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THE INFLUENCE OF DIELECTRIC FLUIDS ON EDM PROCESS CONTROL

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ABSTRACT

The paper describes the effect of temperature and dielectric properties on EDM process. Five dielectrics at different working conditions were tested. The obtained results enable the choice of proper dielectric based on interdependence of its properties and prescribed working conditions.

NOMENCLATURE

U_{ref} - reference voltage
K - amplification
A - open voltage pulse
B - effective pulse
C - abnormal pulse
D - short circuit pulse
t_i - pulse time
t_o - pause time
i_e - discharge current
u_i - open voltage
h - depth of machining

1. INTRODUCTION

The existing EDM process control mainly relies on distinction of different discharges occurring in the gap between the workpiece and the tool. The complexity of EDM process is due to random occurrence and energy content of individual discharges and large number of influencing parameters. An efficient process evolution can be obtained by maintaining stable conditions on randomly scattered spots where the gap between the electrodes is the narrowest and where the occurrence of the discharge is most probable. The conditions of the gap are greatly influenced by the state of the dielectric. The occurrences of stationary located discharges and short circuits are due to incomplete deionisation of dielectric. Its ability to maintain stable conditions in the gap is mainly affected by its properties such as viscosity, dielectric constant, aging etc. as well as the flushing conditions /1,2,3,4/. Identification of dielectric influences on EDM process taking place in the three element interface - namely the workpiece, the tool and the dielectric is of prime importance in view of overall process control and its effects on the environment.

In our investigation we used the existing control system which prevents localy stationary discharges and enables to identify and count the four basic pulses (A-open voltage pulses, B-effective pulses, C-abnormal pulses and D-short circuit pulses) which are taking place in the EDM process. The aim of our work was to explore the useof five different dielectrics in view of their influences on environmental pollution, injurious to operators health and process performance .

2.DIELECTRIC SELECTION FOR EDM

In the working gap the dielectric is exposed to intensive oxidation, high temperature, electrical current and absorption of workpiece and tool particles. The solid products (pure carbon) and liquid particles (acids, pitch, water etc.) of oxidation and dielectric dissociation due to high temperature are gathered by special filters. These products cause local disturbances of discharges in the gap /3/. Apart from that detrimental products such as aromatic hydrocarbons, sulphur and pitch which disintegrate into sulphur dioxide and monoxide are injurious to operators health (they may cause benign and malign tumors) /3/. In the case of dielectric based on mineral oils several detrimental products are expected: policyclical aromats in solid and liquid state, oily fog, metal particles and disintegrated parts of oils and additives /5/. Certain additives based on mineral oils such as antioxidants and dispergators are favorable in case of rough working conditions (high discharge current). In case of fine regime they usually disturb the process and generate localy stationary discharges which cause surface damage (microcraks) /6,7/.

3. EXPERIMENTS

To explore the influences of dielectric on process performance five different dielectrics were tested on an INGERSOLL 80P device with the CR 2200 generator. It is equipped with the specially designed three level controller adaptimat, which enables the classification of different types of pulses. Tests were conducted under rough and finishing conditions (table 1,2).

t_i /µs/	20	40	90	112	225	450
t_o /µs/	2	9	10	12	25	60
u_i /V/	180				140	
i_e /A/	13					

Table 1: Working conditions for roughing

t_i /µs/	17	40	80	95
t_o /µs/	5	9	20.	29
u_i /V/	180			
i_e /A/	3.5		4.25	4.5

Table 2: Working conditions for finishing

Standard electrodes made out of electrolytic copper ϕ=20mm (ρ=8870kg/m^3) and workpieces of tool steel OCR12 (ρ=7600kg/m^3) were annealed and relaxed to hardness of 60-62 HRc. Before EDM machining a 5mm flushing hole had been drilled into every 10mm thin workpiece sample. The flushing pressure was set to p=0.1-0.2bar through the flushing holes. The electrode polarity was positive, the reference voltage (U_{ref}) and amplification (K) were set according to optimal process evolution. Different pulse types were detected and processed on-line and so enabled the analysis of individual dielectric influences on process performance (table 3).

dielectric	EROZOL 19	EROZOL 20	EROZOL 21	EROZOL 150	EROZOL LAB
ν (20^0) /mm^2/s/	2.0	2.0	2.0	15.0	>8.0
ρ (20^0) /g/cm^3/	0.750	0.790	0.750	0.820	0.870
flame point/^{0}C/	>75	>80	>85	>120	>125
aromats /%/	<0.2	<0.1	<0.5	<0.2	<5

