JOJAPS

eISSN 2504-8457

Journal Online Jaringan Pengajian Seni Bina (JOJAPS)

Effect of Pulse Duration Changes in Electrical Discharge Machining on Tungsten Carbide

Norasyidah Binti Mohd Noh[1] & Nurlina Aimi Bt Ramily[2]

(1) POLITEKNIK BANTING SELANGOR, PERSIARAN ILMU, JALAN SULTAN ABDUL SAMAD, 42700 BANTING, SELANGOR. (2) POLITEKNIK IBRAHIM SULTAN, KM10 JALAN KONG KONG, 81700 PASIR GUDANG, JOHOR.

Abstract

Electrical Discharge Machining is the one of modern machining. The machining is widely used for cutting complex design of metal. This paper presents an experimental investigation for studying the effect of different value of pulse duration at a set of 12.8 µs, 25 µs and 50 µs. The problem of this investigation is to define highest microhardness value to produce harder tools of Tungsten Carbide at 32 A peak current and 80 V voltage. An electrode as a cutting tool is Copper Tungsten sized 9 mm diameter and a kerosene as a dielectric medium. Tungsten Carbide 14x7x7 mm sized as a work piece. The cutting process occur when electrical discharge (sparks) happened between the work piece surface and electrode gap. From the sparks, a work piece surface become harder and greater. Three layer that occurs on the work piece surface are recast, heat-affected zone, and parent matrix (base material). Microhardness value depending on these three layers. HVN microhardness number is selected and Shimadzu Microhardness Tester using diamond shape indention. The result shows the microhardness is affected in high value at 12.8 µs pulse duration.

Key-word: - *Pulse duration, sparks, Electrical Discharge Machining*

1. Introduction

Electrical Discharge Machining (EDM) is a machining method primarily used for hard metals or those that would be very difficult to machine and complex geometry with traditional techniques. EDM typically works with materials that are electrically conductive. EDM can cut intricate contours or cavities in pre-hardened steel without the need for heat treatment to soften and re-harden them. Because of the machining surface become harder, this machining is widely used to fabricate engine, gear and other automotive parts. Dielectric is a medium to releasing ions from electrodes during machining. Normally, kerosene and deionized water are selected as a dielectric.

Using EDM machining, material from work piece is removed by rapid recurring (repeating) discharge of current in between the electrodes (cutting tool). The electrodes are separated by dielectric liquid and a high voltage is applied across it. A potential difference is applied across the cutting tools and work piece in pulse form. The cutting tool and work piece must be electrically conductive (Ghanam, 2017) and in a small gap. For the best cutting, the small gap should be maintaining between them.

Similar to other machining process, the most important EDM machining performances are productivity (Lin, 2008), tool wear (Khan, 2009), machining accuracy (Kiyak, 2007), and surface integrity. Productivity is expressed as the material removal rate and refers to the speed of removal per time unit. Tool wear is quantified by tool wear ratio which is the ratio between the eroded volume of the tool and the work piece. Machining accuracy is defined by the tolerances on dimension and shape of the work piece. Surface integrity is expressed through the surface roughness and surface layer properties. Pulse duration in EDM machining is a time interval during the spark (electron discharge).

The sparks occur between electrode and the work piece once the break down voltage of the dielectric is reached causing its ionization. Consequently, the spark then causes erosion of the work piece material. Polarity of electrode can be either negative or positive. The polarity depends on tool material, work piece, pulse duration and current density. Electrode polarity is always positive because of plasma channel is made of ion and electron flows, and electrons have mass smaller than anions (M Gostimirovic, 2012).

Electrode Wear Rate (EWR) is a weight of the electrode worn in the period of working time in minute. The thermal energy of the sparks leads to intense heat conditions on the work piece causing melting and vaporizing of work piece material. Due to the high temperature of the sparks, not only work material is melted and vaporized, but the electrode material is also melted and vaporized. Due to electrode wear, the dimension of electrodes can lose their dimension in accuracy.

