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Research Article – Mechanical Engineering

Electro-discharge machining of aluminum alloy with nickel powder-mixed dielectric

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Abstract

Powder-mixed dielectric fluid is one of the innovations of electrode-discharge machining (EDM) which seeks to improve the process outputs by addition of Nickel powders to the dielectric during machining. In the present study, the influence of Nickel powder in kerosene dielectric fluid on EDM process outputs was investigated. Experiments were conducted with the outputs as material removal rate (MRR) and surface roughness (Ra). During the EDM, the discharge current was varied between 3 and 15 A, while powder concentration ranges between 2 and 10 g/l. Results indicate that the highest MRR of 39.888 mm^3 /min was obtained with Nickel powder concentration of 6 g/l at the current of 9A, where as the lowest SR of 3.397 µm was obtained with Nickel concentration of 3 g/l at the current of 3A.

Keywords: EDM, Nickel powder, Surface roughness, Material removal rate

Introduction

Electrical discharge machining (EDM) is essentially a metal removal process that uses electrical discharges to effect melting and vaporization of materials from the work piece. The machining process has witnessed tremendous developments in different areas. Among these include the use of powders in dielectric fluid to facilitate material removal, reduce the electrode wear ratio and improve the surface integrity of the work piece. In the powder-mixed dielectric EDM, conventional tool electrodes are used with suspended powder particles in the dielectric medium to obtain improvement in the surface of the materials. The powder particle facilitates the ignition process thereby improving the sparking efficiency [1]. They enlarge the gap distance between the electrode and the work piece leading to improved surface finish and material removal rate (MRR)and reduced tool wear rate (TWR), in addition to smoother and reflective craters [2, 3]. Wu et al. [4] investigated the effect of surfactant and Al powders added in the dielectric on the surface of the work piece after EDM. They observed an improvement of up to 60% in the surface roughness (Ra) (0.43 µm) of the work piece when compared to EDM under pure dielectric. The combination of PMEDM with USM was reported to have yielded an alloyed layer that improved the hardness and wear resistance of Al-Zn-Mg alloy when it was machined with TiC powder additive [5]. The use of PMEDM combination was also reported have increase material removal rate and surface quality [6, 7]. In another study, increase in peak current and addition of Al_2O_3 powder produced higher recast layer thickness and the micro-cracks [8]. Among the powders used, TiC gave lower layer thickness, higher hardness, more tool material and carbon depositions on the work surface than Al_2O_3 powder.

In this present research, Nickel powder in three different concentrations were mixed in dielectric fluid during machining of HE30Alluminum Alloy work piece at various levels of peak currents. The objective is to study the influence of these powder particles in the dielectric fluid on EDM process parameters. The outputs of the machined surface investigated were MRR and SR.

Experimental Procedures and Materials

Materials Preparation

The Materials used in this investigation are copper electrode, Aluminum Alloy He30 work piece and Nickel powder. The Aluminum Alloy HE30 has the following chemical composition: Sil 0.90%, Iron 0.40%, Cu 0.09%, Mang 0.30%, Mg 0.90%, Chr 0.23%, Zn 0.18%, Ti 0.08% and the rest is Aluminum. The work piece material was prepared to 14 X 14 mm square dimension. The copper electrode used to machine the work is made of 12 mm square cross-section.

Experimental Procedures

The experiments were conducted with a die-sinking EDM machine (Tool crafts A-25), using Nickel powder with the specified concentrations in kerosene dielectric fluid.

This arrangement was made in a separate machining tank as shown in Fig. 1.

The machining conditions used are shown in Table 1. The effects of both the concentrations and the peak current on MRR and surface roughness were examined. MRR was measured with Sartorius CP 224S precision weighing machine by taking the weight difference of the work piece before and after machining. The machined surface roughness was measured with Mitutoyo Surftest SJ-210 respectively.

Results and Discussion

The machining efficiency is improved if there is increase in MRR, reduction in electrode wear and improved

Fig. 1: The experimental set-up

Table 1: Machining conditions

Machining Conditions	
Dielectric fluid	Kerosene
Nickel powder concentration (g/l)	2–10
Polarity	+ ve
Peak current (A)	3–15
Pulse on-time (μs)	200
Pulse off- time (μs)	50
Gap voltage (V)	110

surface finish. Suspended powder particles are said to facilitate all these features [1]. These are achieved by the increase in the gap distance and uniformly dispersed discharges over the surface being machined [2]. The EDX spectra image of the EDMed surface indicates the presence of Ni peaks on the surface with the powder-mixed dielectric, while Ni is not detected in the one without powder (Fig. 2a).

