A Stable Curved Hole Creation by Electrical Discharge Machining and a New Curved Mechanical Mechanism

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Abstract: In this paper, creation of curved holes became hard to do and therefore we were searching for a new mechanism or even a new way to do so, then we designed a new curved mechanical mechanism to try and after it worked good, we wanted to make a stable curved hole with the same dimension in the inlet and outlet hole by repeat putting the half ball's electrode to get the same diameter in the inlet and outlet hole. Then, we measured the electrode wear rate for the different entries we did, and afterwards we saw the shape of that curved hole after it had radiography test by X-Ray.
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1. Introduction

EDM machining was originally found by Joseph Priestly in 1770. It was commercially developed in the middle of 1970s, wire EDM started to be a well-known technique that helped to shape the metal forming industry that we have today. In the middle of 1980s, The EDM techniques became useful to use them with the machine tools. This transformation made EDM more and more available over traditional machining processes. Electrical discharge machine (EDM) is commonly used in so many things such as tool and die-making industries. The heat-treated tool steels material is difficult to be cut when we use traditional machining process. One of the most main problems in EDM is the high tool's wear rate. The wear rate is defined as the difference of the weight of the electrode before and after the machining divided by the time. If the rate of tool wear is high then the material of the work piece is easy to be wear and it will not be good for the machining performance [1,2]. Electro Discharge Machining is a Process, that electrical energy is used to generate an electrical spark and the material is removed mainly due to the thermal energy came from the spark. The area we are using the machining of should be washed from the gap by the continuously flushing dielectric fluid. EDM is mainly used to machine difficult materials of being machined and high strength temperature resistant alloys. EDM could machine difficult geometries in small batches. The work piece machined by EDM should be electrically conductive [3].

The aim of this paper is to study the possibility of creating a stable curved hole by using multiple curved ball's electrodes to get the same inlet and outlet diameter in the work piece.

2. Experimental Work

2.1 The Mechanism

Preparing of the mechanism to get the stable curved hole as shown in **Fig. 1**.

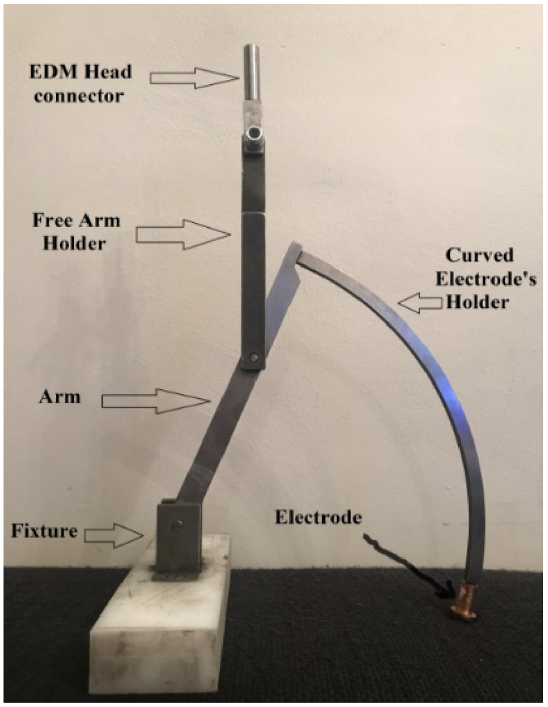

Fig. 1. Curved hole Mechanism

2.1.1 The Electrode

A half ball of pure copper (USN C80100) made by turning process on a turning machine with a half ball shape to let the shape of the hole circular with a 15mm diameter and its chemical composition of copper (UNS C80100) is given in **Table1**.

Table 1. Chemical composition of copper (UNS C80100)

Element	Content (%)
Copper, Cu + Silver, Ag	99.95 min
Others	0.05 max

2.1.2 The arm

A C45 arm steel is used to hold the curved electrode's holder and its length is really important as it should be equal to the value of the curved electrode holder's radius. Its chemical composition is given in **Table 2**.