Table 3: Properties of tested dielectrics

4. THE INFLUENCE OF TEMPERATURE ON EDM PERFORMANCE

The influence of dielectric temperature on process

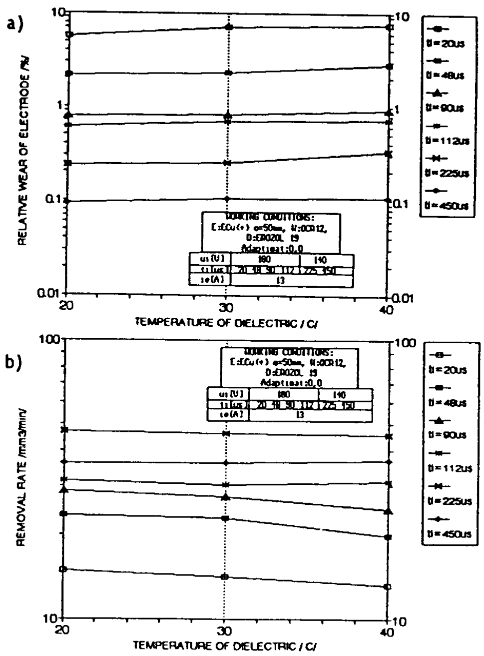

Fig.1: Electrode wear and metal removal rate versus temperature of dielectric

performance and pulse Type portions has been investigated first. The increasing temperature lowers the dielectric viscosity which in its turn causes the increase of electrode wear (fig.1a) and the decrease of metal removal rate (fig.1b). This effect is particularly evident in the case of shorter pulse time values (t_i<90μs). The influence of temperature rise affects evidently the portion of pulse types. Higher temperature lowers the portion of effective pulses for an average value of 5-10% at shorter pulse time (fig.2).

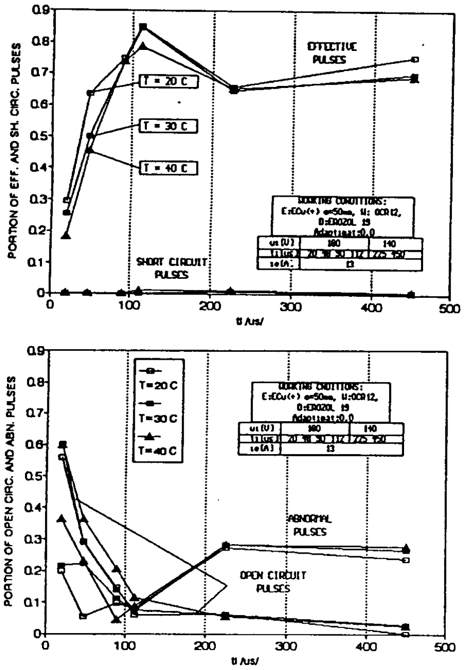

Fig.2: Portion of individual pulses versus pulse time

5. THE INFLUENCE OF DIELECTRIC ON THE PERFORMANCE OF EDM

The tests were carried out with repetition at various working conditions. The spread of results at same conditions was 5%. The dependence of the portion of individual pulses (A,B,C,D) at different dielectrics used and different pulse time is shown in Fig.3.a,b. In case of finishing the dielectric EROZOL 21 assures the best conditions in the gap since the portion of effective pulses is the highest when this dielectric is applied. The same conclusion is valid for the dielectric EROZOL 20 in the case of rough regime.

