values. Higher grain concentration also contributes to the improvement in surface smoothness (Fig. 3). The EDM using powder suspended kerosene can make surface roughness values 2.5 less than those without powder.

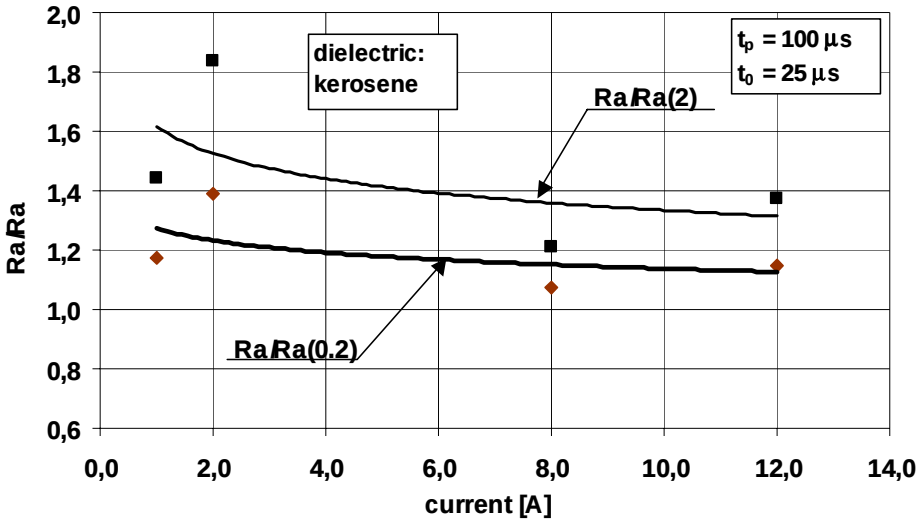

Figure 2. Effect of current on relative value Ra / Ra: Ra / Ra (0.2) at powder concentration of 0.2 %, Ra / Ra(2) at powder concentration of 2 % (Ra - roughness of surface machined in kerosene)

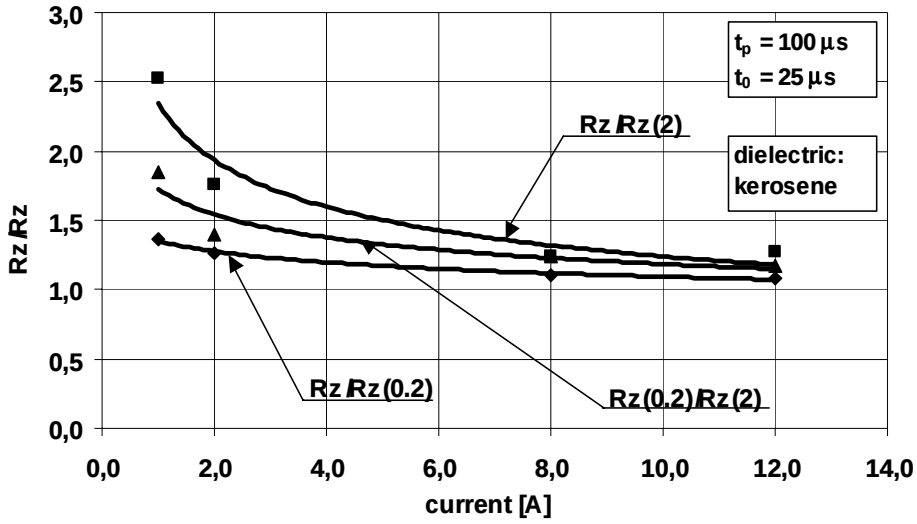

Figure 3. Effect of current on relative value Rz / Rz: Rz / Rz (0.2) at powder concentration of 0.2 %, Rz / Rz(2) at powder concentration of 2 % (Rz - roughness of surface machined in kerosene)

Variation of Rz parameter is shown in Fig. 4, for different SiC-powder concentration and pulse current values. Higher powder concentration results in improvement of surface quality. Greater reduces of surface roughness can be obtained for higher pulse current values.

