An Assessment of EDM Parameters on Copper Electrode Wear Rate on AISI 4340 Alloy Steel

John Arthur Gavino[1], Jovelito Sale[2]

[1,2]College of Engineering, Computer Studies, and Architecture

[1,2]Lyceum of the Philippines University - Cavite, General Trias City, Philippines

Abstract: **Electrical Discharge Machining (EDM) is a machining process used for producing complex metal fabrication that cannot produce using conventional machining processes. Proper selection of material is important for the benefits of the machining rate. Good selection of material leads to better performance. The present study mainly focusing on copper as the electrode. The objective of this is to assess the wear rate of the copper on AISI 4340 alloy steel and output parameters such as pulse current, pulse on time, and pulse off time.**

Keywords: **AISI 4340 Alloy Steel, Copper Electrode, Electrical Discharge Machining (EDM), Electrode Wear Rate (EWR), Pulse Current, Pulse off time, Pulse on time.**

I. INTRODUCTION

Electrical discharge machining (EDM) is a machining process that used sparks coming from electrical discharges to obtain the desired shape of the piece. EDM is the answer to a complex machining process that requires high accuracy and demanding applications that conventional manufacturing is having difficulty or impossible.

Having many other names, like spark machining, the EDM process is also a very interesting topic to study. Known by its ability to produce an intricate high-quality product, EDM has many components to be familiar to very understand how it works. It is surprising that with the rapid rise of technologies, our local manufacturing industries have a limited amount of knowledge in this kind of technology.

In this study, the researchers are focusing on copper as the tool-electrode of our EDM and by the use of medium carbon steel as our workpiece. The potential of copper as an electrode can play a major role in metal fabrication with the use of EDM. The researchers are able to find out the wear rate of the copper by use of different parameters to assess its wear rate on medium carbon steel. This study will give more insights into the EDM process and contribute to the body of knowledge to aid our local manufacturing industries providing them helpful information for their work.

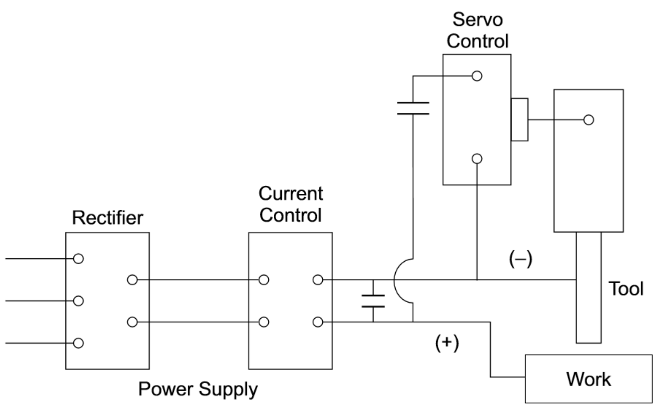

Fig. 1 Schematic arrangement of servocontrol for tool feed in EDM

II. EDM PARAMETERS

A. The experimental EDM parameters

The three main parameters to be used are pulse current, pulse on time and pulse off time. There are three levels in this study and each levels have three trials shown in Table.1.

TABLE I: EDM PARAMETERS

	Parameters	Unit	Level 1	Level 2	Level 3
A	Pulse Current	A	1	6	10
B	T_{on}	μs	30	180	300
C	T_{off}	μs	10	18	30
D	Time	Min	15	9	6

B. Data-Gathering Procedure

In order to run the experiment properly, all procedures must be properly executed with right work flow.

1. Selection of workpiece

The proponents decided to use a medium carbon steel as our workpiece to determine the wear rate of the copper in this experiment. The workpiece is heat treated with the thickness of 15 mm and diameter of 24 mm.

Fig. 2 AISI 4340 Alloy Steel

2. Selection of electrode

The researchers selected copper as the electrode material. The main focus of this study is to determine the wear rate of the copper on medium carbon steel. The copper has a length of 30 mm and diameter of 8 mm.

Fig. 3 Copper electrode

3. Block and tool holder arrangement

It is important to arrange the block and tool holder in a proper place to execute the machining process correctly and avoid any damage on machine and tools.