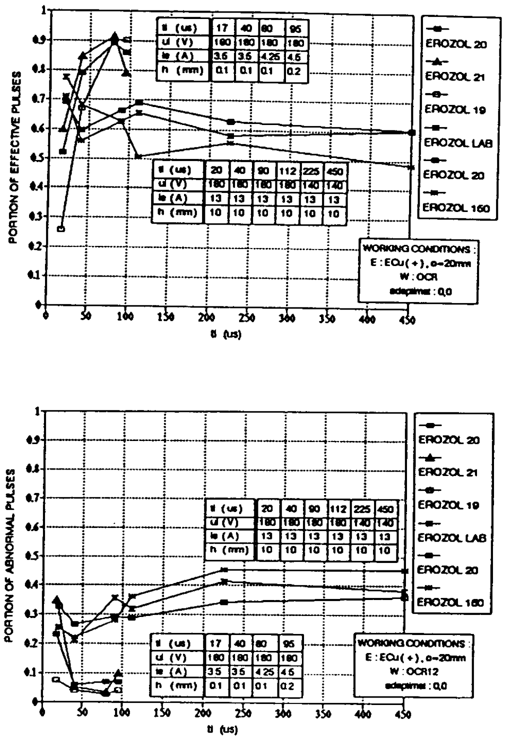

Fig.3: Portion of individual pulses versus pulse time

When observing the material removal rate at roughing one can see that the values obtained in the case of EROZOL 20 are the lowest which is in contradiction with the conclusions obtained from observation of pulse portions (fig.4). The relative electrode wear decreases abruptly with increasing pulse time and with lower discharge frequency(fig.5). The reason for that phenomena lies in the fact that the main amount of wear occurs at every start of the pulse.

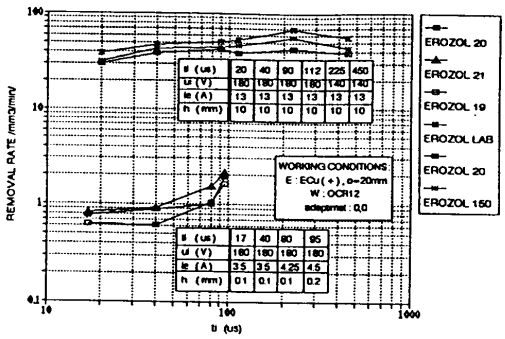

Fig.4: Material removal rate versus pulse time

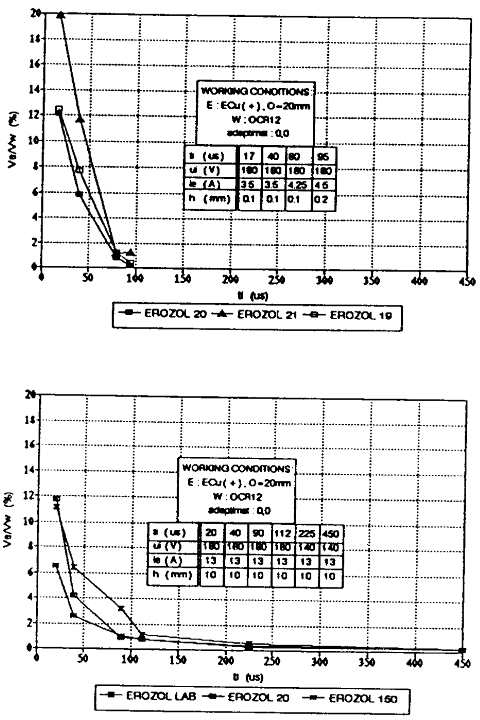

Fig.5: Relative electrode wear versus pulse time

In order to summarize the influence of dielectric on process performance the generated surface roughness was measured and analyzed for each test (fig.6). Here we can see that with the EROZOL LAB best surface roughness Ra is attained in the case of roughing especially at pulse time length over 100μs. In the case of finishing best results are obtained with the EROZOL 20.

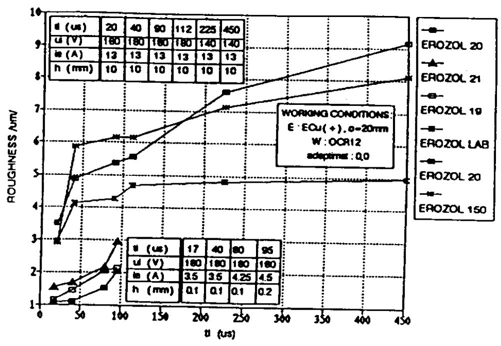

Fig.6: Surface roughness versus impulse time

6. CONCLUSIONS

From the study of influences of different dielectric on EDM process the following conclusions can be drawn:

- the influence of dielectric temperature on process performance is evident especially at shorter pulse time (t_i<100μs). Here the maintenance of constant temperature (20°C) should be assured.
- the dielectric properties affect greatly the conditions in the gap which can be detected on line by measurement of different types of pulse portions.
- process performance parameters such as material removal rate, relative electrode wear and workpiece surface roughness are strongly dependant on the type of dielectric used.

The results obtained in the presented work can serve as a knowledge data-base for the selection of dielectric and appropriate optimal process parameters in order to obtain optimal process performance. Further research work should be focused into development of the decision making algorithm enabling optimal dielectric and process parameters selection.

7. LITERATURE

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