Material Removal Rate (MRR) is a speed of the cut refers to how fast metal is removed from the cavity (Shahruzaman, 2013). This is the indicator of the efficiency and cost effectiveness of EDM process. Increasing MRR is not always desirable for all applications. This because a rough surface finish affected the surface integrity of the work piece. Surface Roughness (Ra) after EDM machining consist a multitude of small crater randomly distributed all over the machining surface. The quality of surface mainly depends up on the energy per spark. If the energy content is high, deeper craters will result, leading to poor surface.

2. Methodology

The parameters of electrical discharge machining for this experiment shows in Table 1. The machining is using EDM Roboform 100 die sinking machine produce from Charmilles Technology. Copper Tungsten 9 mm diameter as an electrode and the work piece is Tungsten Carbide with size 14x7x7 mm. Peak current is set at 48 A and current voltage is 80 V. Kerosene is chosen as a dielectric. Three sets of pulse duration which are as a depending parameter. Second parameters that considered in this experimental are pulse interval, electrode weigh, density of electrode material, and servo. During experimental, any process was monitored and recorded.

Table 1 EDM Die Sinking Machining Parameters

Machining Parameters	Work Condition
EDM Machining	EDM Roboform 100, Charmilles Technology
Electrode	Copper Tungsten (9 mm diamater)
Work Piece	Tungsten Carbide (14x7x7 mm)
Peak Current	32 A
Voltage	80 V
Pulse Duration	12.8 µs, 25 µs , 50 µs
Dielectric	Kerosene

After EDM machining, the work piece needs to cut into two. This is to measure the microhardness along the cutting part. This specimen needs to do several processes to make the specimen easy to hold when make a microhardness testing. The first step is mounting. Hot mounting is the process to make a holder to the specimen. Plastic resin is used as a holder. Next step is grinding the specimen surface using sand paper from grading 240,400,600 and 1200. Surface grinding are to clean from any resin and dust, and also make the specimen surface flat. The last process is polishing. Emery cloth is used to polish the specimen. The specimen surface must have a rays and lighting effect when look at the microhardness tester screen. Shimadzu Microhardness Tester with diamond indentation 136° ± 0.5° is used to take the microhardness value.

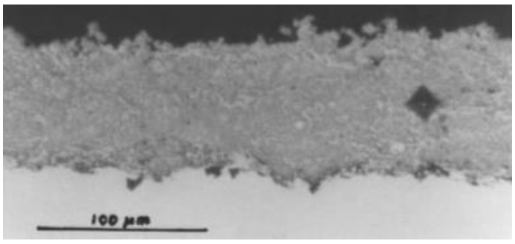

Figure 1 Indentation at the specimen within distance from machining surface

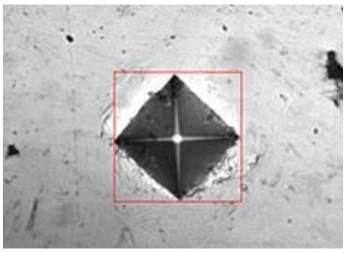

Figure 2 Diamond shape indentation

Figure 1 shows the indention at the recast layer 20 µm from machining surface. Figure 2 shows the indention of diamond indent using Shimadzu Microhardness Tester. Surface of work piece must be clean and flat condition to get best indentation. The gap distance in every indentation is 20 µm consistently. 15 values of microhardness from machining surface recorded in Table 2.

Table 2 Microhardness Value in Every Distance from Machining Surface

Distance from machining surface (µm)	Voltage = 80 V, Peak Current = 32 A Vickers microhardness value (HVN) 12.8 µs	25 µs	50µs
20	1216	1149	1068
40	1007	1172	1013
60	989	1064	988
80	981	1045	981
100	971	985	976
120	951	973	962
140	938	969	946
160	927	946	931
180	911	941	915
200	893	919	894
220	877	900	880
240	864	884	873
260	843	872	856
280	840	854	844
300	829	843	833

From the table above, microhardness value shows high value for 12.8 µs is 1216 HVN, for 25 µs is 1149 HVN and for 50 µs is 1068 HVN. All the microhardness highest value is at the distance 20 µm from machining surface. Graph machining surface distance versus microhardness value are plotted as shown in Figure 3 below.