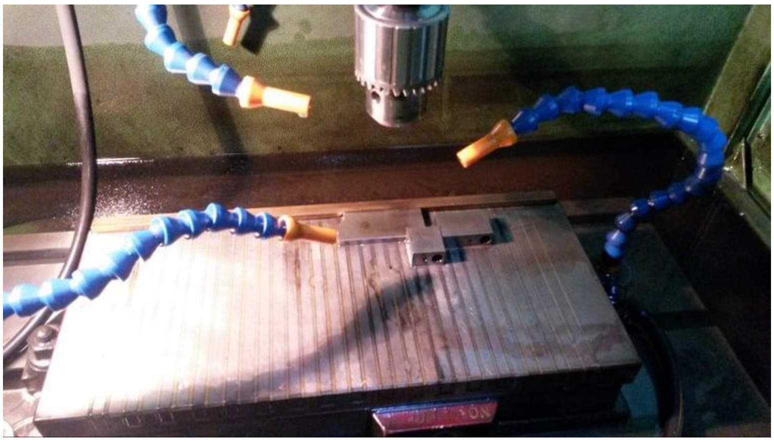

Fig. 4 Block and tool holder setup

4. Flatness of workpiece

The medium carbon alloy is placed on block in a flat position to align in a proper direction along with the tool holder and to maintain the geometry of the process.

Fig. 5 Securing the flatness of workpiece

5. Perpendicularity of electrode

The perpendicularity of electrode is important to maintain before performing the machining operation on EDM machine to secure the right position of electrode along with workpiece.

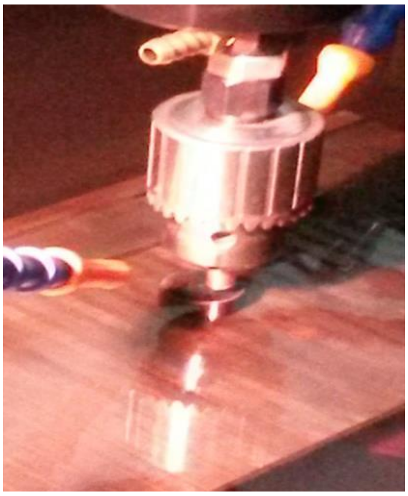

Fig. 6 Perpendicular of electrode

6. Gap Setting

The gap between the tool electrode and workpiece must be maintained for consistency of experiment, not too far and not to near. Generally, it is set to .025mm.

Fig. 7 Gap setting between electrode and workpiece

7. Jet Flushing Nozzle Setting

The jet flushing nozzles must be properly positioned. Nozzles will help to flush the eroded particles between the tool and the workpiece that prevents the carbon submission on tool electrode and workpiece.

Fig. 8 Jet flushing nozzle setup

8. Feed data in Control Unit

Set the values according to the experimental setup of this study.

Fig. 9 Feed data in control

9. Machining of workpiece

After all the preparations are ready, the experiment can now be performing.

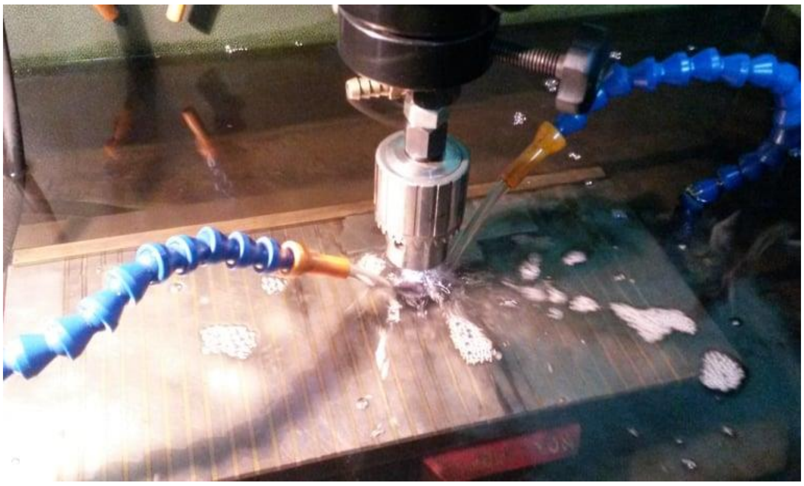

Fig. 10 Machining of workpiece

10. Record the process result

Record all the necessary data obtained by the process.

11. Repeat test with different process parameters

Prepare for the next experimental setup with different parameters and repeat the whole procedures.

C. Experiment Testing and Evaluation

Electrode Wear Rate (EWR) is expressed as the ratio of difference of mass of the electrode before and after the machining to the machining time. This calculation can be obtained with this following formula:

$$EWR = \frac{Web - Wea}{T}$$

Where:

EWR = Electrode Wear Rate (g/min)

Web = Mass of Electrode before machining (g)

Wea = Mass of Electrode after machining (g)

T = Machining time (minutes)

The materials needed in the experiment must meet the setup the researchers set to be able to execute the experiment properly without any discrepancies to minimize the potential errors and make the process smooth.

