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EFFECT OF ELECTRODE MATERIAL ON HOLES QUALITY MACHINED USING EDM PROCESS OF AISI H13

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ABSTRACT
This paper presents the results of experimental studies carried out to conduct a comprehensive investigation on the influence of Electrical Discharge Machining (EDM) input parameters on the Holes Quality of the EDM process. The experiments performed under the designed partial factorial procedure, and the considered EDM input parameters included pulse on-time, Gap and pulse current. The results of this study could be utilized in the selection of optimum process parameters to achieve the desired EDM efficiency(surface roughness and diameter accuracy) integrity when machining AISI H13 tool steel. Copper is found to be the best electrode material for dimensional accuracy (diameter error and surface finish) followed by brass.

Keywords:
Electrical Discharge Machining , Surface Roughness, Diameter Error ,Electrode Material.

INTRODUCTION

Electrical Discharge Machining (EDM) is a popular non-conventional machining process that is capable of machining precise and complex geometries in electrically conductive hard materials [1]. The working principle of EDM is essentially an electro-thermal mechanism wherein, electrical energy of discrete electrical discharges between two electrodes (work piece and tool), immersed in a dielectric fluid is converted to thermal energy that produces a plasma channel of very high temperature ultimately resulting into erosion of work piece material. The unique benefit of EDM includes the machining of conductive materials either soft or hard by the application of thermal energy which is produced in EDM process. In this way, any hard conductive material can be cut which is difficult to machine in conventional machining processes[2].

PRINCIPLE OF EDM PROCESS

Thermoelectric energy is considered as the underlying concept of the controlled electric discharge machining. The machining motivates material removal to happen due to the high temperature generated as a result of passaging the electric current between the workpiece electrode and tool electrode. The two electrodes are supposed to be separated by a dielectric liquid such as deionized water or hydrocarbon oil. The small gap between the workpiece and electrode (tool) is called the spark gap. The pulsed discharge is typically happened in this gap. The series of rapid sparks is the cause of material removal (erosion) process as shown in Figure(1). [3].

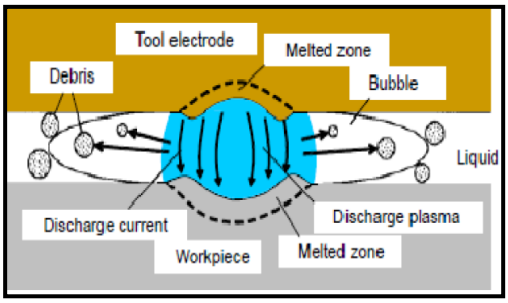

Fig.1 : Sparking occurs at closest points [3].

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Barman *et al*. studied the size, shape and quality of high aspect ratio micro blind holes, which were machined via EDM (die sinker), taking various process parameters namely gap voltage, feed, discharge capacitance, polarity and threshold in the study. The depth of the hole generated was found smaller due to the wear of the tool Barman *et al.*, (2013)[4]. Furthermore, tool wear was found to be influenced by peak current in EDM of Stainless Steel for micro holes. The effect of current on over cut was investigated for Stainless Steel in the same study. Peak current was found to influence the value of overcut Johan, (2010)[5], whereas surface roughness increases also with increasing the peak current . EDM performance is affected not only by the process parameters but also by the type of electrode. Various studies Khan, (2008)[6]; Klockea,(2013)[7]; Singh, (2012)[8]; Gopalakannan, (2012)[9]; Shankar *et al.,(* 2004)[10]) were conducted to evaluate the performance of the electrodes. Khan (2006) found the copper electrodes more effective as compared to Brass electrodes due to low tool wear rates of Copper electrodes as compared to Brass electrodes. Klocke (2013)[7] worked on different grades of Graphite as electrode materials in an EDM process. Graphite showed different performance characteristics as an electrode material. According to Klocke, Graphite has low wear rate as compared to Copper. Singh *et al.* (2012)[8], Gopalakannan *et al.* (2012)[9] and Shankar *et al.* (2004)[10] used different types of electrodes for die steel, Stainless Steel and hardened tool steel to evaluate the performance of electrodes. They found that electrode materials play an effective role on performance of EDM (Singh *et al.*, (2012)[8], Gopalakannan *et al.*, (2012)[9]; and Shankar *et al.*, (2004)[10] . A study found was aimed to find the (MRR) and Tool Wear Rate (TWR) using various process parameters namely peak current, voltage and frequency for Brass and Tungsten Carbide Electrode in a hole making process using EDM (die sinker). It was found that electrode material influences MRR and TWR for EDM drilling process. Brass as an electrode achieved higher MRR than Tungsten Carbide. On the other hand, Tungsten Carbide achieved lower TWR as compared to Brass (Urso *et al.*, (2012),(2014)[11][12]).The literature shows that material of the electrode has an important role for the quality of the holes in EDM operation. A lot of research work has been done to evaluate the effect of process parameters on the quality of electric discharge machined holes. Copper as an electrode has been mostly used for the research studies whereas little research studies are found on the effect of electrode material on the quality of electric discharge machined holes.