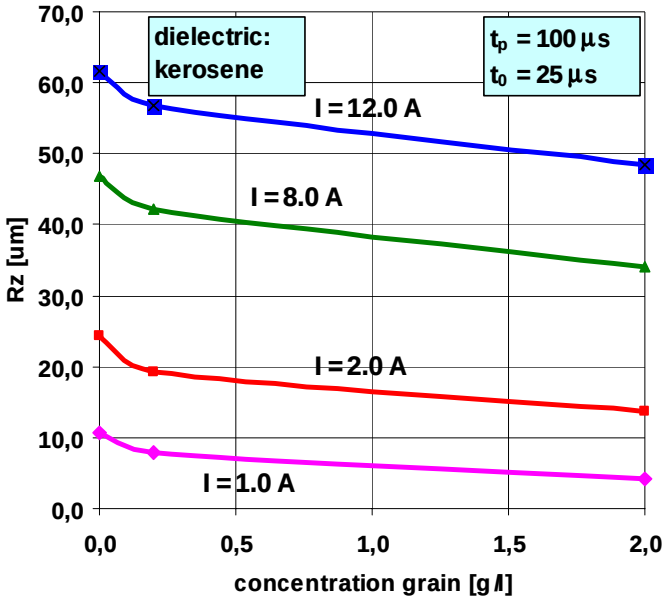

Figure 4. Effect of grain concentration in kerosene on Rz. Powder SiC 180 grade

4. EXPERIMENTAL RESULTS FOR EDM USING POWDER SUSPENDED DEIONIZED WATER

Deionized water would be used for reasons of its environmental compatibility and the workplace conditions but, however, it must be rejected for economic reasons due its poor

performance during sinking [**7**]. The advantages of water-based dielectric incur a few limitations: the high MRR are only achieved with graphite electrodes, the electrode tool wear is usually higher than with oil-based dielectrics and the finest achievable surface finish is approx. 15 µm Rz [8].

The main objectives of presented investigations were recognizing the effects of using powder suspended water on performance EDM characteristics.

The relations between surface roughness has been obtained in the EDM process using pure kerosene and surface roughness obtained for machining in pure water and in water suspension of powders Al_2O_3, 1200 grade and Al, 180 grade, of concentration 10 g/l.

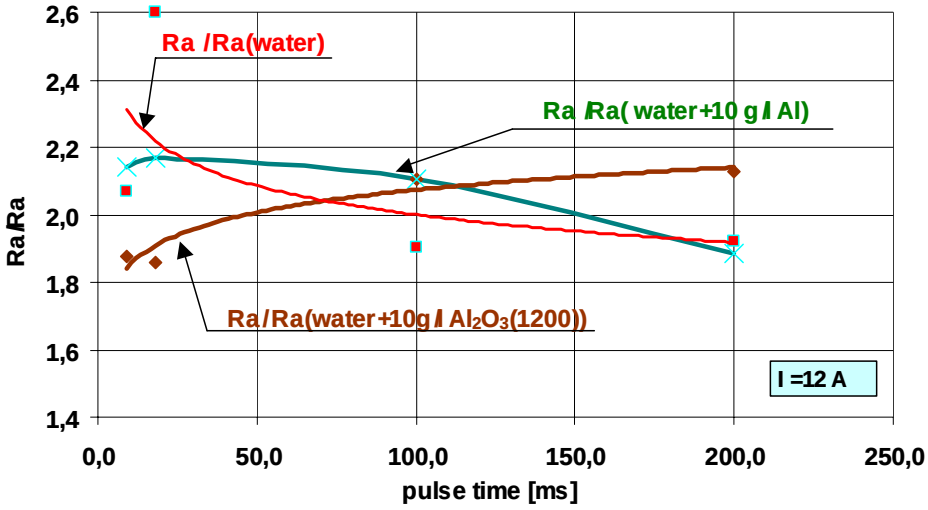

Figure 5. Effect of pulse time on relative value Ra / Ra: Ra / Ra (water), Ra / Ra (water) at powder concentration of 10 g/l Al_2O_3 (1200), Ra / Ra (water) at powder concentration of 10 g/l Al (180), (Ra - roughness of surface machined in kerosene)

Figure 5 shows the relative changes in surface roughness as ratio Rz obtained using kerosene to Rz at EDM using water and powder suspended water. Surface roughness after EDM using water or powder suspended water is 1.6 – 2.2 times less in comparison EDM using kerosene.