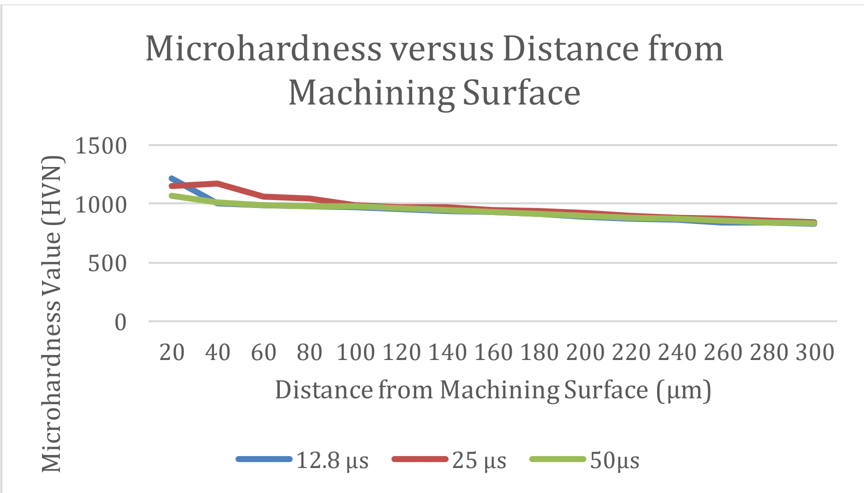

Figure 3 Microhardness versus Distance from Machining Surface Graph

3. Result and Discussion

From the plotted chart, microhardness value showing that the value decreases according to machining surface depth. Highest microhardness value shows at the distance 40 µm from machining surface. The microhardness value consistence around 240 µm from machining surface. For 50 µs pulse duration shows that the microhardness decreasing look small differentiation. For 25 s pulse duration shows the quiet large decreasing at every indent point. At the 12.8 µs pulse duration shows the decreasing microhardness value at distance 40 µm from machining surface. Three layers at the machining work piece are recast, heat-affected zone and parent matrix shown at Figure 4.

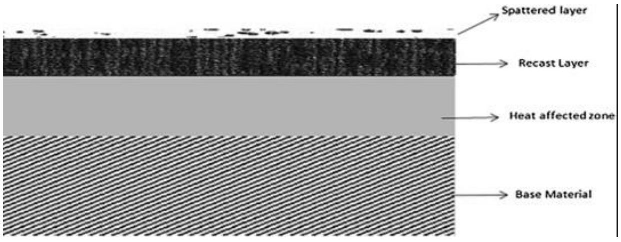

Figure 4 Recast, heat-affected zone and parent matrix layer

A recast layer become harder after EDM machining because of releasing carbide particles from cobalt binder in a high thermal at 3000 °C, more than the carbide melting thermal 2982 °C. The recast layer occurs when the carbon particles from the work piece (parent matrix) that melts (H Wijaya, 2019) then freezes again and forms a layer on the surface of the work piece. Recast layer formed under the influence of heat generated by a spark jumps from the electrode. The distance of recast layer from machining surface between 0 – 40 @ 45 µm shown in Figure 5.

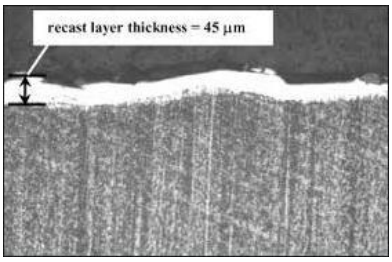

Figure 5 Distance of recast layer

4. Conclusioms

Microhardness on recast layer at 12.8 µs pulse duration is harder because of the short time to electrode need to pulse on and pulse off to make a spark. The microhardness HVN value is high between 0-45 µm distance from machining surface. Pulse duration influencing the material removal rate, electrode wear rate and machining surface. Pulse duration important to equalize machining energy as well as influence the rate of material discharge.

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