Table 2. Chemical composition of arm

Chemical composition: (Typical analysis in %)	C	Si	Mn	P	S	Cr	Mo	Ni	Cr+Mo+ Ni
	0,42 0,50	<0,40	0,50 0,80	<0,045	<0,045	<0,40	<0,10	0,40	<0,63

2.1.3 The free arm holder

The free arm holder which made from the C45 steel is to hold and let the arm moves circularly free when the EDM's head moves vertically.

2.1.4 Curved electrode's holder

The curved electrode's holder is made from the C45 steel and its role here is to hold the electrode from its threaded part and its radius changes depends on the required radius.

2.2 EDM Machining Parameters

We used the ram sinker EDM machine (HO CHEN) PNC EDM 75A at EL SAFAA PLAST Company and EDM drilling conditions are listed in the **Table 3**.

Table 3. EDM drilling conditions

Half ball electrode	pure copper (USN C80100)
Electrode polarity	Positive
Working fluid	Kerosene
Open circuit voltage (ui)	200 V
Discharge current (ie)	12 A
Pulse duration (te)	10 s

2.3 Preparation of work piece

The Works piece as shown in **Fig. 2** is made also from C45 steel with dimension 250x250x25 mm.

2.4 Machining steps

After the preparations for making the curved hole by the electrical discharge machine (EDM) and the mechanism mentioned above, we decided to repeat the process to have the same inlet and outlet diameter in that curved hole with radius 150 as shown in **Fig. 3**. So, we put the mechanism on the EDM mentioned above submerged in the kerosene, after we finished the required number of repetition, we measured the electrodes weights before and after each process to check the wear rate and then we took the work piece to make the radiography test with X-Ray with the parameters are listed in **Table 4**.

Fig. 2. The workpiece

Table 4. The parameters of X-Ray

Source	X- Ray – Andrex 300kw
Tube Voltage	150 KV
Film Type	Kodak AA400
SFD	700mm
Tube Current	3mA
Exposure Time	7.0 Min
Processing	Manual

The Electrode wear was measured by the following equation:

$$\text{Electrode wear rate} = \frac{\text{Electrode weight before machining} - \text{Electrode weight after machining}}{\text{time}} \text{ (gram/min.)}$$

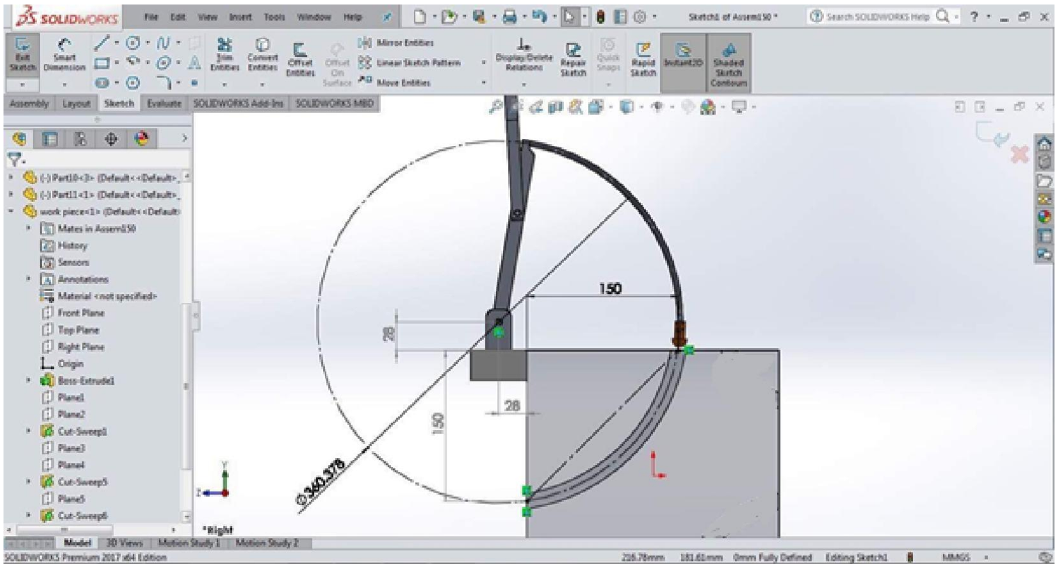

Fig. 3. Radius 150 with the same inlet and outlet diameter

3. Results and Discussion

3.1 Machining Table as shown in **Table 5**.

Table 5. The electrode's diameter before and after machining

X (mm)	Y (mm)	Electrode's Diameter Before Machining (mm)	Electrode's Diameter After the 1st Entry (mm)	Electrode's Diameter After the 2nd Entry (mm)	Electrode's Diameter After the 3rd Entry (mm)
150	150	14.9	10.6	13.7	14.7

The shape of the Electrode Before and after the three entries Machining as shown in **Table 6**.