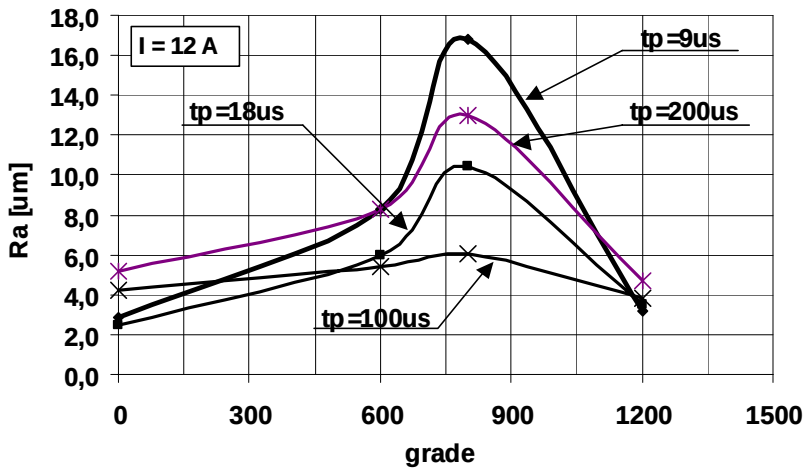

Figure 6. Effect of grade in water on Ra. Powder Al_2O_3

The increase of pulse time for pure water and for Al powder suspended water makes smaller differences between in surface roughness for kerosene and water.

The influence of the grain size on surface roughness for various pulse duration time is shown in Fig. 6. Rapid increase of surface roughness can be observed for 800 grades and it is valid for all pulse time duration. It can thus be concluded that the grade of grains is significant for the process.

Similar influence can be noticed in Fig. 7, where the relation between surface roughness (Ra) and pulse current value is presented. The highest surface roughness is obtained for 800 grade and the lowest one for the process carried out in Al powder suspended water.

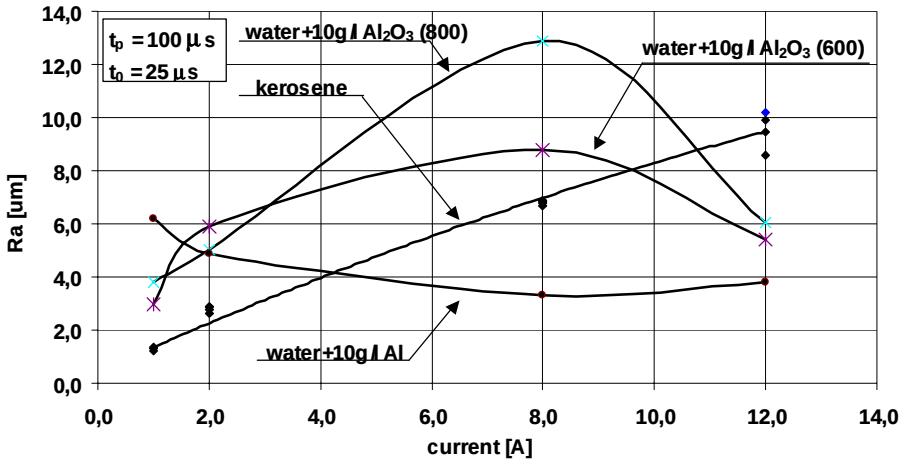

Figure 7. Effect of grain concentration in kerosene on Ra. Powder SiC 180 grade, Al_2O_3 600 and 800 grade, Al 180 grade

CONCLUSION

EDM performance characteristics has been experimentally studied using powder suspended working fluid instead pure dielectric such as kerosene and deionized water. It was found that application of powder in the dielectric lead to reduce surface roughness. The investigation results show that there are chances for replacing the conventional dielectric with powder suspended deionized water and that would imply considerable economic and ecology advantages.

ACKNOWLEDGEMENTS

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