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Research Paper

Material Removal Rate and Surface Roughness in Powder Mixed Electrical Discharge Machining Of Skd61 Steel

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ABSTRACT
This study investigated the material removal rate (MRR) and surface quality after EDM using powder mixed dielectric fluid (PMEDM). SKD61 die steel, titanium powder and copper electrode (Cu) were used. Results showed that mixing titanium powder in the oil dielectric fluid significantly affected MRR and surface roughness of the machined surface after EDM. Titanium powder mixed in the dielectric fluid increased MRR, decreased surface roughness (Ra). Results indicated that PMEDM is a viable method to improve the productivity, accuracy and surface quality in EDM.

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I. INTRODUCTION

The introduction of EDM has resolved many limitations of traditional manufacturing methods in the machining of conductive materials which were difficult or impossible before to work into complex shapes. EDM uses very large heat energy (10,000 to 12,000) $^{\circ}$C generated from the discharge sparks to melt and evaporate the workpiece. EDM therefore overcomes the negative influences in traditional manufacturing methods, which include vibration, deformation and mechanical stresses requiring hard tools. However, EDM has lower productivity and electrode wear and great influence on machining accuracy. The principle of this manufacturing method is that the workpiece surface features formed after EDM are altered in comparison with the substrate. Normally, the surface machined layer has reduced mechanical properties with microscopic cracks of varying depth. The surface is also undulating giving a poor fit for the working surface of the machine parts. Before use the surfaces after EDM require extra or super fine machining. Therefore, many methods have been tested to improve the surface quality after EDM, such as polishing and grinding. Thus, if it is possible to simultaneously improve the productivity and surface quality defects, limit the surface erosion and reduce electrode wear, then this will reduce machining time and increase machining accuracy.

The existing research works in powder mixed electric discharge machining (PMEDM) methods have proven promising as methods to improve both the productivity and quality. A suitable powder mixed dielectric fluid used in EDM, can lead to higher material removal rate (MRR), tool wear rate (TWR) and micro hardness with lower surface roughness (SR).

The higher powder concentration of 2-6g / l can lead to higher MRR with lower TWR [1]. The Graphite powder mixed dielectric fluid can enhance the EDM process with increased MRR by 68% with decreased TWR by 28% as that of breakdown voltage by 30% [2]. The surface layer quality of steel H13 after machining by PMEDM has also been improved significantly [3]. The larger size of electrode can increase both the surface roughness and recast layer thickness. The white powder mixed dielectric fluid can considerably increase the MRR in EDM [4]. The graphite powder is more influential than silicon powder on determining SR, MRR, and TWR in PMEDM [5]. The Productivity and surface quality of EDM can be increased with Al powder mixed dielectric fluid [6]. The higher powder concentration led to an increase in MRR while machining [7].

This study investigated the influence of the concentration of titanium powder mixed in the oil dielectric fluid on the quality of SKD61 steel surface after EDM. The characteristic elements of surface quality, such as MRR, TWR, Ra, the heat-affected zone thickness, hardness of the surface microstructure, chemical composition and surface profile were measured. The addition of the powder material mixed in the dielectric fluid and the effect of the electrode materials on the surface after EDM were also assessed.

II. EXPERIMENTAL PROCEDURE

The experiments were conducted using the electrical discharge machine model CNC-AG40L from Sodick, Inc. USA at The Central Laboratory of Thai Nguyen University of Technology. The material used for the workpiece was SKD61 (Japanese Industrial Standard) hot-die steel that is used extensively for hot-forged dies. The workpiece dimensions were 45 × 27 × 5 mm^3 (L x W x H). Copper and graphite have excellent electrical and thermal conductivity and both are major commercial materials. The powder material chosen was titanium at 45 µm grain size. The dielectric fluid used was HD-1. The tank was installed in the EDM machine as shown in Figure 1. Machining parameters are shown in Table 1.Surface roughness was measured using a portable SJ-301 machine from Mitutoyo, Japan. A precision balance measured the weight of the workpiece and the electrode before and after the machining process (model vibra AJ-203 shinko max 200 g /d = 0.001 g, Japan).