TABLE II: DATA COLLECTION OF EWR AT 1A

Exp. No.	Weight of Electrode before	Weight of Electrode after	Time	ΔW	EWR
1	13.5251	13.5239	15.30	0.0012	0.00008
2	13.5224	13.5213	15.23	0.0011	0.00007
3	13.5314	13.5302	15.25	0.0012	0.00008

TABLE III: DATA COLLECTION OF EWR AT 6A

Exp. No.	Weight of Electrode before	Weight of Electrode after	Time	ΔW	EWR
1	13.5108	13.3958	9.10	0.115	0.0126
2	13.5188	13.4088	9.07	0.11	0.0121
3	13.5206	13.4056	9.08	0.115	0.0127

TABLE IV: DATA COLLECTION OF EWR AT 10A

Exp. No.	Weight of Electrode before	Weight of Electrode after	Time	ΔW	EWR
1	13.5323	13.5123	6.12	0.02	0.0033
2	13.5278	13.5098	6.10	0.018	0.0030
3	13.5269	13.5089	6.10	0.018	0.0030

Variation of electrode wear rate for Copper electrode with respect to Pulse current 1A, 6A, and 10A are shown respectively.

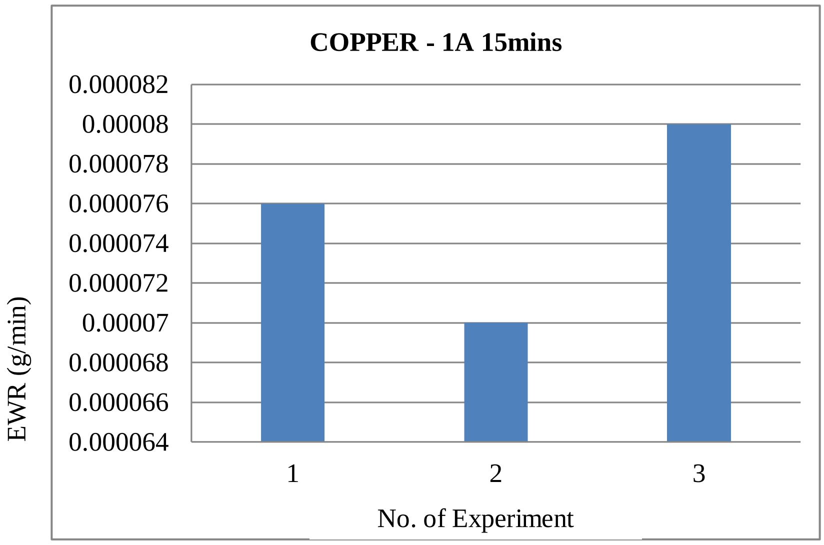

Fig. 11 Electrode Wear Rate at 1A

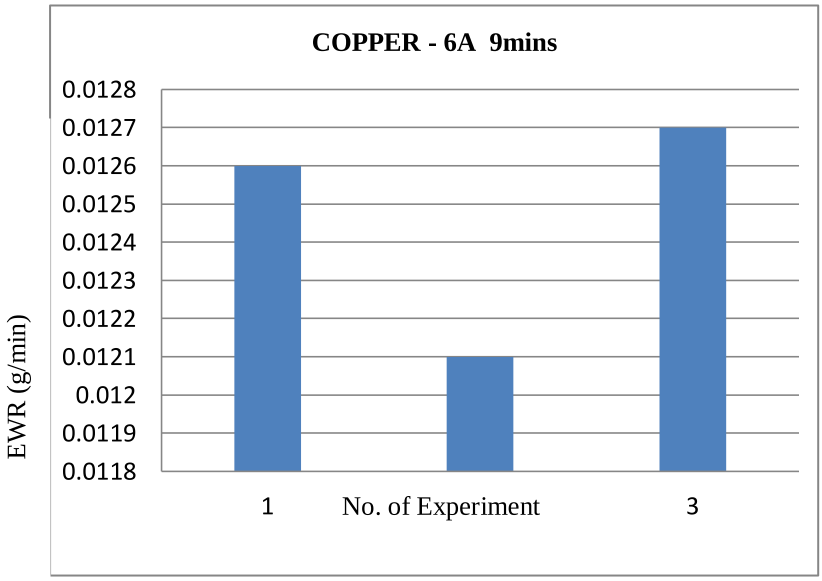

Fig. 12 Electrode Wear Rate at 6A

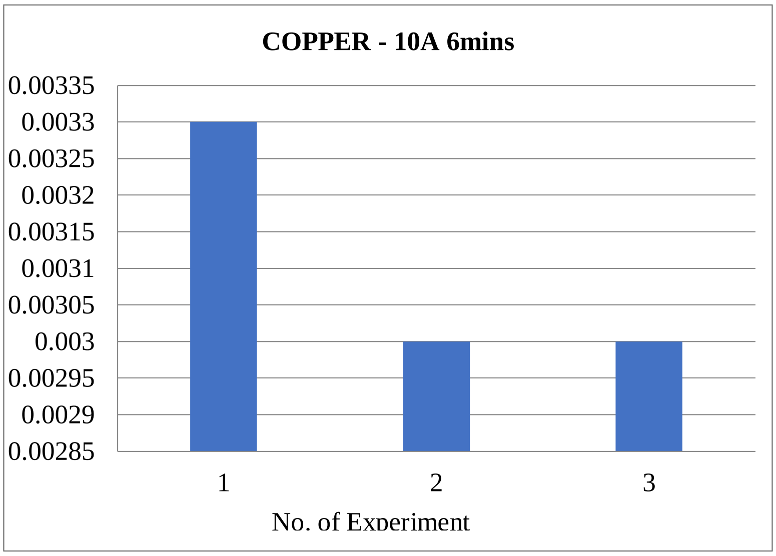

Fig. 13 Electrode Wear Rate at 10A

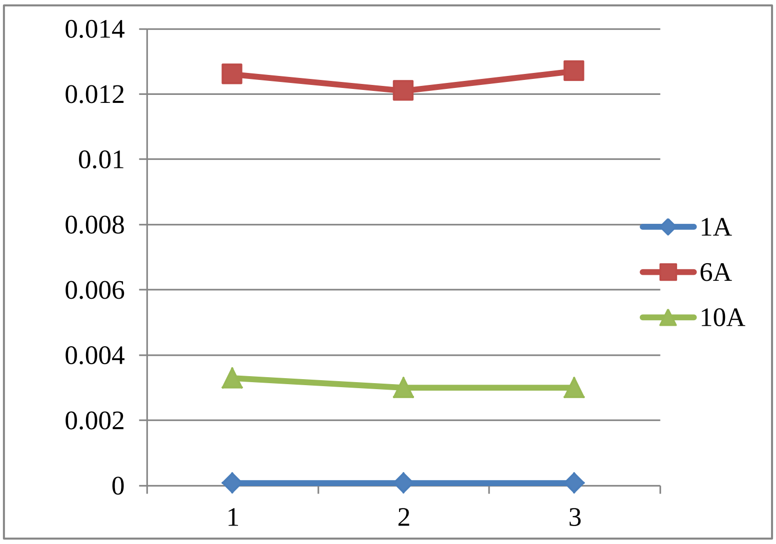

Fig. 14 EWR vs Pulse Current

