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INVESTIGATION ON CR, MRR AND SR OF WIRE ELECTRICAL DISCHARGE MACHINING (WEDM) ON HIGH CARBON STEEL S50C

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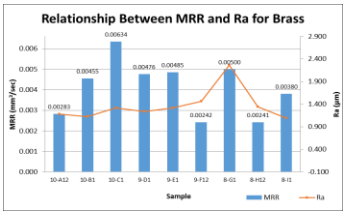
Graphical abstract



Abstract

The purpose of this project is to study the encouragement of three machining parameters on wire electrical discharge machining that consist of peak current (IP), pulse OFF time (OFF) and wire tension (WT) to three machining responses which are cutting rate (CR), material removal rate (MRR) and surface roughness (SR) on high carbon steel (S50C). Brass wire with diameter 0.25 mm was used as the cutting tool for machining a high carbon steel (S50C) using Mitsubishi FX Wire Electrical Discharge Machine (WEDM). The machining parameters such as pulse off time, wire tension and peak current were determined by referring from the guideline in the manual book for Mitsubishi FX Wire Electrical Discharge Machine (WEDM). The calculation of material removal rate and cutting rate were obtained using mathematical equation. The surface roughness was measured using optical measurement "Alicona Infinite Focus" machine. The relationship between material removal rate and surface roughness shows that the optimum machine parameter using brass wire as the electrode is C1. From the spark analysis using brass wire as the machine's electrode, the deeper the spark occurred, the higher value of the surface roughness.

Keywords: High carbon steel S50C, brass wire electrode, wire electrical discharge machining

1.0 INTRODUCTION

S50C steel is one of the manufacturing friendly material in industry of mould making. Wire electrical discharge machining (WEDM) can machine various materials such as aluminium-316L stainless steel, Titanium Ti-6Al-4V and aerospace alloys [1-3]. Brass wire is the common wire used in Electrical Discharge Machine. The manufacturer should consider that there is a real difference in the class and cleanliness of the wire itself. Cost of investment seems to be low in the beginning, but when the other factors were included such as slow cutting speed, increment in wire breakage and maintenance due to dirty wire clogging guides and other components, process commonly causes a back end loss of profit. This situation can end up costing considerably more than any up front savings [4].

The purpose of this project is to study the influence of three machining parameters on wire electrical discharge machining that consist of peak current (IP), pulse OFF time (OFF) and wire tension (WT) to three machining responses which are cutting rate (CR), material removal rate (MRR) and surface roughness (SR) on high carbon steel (S50C).

2.0 EXPERIMENTAL DETAILS

2.1 Work Piece Material And Machine's Electrode

The material used as the work piece in this study was high carbon steel S50C which was already harden which contributed to very high of its hardness. The function of using the Wire Electrical Discharge

Machine (WEDM) itself was to shorten the step on re-harden the work piece material. The weight and density of this material also were very high. This study involved on using the brass wire as the electrode in Wire Electrical Discharge Machine (WEDM) for the cutting process. Sample dimension before machining was 350 x 50 x 10 mm^3 and target sample dimension after machining process was 30 x 5 x 10 mm^3.

2.2 Parameter Setting

In designing the parameter that will be used to be inserted into the machine input, data was tabulated in a table. The several variables had been chosen to manipulate the experiment. K. Kanlayasiri and S. Boonmung investigated on the machining variables that consist of pulse-peak current, pulse-on time, pulse-off time, and wire tension [5]. The range of machining parameters were referred from the guideline in the manual book for Mitsubishi FX Wire Electrical Discharge Machine (WEDM) [6]. Base on the table, the machine had been operated with the same design but different variables on the machining process. Some samples were run twice to do the confirmation test because of the long processing time occurred.

Table 1 Parameter arrangement for machining process

Number	Wire Tension (WT)	Off Time (OFF)	Peak Current (IP)	Wire (Brass)	
				Sample	Sample
1	10	1	4	BA1	BA2
2	10	2	5	BB1	-
3	10	3	6	BC1	-
4	9	1	5	BD1	-
5	9	2	6	BE1	-
6	9	3	4	BF1	BF2
7	8	1	6	BG1	-
8	8	2	4	BH1	BH2
9	8	3	5	BI1	-

2.3 Sample Preparation And Experimental Procedure

Before and after the machining process, all of the specimens were weighed. After that, the specimens were kept in special storage to prevent the miss check and wrong labeling on the surface. High carbon steel S50C work pieces were cut into the desired size using Wire EDM Mitsubishi FX Series Machine (flushing type) in the presence of dielectric fluid (deionized water) with the addition step of submerging the work pieces into anti-rust agent liquid KC-12 to reduce the surface rust.