Figure 1. Experimental setup

Table 1. Machining conditions

Variable	Set-up
Intensity of discharge(A)	15
Pulse-on time(µs)	50
Pulse-off time(µs)	85
Dielectric	HD-1
Machining time	15’
Voltage of discharge (V)	150
Tool material	Copper, Graphite (Ø25mm)
Flushing	10 liters/min
Powder	Titanium: - grain size 45µm. - concentration 0, 5, 10, 15, 20 g/l.

Performance Measures In Pmedm Process:

- *Material removal rate (MRR)*: It is calculated by the amount of volume of workpiece material removed per minute. This affects the productivity and time of the machining process.

$$MRR = \frac{W_b - W_a}{\rho_w . t} \text{ mm}^3/\text{min} \quad (1)$$

Where, W_b is weight of workpiece before machining (gram), W_a is weight of work piece after machining (gram), t is machining time (min), ρ is density of material (gram/mm3).

Surface roughness (Ra): This criterion directly affects the smoothness of the surface after machining in PMEDM process.

$$R_a = \frac{1}{L}\int_0^L |h(x)|\, dx \quad (3)$$

Where, L is the sampling length (mm), h is the profile curve and x is the profile direction.

III. RESULTS AND ANALYSIS

3.1. Material removal rate (MRR)

Table 2. Results for MRR

Trial no	MRR (mm^3/min)		Concetrations (g/l)
	Cu	Gr	
1	0.747	30.089	0
2	0.896	93.918	5
3	1.438	136.203	10

4	1.660	150.672	15
5	1.699	174.263	20

Table 2 shows that the graphite electrode produced maximum MRR followed by the positive polarity copper electrode.. MRR using graphite electrodes was much higher than the copper electrodes. With no powder mixed in the dielectric fluid, the MRR using graphite electrodes was 40 times larger than the reverse polarity Cu. The conductive titanium powder mixed dielectric fluid increased the material dissection productivity. EDM with graphite powder mixed in the dielectric fluid increased MRR by 474.1 % at 20 g/l compared with no mixed powder. With powder mixed dielectric fluid, the MRR maximum of the graphite electrode increased compared with the copper electrode (20 g/l). It was 102.57 times higher than the reverse polarity Cu.

3.2 Surface roughness

The undulating surfaces were examined with the two types of electrode materials, Cu and Gr. Cu is often used to make crystal electrodes using both straight and reverse polarity. The results are shown in Figure 5. The smallest Ra (Ra_{min}) was 2.54 µm. Table 2 shows MRR and Ra values for positive electrode polarity with Ti powder mixed in the dielectric fluid at concentrations of 0 to 10 g/l. Gr electrodes gave more efficient machining. For improved surface machining quality, it is advisable to choose a negatively polarised copper cathode. The graph shows that the concentration of powder (0 to10) g/l has the most influence on Ra. Increasing the concentration of powder reduces the slope of the graph, thereby reducing the influence of the Ti powder on Ra.