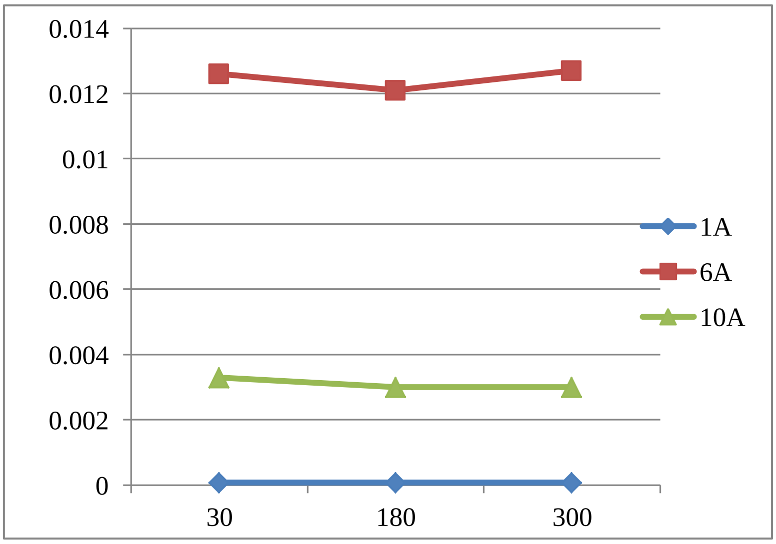

Fig. 15 EWR vs T_{on} µs

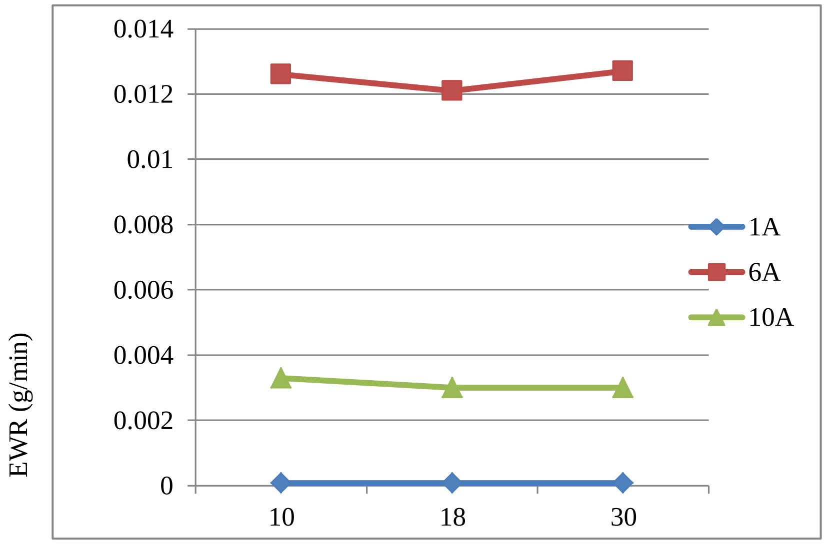

Fig. 16 EWR vs T_{off} μs

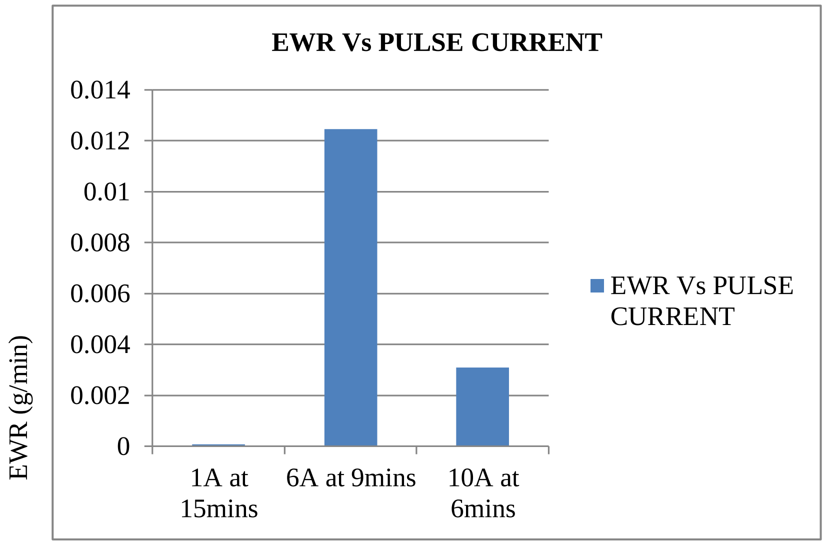

Fig. 17 EWR vs Pulse current

D. Conclusion Acknowledgement and Appendix

The experimental results reveal that the values of electrode wear rate (EWR) increase at higher values of pulse current and pulse on-time. It means that the electrode experiencing higher heat. The increase in peak current causes increase in spark energy resulting in higher current density. This rapidly over heats the work piece and the electrode and increases the EWR with peak current. The electrode wear vs pulse current using AISI 4340 alloy steel is shown in Fig. 16.

The graph shows that the wear rate at 6A has the highest value compare to the rest of the pulse current selections. The reason is that at 6A the electrode undergone nine minutes of machining which is long enough to produce more heat compare to 1A that has a longest time but lowest current and to 10A that has the highest current but lowest machining time. The values can also be observe at Fig. 13, Fig. 14, and Fig. 16 that shows same results at pulse current, pulse on time, and pulse off time and that at 6A occurs highest electrode wear rate.

III. CONCLUSION

The less electrode wear ratio (EWR) will make the machining performance better which shows that the potential of copper can last long. From this research, results presented obtained by the experiment shows the effects of different parameters of EDM to copper electrode. Therefore, copper as the electrode has low wear ratio. Furthermore, copper is easy to fabricate, accessible and can prove its potential on a wide application for any kinds of metal. It is an ideal electrode for any kinds of use in EDM fabrication. From this research, proponents can conclude that wear rate occurs on electrode when a buildup of heat starts to increase for an extended machining time. The causes of heat on the electrode are the increase in pulse current, and pulse on time and the duration of the machining process. Additionally, copper can withstand the heat due to its mechanical properties that has a high melting point.

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