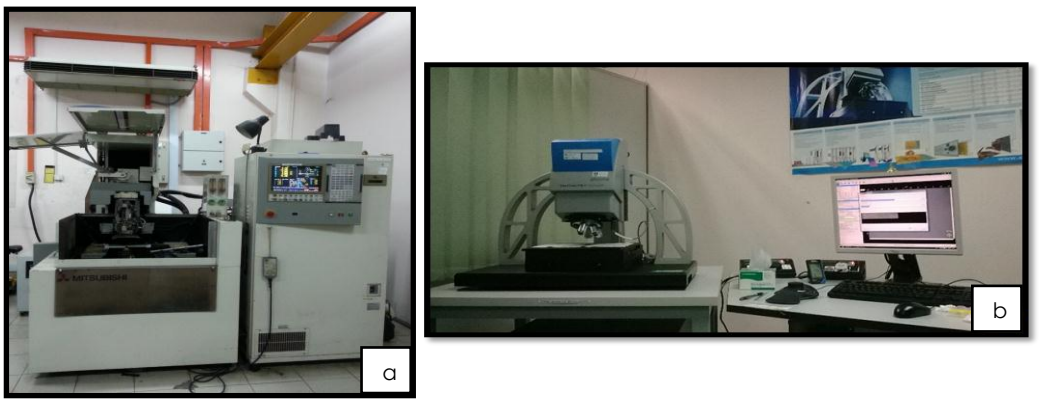


Figure 1 (a) Wire EDM Mitsubishi FX Series Machine (b) Infinite Focus Alicona Machine

The surface roughness of the specimens were measured using the Infinite Focus Alicona Machine. The surface roughness values were exposed in screen readings and the average value of these readings was taken as the data collection. The material removal rate (MRR) was calculated using the equation below.

$$MRR = \frac{w^a - w^b}{Tm - \rho} (\text{mm}^3/\text{sec})$$

Where; W^b = weight of workpiece material before machining (g)
Wa = weight after machining (g)
T_m = machining time (sec)
ρ = density of S50C (g/mm³) [7]

3.0 RESULTS AND DISCUSSION

3.1 Brass Wire

Brass wire is the common electrode used in manufacturing industry nowadays. Therefore, a lot of studies are made to update new parameters by using brass wire as electrode in Wire Electrical Discharge Machine.

The end surfaces of a product that has been produced in a water dielectric frequently used in Wire Electrical Discharge Machine have a lower hardness than its raw material due to the anode oxidation. The anodic oxidation together with electrolysis can reduce cobalt, carbon and other material's surface. Apart from that copper atoms that exist in the brass wire can adapt into the open surface of the work piece material, further funding to alloying process and reducing the hardness of the parent materials [8].

A number of studies using brass wire as electrode for wire electrical discharge machining were reported elsewhere [2, 9-10]. Table 2 shows values of MRR, Ra and CR using brass wire as the electrode in WEDM.

Table 2 Result of MRR, Ra and CR using brass wire as machine's electrode

Brass	WT	OFF	IP	MRR	Ra	CR
A12	10	1	4	0.00283	1.1776	0.016
B1	10	2	5	0.00455	1.1199	0.026
C1	10	3	6	0.00634	1.3195	0.036
D1	9	1	5	0.00476	1.2372	0.027
E1	9	2	6	0.00485	1.3172	0.028
F12	9	3	4	0.00242	1.4592	0.014
G1	8	1	6	0.00500	2.2638	0.028
H12	8	2	4	0.00241	1.3398	0.014
I1	8	3	5	0.00380	1.0938	0.021

3.2 Material Removal Rate Using Brass Wire

Figure 2 shows the graph of the relationship between material removal rate (MRR) and surface roughness (Ra) of the samples using brass wire as the electrode of WEDM. For the graph of MRR of the samples, it shows a constant increase in value for the first three samples, and drop in value for the fourth sample. The value has a little increase in the fifth sample but unexpectedly dropped half of the value in the sixth sample. The seventh sample doubled in value but again dropped in the eighth sample and rise again in the ninth. This event gives a fluctuation wave. Sample C1 has the highest value of MRR with the value of

0.00634 mm³/sec and the sample H12 has the lowest value of MRR with the value of 0.00241 mm³/sec.

Figure 2 also shows the graph of the surface roughness (Ra) of the samples that were machined by WEDM using brass wire as the electrode. The graph shows an almost constant value for all samples, with a sharp increase in the seventh sample making a peak in the graph. Sample G1 has the highest value of surface roughness with the value of 2.2638 µm and sample I1 has the lowest value of surface roughness with the value of 1.0938 µm. The graph also shows that at some points in the graph are intercepts and can be defined as the most optimum sample with optimum machine parameter. The 10-A12 sample shows that the lowest Ra and MRR. From this study, it can be seen that the smaller the value, the better the product is produced. The graph shows that the most significant result is on sample 10-A12 with machine's parameters that are mentioned before.