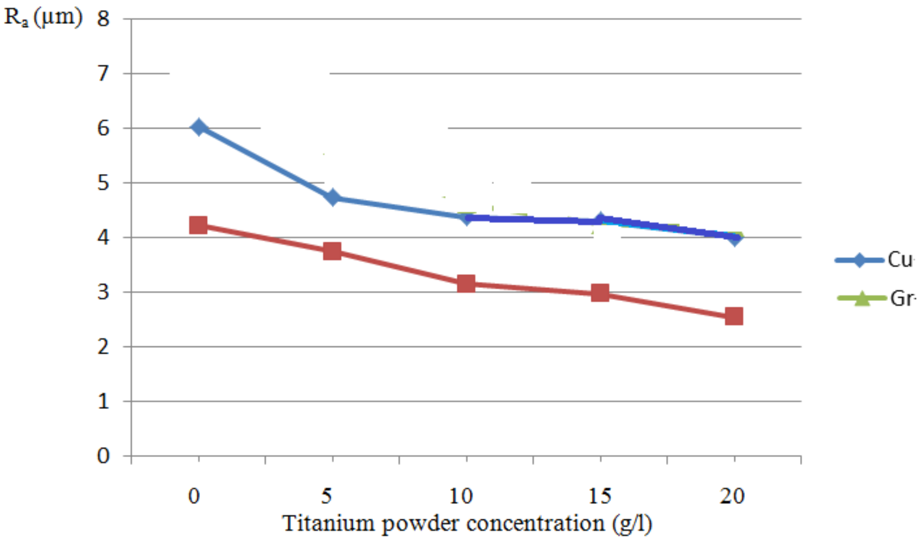

Figure 5. Variation of R_a with titanium powder concentrations

IV. CONCLUSIONS

In PMEDM, graphite electrode produces better machining efficiency than copper electrode. Titanium powder mixed in the dielectric fluid at suitable concentration improves the dissection productivity of the material, increases surface quality and surface machining, and reduces electrode erosion. This improves productivity and accuracy, and also reduces machining time in parts manufacturing.

Titanium powder mixed in the dielectric fluid in EDM increases MRR; this is very beneficial for roughing. However, titanium has a high material cost and more research is required to find other suitable cheaper materials.

The SKD61 steel surface changes positively after EDM. Ra decrease. This reduces the cost of refined manufacturing methods, particularly in the machining of smaller surface holes.

REFERENCE

[1]. Ojha K, Garg RK, Singh KK (1981) Experimental Investigation and Modeling of PMEDM Process with Chromium Powder Suspended Dielectric. International Journal of Applied Science and Engineering.

[2]. Jeswani ML, Effect of the addition of graphite powder to kerosene used asthe dielectric fluid in electrical discharge machining. Wear 70:133-139.

[3]. Peças P, Henriques E (2003) Influence of silicon powder-mixed dielectric on conventional electrical dischargemachining. International Journal of Machine Tools & Manufacture 43:1465–1471.

[4]. Peças P, Henriques E (2008) Electrical discharge machining using simple and powder-mixed dielectric: The effect of the electrode area in the surface roughness and topography. Journal of materials processing technology 200:250–258.

[5]. Zhao WS, Meng QG, Wang ZL (2002) The application of research on powder mixed EDM in rough machinng. Journal of materials processing technology 129:30–33.
[6]. Kansal HK, Singh S, Kumar P (2005) Parametric optimization of powder mixed electrical discharge machining by response surface methodology. Journal of Materials Processing Technology 169:427–436.
[7]. Kansal HK, Singh S, Kumar P (2007) Technology and research developments in powder mixed electricdischarge machining (PMEDM). Journal of Materials Processing Technology 184:32–41.
[8]. Özerkan B, Çoğun C (2005) Effect of mixed dieleectric on machining performance in electric discharge machining. Gazi University Journal of Science 18.
[9]. Singh P, Kumar A, Beri N, Kumar V (2010) Influence of electrical parameters in Powder mixed electric discharge machining (PMEDM) of hastelloy. Journal of Engineering Research and Studies 1:93-105.
[10]. Kansal HK, Singh S, Kumar P (2007) Effect of Silicon Powder Mixed EDM on Machining Rate of AISI D2 Die Steel. Journal of Manufacturing Processes 9.
[11]. Kumar A, Maheshwari S, Sharma S, Beri N (2010) Effect of Aluminium Powder Characteristics in AdditiveElectric Discharge Machining of Nickel Based Super Alloy Inconel 718. 2nd International Conference on Production and Industrial Engineering.