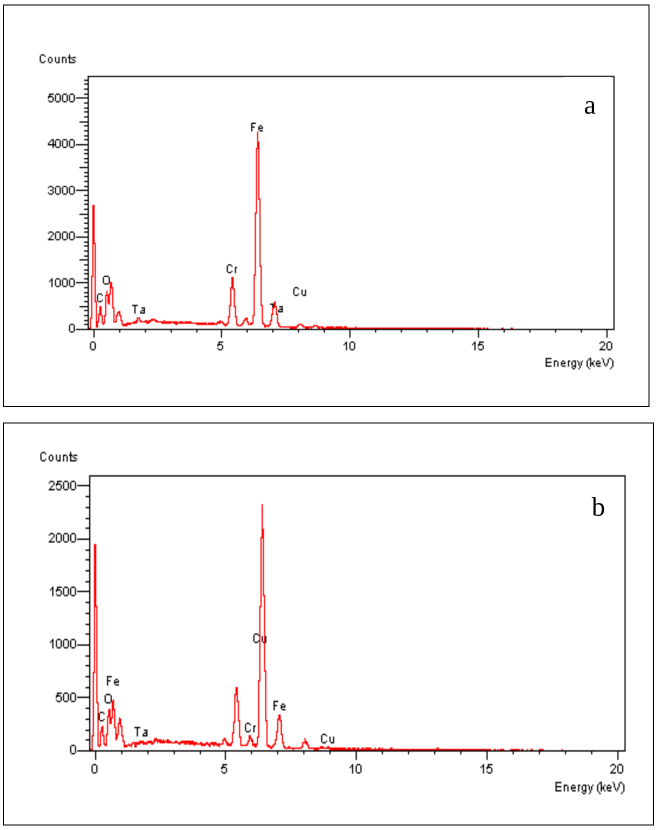

Fig. 2 EDX spectra image of the EDMed surface at and peak current 9 A (a) with Nickel powder concentration of 15 g/l, (b) without powder

Generally, for all powder concentrations, the machining time decreases with increasing peak current (Fig. 2b). Thus, the cutting rate increases with peak current. However, at lower currents powder concentration shows some influence in reducing the machining time.

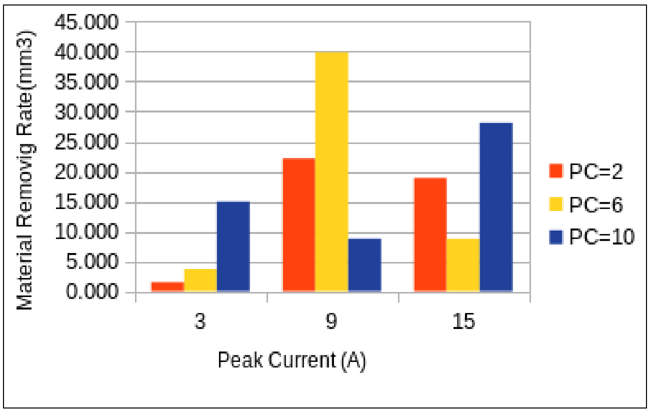

Fig. 3 Material removal rates at various peak currents

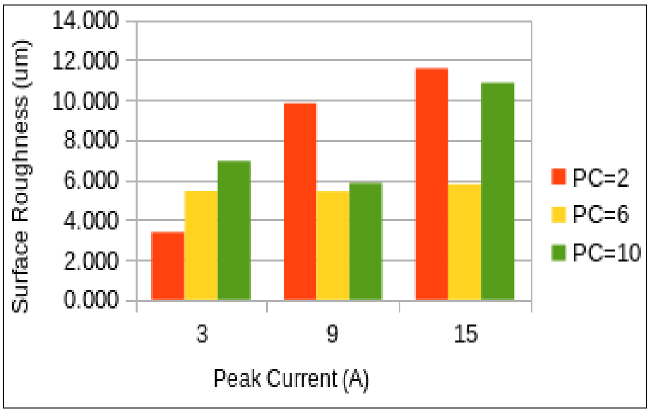

Fig. 4 Surface roughness with peak current

In Fig. 3 the MRR can be seen to be generally increased with current at 9A. The powder concentration behavior is not uniform. The highest MRR of 39.888 mm^3 /min is obtained with the concentration of 6g/l at 9 A, while the effect of powder-mixed dielectric on MRR is not felt at the lowest current. It was observed that there was much change in MRR pattern with powder concentration.

The surface roughness (Ra) of Fig. 4 were obtained from the average of three measurements taken. The Ra increases with increase in current. At the current of 3 A, the presence of powder in dielectric fluid does not affect the Ra, because they are virtually the same. The roughness of the EDMed surfaces at all the concentrations under those current remains fairly low. Though the Ra is high at higher peak currents, increasing powder concentration can reduce it. The best surface roughness of 3.397 μm attained at 3A is with powder concentration of 2g/l. This implies that Nickel powder can offer good surface finish while machining at lower peak currents.

Conclusions

Results show that Nickel PMEDM affects the EDM output parameters in the following ways:

1. The EDMed surfaces were confirmed to have been alloyed by Ni and C from the powder. Peak current has general direct effect on both the MRR and Ra. Thus, both

increases with increasing current and vice versa.

2. Though the powder concentration's behaviour is not uniform, 6.0 g/l gave highest machining rate at 9A. The highest MRR of 39.888 mm^3 /min , the comparatively lower Ra among the powder concentrations at the current of 3A were also obtained with 2.0 g/l.

3. The effect of powder addition is insignificant at the lowest current, however it is influential to the level surface finish.

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