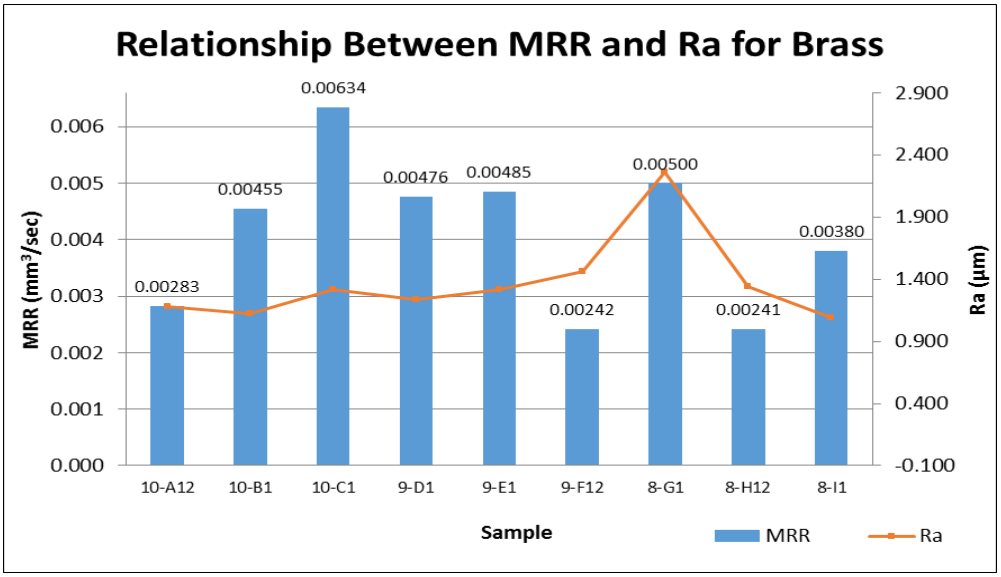


Figure 2 Relationship between material removal rate and surface roughness of various samples

3.3 Spark Analysis Using Brass Wire

Figure 3 shows the graph of comparison between spark analysis and surface roughness of different samples using WEDM with brass wire as machine's electrode. The graph show result of the measurement data after cutting process was conducted. The graph show that the dimensions are not accurately follow the design because the original dimension for the cutting parameter is 5 x 5 mm². The deepest of the cutting occurred on sample F12. From Figure 3, it can be seen that the deeper the spark occurred, the higher value of the surface roughness.

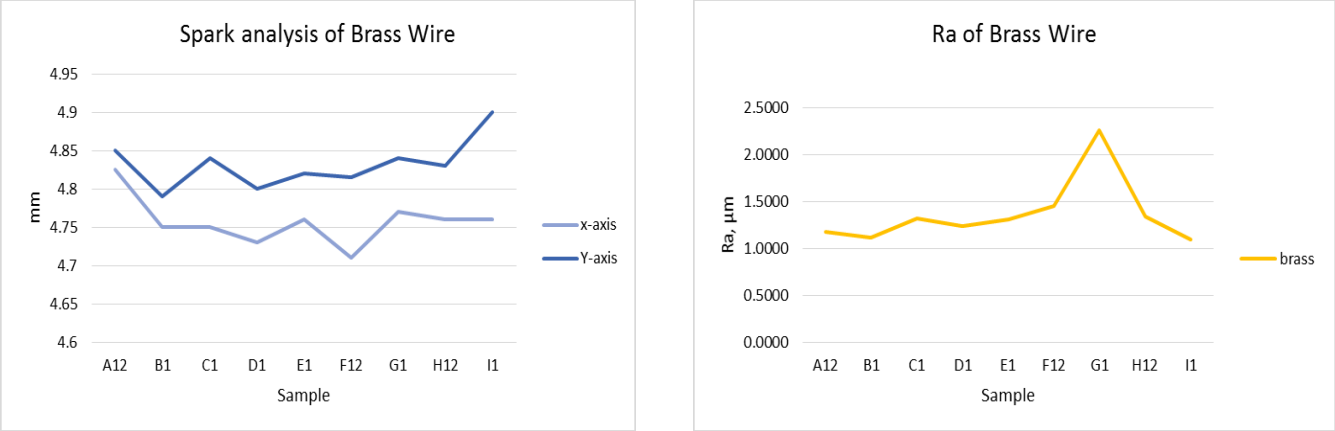


Figure 3 Comparison between spark analysis and surface roughness of different samples

4.0 CONCLUSION

In a conclusion, the study on the encouragement of three machining parameters on wire electrical discharge machining that consist of peak current (IP), pulse OFF time (OFF) and wire tension (WT) to three machining responses which are cutting rate (CR), material removal rate (MRR) and surface roughness (SR) on high carbon steel (S50C) using brass wire as the machine's electrode was completed. The values of CR, MRR and SR are different with different machining parameters used.

In the surface roughness, it usually depends on the demand from the manufacturer. Some of the product needs very itching surface where high surface roughness occurred because the function of the product should be grip or high friction depends on its purpose. Some may need the surface very smooth and shiny because the surface usually use as outer or mounted part so the mounted process are smoothly done.

Acknowledgement

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