Table 6. The shape of the electrode before and after machining

Before Machining	After Machining		
Plain	1st Entry	2nd Entry	3rd Entry
			

The length of the head of the electrode before and after the tree entries as shown in **Table 7**.

Table 7. The length of the head of the electrode before and after machining

Electrode's Head length before machining (mm)	Electrode's Head length after the 1st Entry (mm)	Electrode's Head length after the 2nd Entry (mm)	Electrode's Head length after the 3rd Entry (mm)
7.5	2.5	7.5	7.5

The shape of the workpiece after making the required hole as in **Fig. 4**.


Fig. 4. The workpiece after machining

3.2 Wear Table

The hole's inlet and outlet diameter as shown in **Table 8**.

Table 8. The diameter of the hole before and after the machining

	Hole's Inlet Diameter (mm)	Hole's Outlet Diameter (mm)
Radius 150	15	15

The weight of the electrode before and after the three entries as shown in **Table 9**.

Table 9. The weight of the electrode before and after the machining

Weight of the Electrode Before Machining (gram)	Weight of the Electrode After the 1st Entry (gram)	Weight of the Electrode After the 2nd Entry (gram)	Weight of the Electrode After the 3rd Entry (gram)
17.4	10.49	15.93	17.1

The electrode's wear rate after the three entries as shown in **Table 10**.

Table 10. The electrode's wear rate after the machining

Electrode Wear Rate (gram/min.)		
1st Electrode	2nd Electrode	3rd Electrode
0.023	0.025	0.01

3.3 Radiography visions

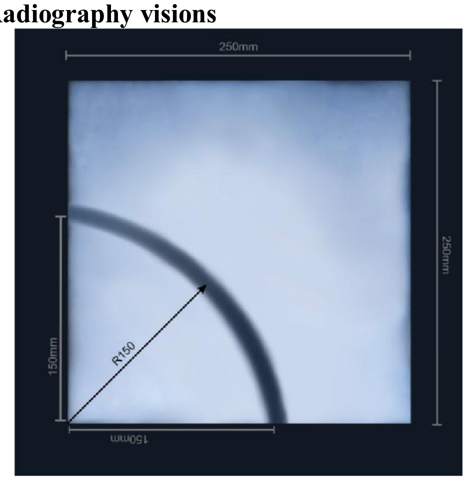

Fig. 5. X-Ray for the same inlet and outlet diameter

The curved hole's shape for radius 150 after getting the same inlet and outlet diameter using the X-Ray as show in **Fig. 5**.

4. Conclusions

After designing the mechanism which allows us to make a curved hole with any length and radius we need, we found that the outlet diameter is always smaller than the inlet diameter as there is a wear happened to the electrode used. So, we wanted to keep the diameters to be the same and we discovered that we could; just by changing the electrode after getting out with another one identical to the one before till we have the same diameter we wanted.

Also, the wear rate decreases when we put any electrode after the first one as the first electrode finish almost most of the hole and we just follow it by the other ones to get the required hole's diameter.

References

1. Sameh Habib, Experimental study of electrical discharge machining of PS-M A-463 Plastic Material, i-manager's Journal on Material Science 1(3): 12:21.
2. Sameh Habib, Akira Okada and Yoshiyuki Uno, Improving the productivity of electrical discharge machining process by using multi-thin electrodes, Machining Science and Technology 17(1): 110:128, January 2013.
3. The International Journal of Engineering and Science (IJES), Volume 3, Issue 2, Pages 24-35(2014), ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805.

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