Experimental study of different dielectric fluids used in Micro-Electrical-Discharge-Machining with carbon fibres as tool electrodes

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Abstract

This paper presents the study of different dielectric fluids in µEDM with carbon fibres as tool electrodes. The experiments were executed using the newly designed experimental stand. The new procedure to prepare electrodes was applied. For the purpose of tests 4 different dielectric fluids were used. The results shows the large EDM affected zone.

1 Introduction

Carbon fibres as tool electrodes in µEDM has been previously studied [1,3]. Different modifications of dielectric fluids were also presented in the literature before, e.g. to obtain certain improvements by adding powders [2]. During the previous experiments certain problems occurred, like oscillation of tool electrodes. In this study, the different dielectric fluids are examined in terms of helping in the electrode oscillation reduction and in the removal of debris in µEDM. Those two issues determine strongly the quality of microcavities obtained in the manufacturing process with carbon fibres electrodes. The dielectric fluids were chosen from standard substances used for EDM like kerosene or commercially available fluids.

2 Experiments and conditions

The preliminary experiments were conducted under microscopic observation using a precise microscope table to perform the feed of the electrode. This proved that the stable µEDM conditions were present. The core experiments were carried out using specially designed experimental setup.

2.1 Electrode preparation

For all the experiments the procedure of electrode preparation was developed. It improved the previous one [1]. As a key part in the electrode preparation shanks with already existing deep microholes were used. A single carbon fibre (diameter about 7µm) can be then inserted into the shank and soldered- Fig. 1. This procedure ensures both mechanical and electrical connection of two parts.

a) b)

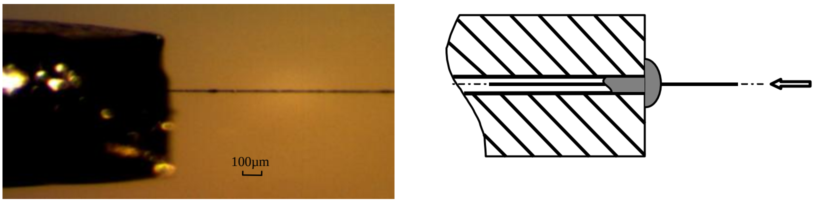

Figure 1: a) Example of an electrode (carbon fibre diameter ~ 7µm); b)Procedure of electrode preparation

2.2 Experimental setup

The setup consists of the RC generator for µEDM with a possible extension to RLC, a stepper motor and a motor control with user's panel and a comparator - Fig. 2. The feed during the process is controlled by a microcontroller according to signals from the comparator which detects short-circuits [3].

a) b)

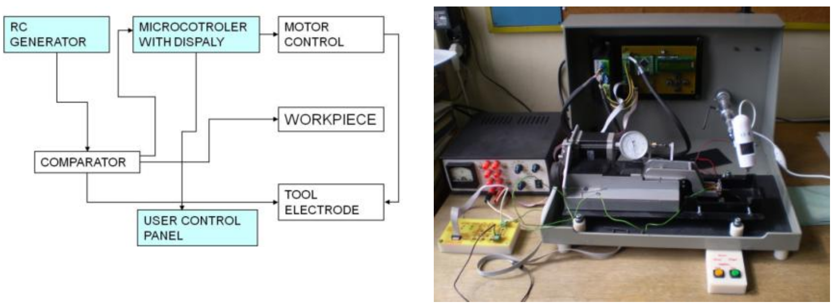

Figure 2:a) Diagram presenting experimental setup; b) Experimental setup

2.3 Experimental conditions

In the experiments 4 different dielectric fluids were used: cosmetic kerosene, commercially available fluid for EDM - Exxsol D80 and two oils - synthetic 5W/40 (oil 1) and special selektol 20W/40 (oil 2). Certain properties of those fluids are gathers in table 1.

Table 1. Properties of tested dielectric fluids

	Kerosene	Exxsol D 80	Oil 1	Oil 2
Kinematic viscosity	2.71 mm^2/s (20°C)	2.18 mm^2/s (20°C)	14 mm^2/s (100°C)	12.5-16.3 mm^2/s (100°C)
Density	0.78–0.81 g/cm^3	0.795 g/cm^3	0.8521 g/cm^3	0.850 g/cm^3

The oils chosen for experiments are characterised with the high autoignition temperature over 200°C. The other aspect was to search for substances with different viscosity values to verify the influence on the electrode oscillations - Fig. 3

The tests were performed according to the following procedure: each of the trials lasted 2 min, electrodes were prepared as described in the previous section and had length of single fibre of about 10 mm. For each of the fluids 4 to 6 tests were performed. The electrical conditions supplied form the RC generator were identical - 135 V, 10kΩ, 10 pF. The workpiece was a gauge block which enables an easy localisation of machined cavities.

3 Experimental results

The microcavities obtained in experiments were measured using an optical microscope before the cleaning process and the optical profilografometer Veeco after the cleaning process. The area machined with µEDM was always covered with a dielectric fluid sludge which occurred after its pyrolysis - Fig. 3. The values of an average diameter of cavity in two perpendicular directions are shown in Fig 4.

Before the cleaning of the workpiece the average affected area was in the range of 400 µm to 100 µm. The cleaning removed the sludge and the dielectric fluid film from the surface of workpiece - Fig 3. The values of the average affected area was then in range of 250 to 50 µm. The obtained cavities are also very irregular in the both measured directions. For kerosene and Exxsol fluid (lower values of viscosity) cavities were more oval - Fig 3, 4b.

a) b) c)

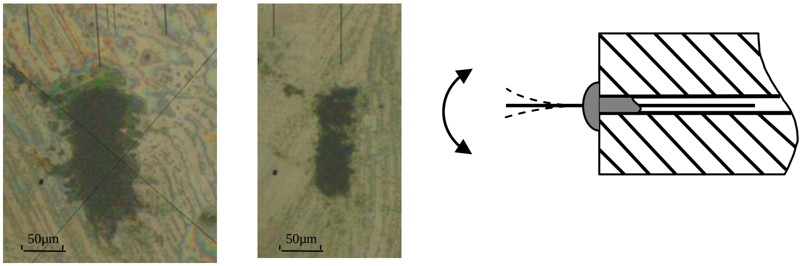

Figure 3: Example of machined cavity with Exxsol D 80 a) before removing oil sludge; b) after removing oil sludge; c) schematic diagram of tool oscillation

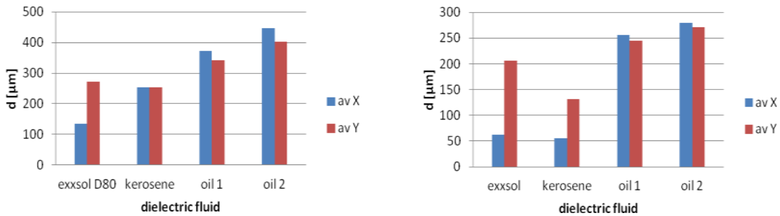

Figure 4: Affected are by μEDM a) before removing oil sludge, b) after removing oil sludge (avX, avY average diameter of cavity in perpendicular directions)

For oils the differences are less noticeable. Nonetheless, the performed experiments showed that the chosen oils did not reduce oscillations and the diameter of cavities.

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