EXPERIMENTAL WORK

The impacts of EDM operating factors (Gap ,Ton and electric current)on hole diameter and Surface Roughness (Ra) have been investigated. The experiments were conducted on EDM CM323Cwhich is available in the Training and Workshop Center / University of Technology / Baghdad as shown in Figure (2) and its specifications listed in Table (1). Two types of electrodes (copper and brass electrode) have been used. The work material used in this paper is AISI H13 steel. The chemical composition of the work material are given in Table(2) .

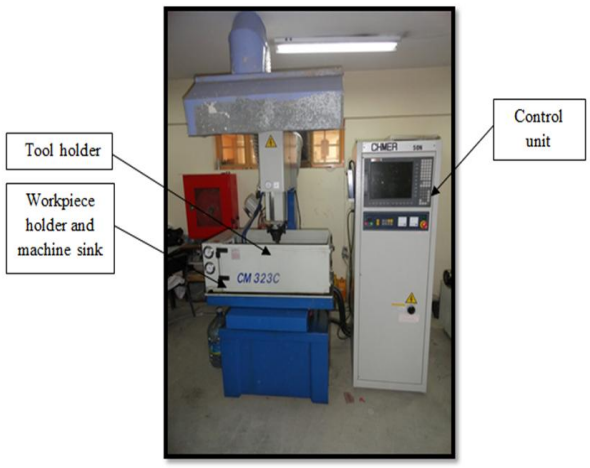

Fig.2 : EDM CM323C machine.

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Table 1: Specification of machine used.

Model	Unit	CM323C
Table size (WxD)	mm/inch	500x350/19.7x13.8
Work tank size(WxDxH)	mm/inch	820x500x300/32.3x19.7x11.8
Table travel (X,Y)	mm/inch	300x200/11.8x7.9
Ram travel (Z1)	mm/inch	300/11.8
Max. electrode weight	kg/lb	60/132
Max. workpiece weight	kg/lb	500/1100
Outside dimensions	mm/inch	1200x1350x2250/47.2x53.1x88.5
Weight	kg/lb	1000/2200
For Dielectric	-	D323

Table 2: Chemical composition of workpiece material.

Elements	C	Si	M n	P	S	Cr	Mo	Fe
percent	0.45	1.2	1.75	0.03	0.03	12	-	balance

Electrode Material

Among the various conductivity electrodes material Copper and Brass with (15 mm) diameter and (40 mm)length have been used as tool as shown in Figure (3) and Figure (4) With common characteristics below:

Copper:-
Melting point = 1084°C
Density = 0.007611 gm/mm3
Electrical resistivity = 1.67 × 10-8 Ω-m

Brass:-
Melting point = 930°C
Density = 0.007388 gm/mm3
Electrical resistivity = 6.6 × 10-8 Ω-m

Fig.3 : shown copper electrode after cutting process

Fig.4 : shown brass electrode after cutting process

The specimens used of AISI H13 Steel as workpiece for experimentation are shown below Figure(5).

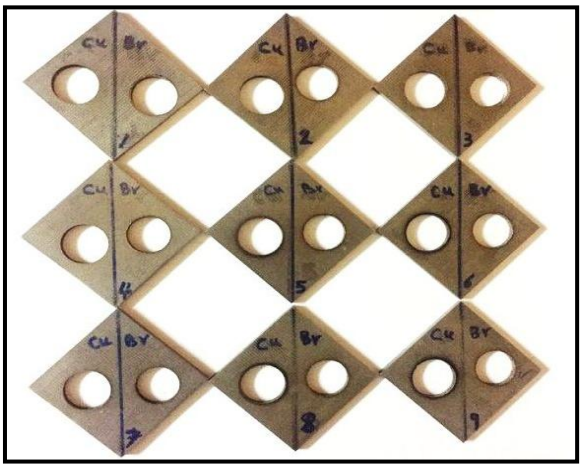

Fig.5 : Workpiece after cut.

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The surface roughness (Ra) is measured by the POCKET SURF EMD-1500 tester, on the inner surface of the resulting hole; the roughness measuring device is shown in figure (6).

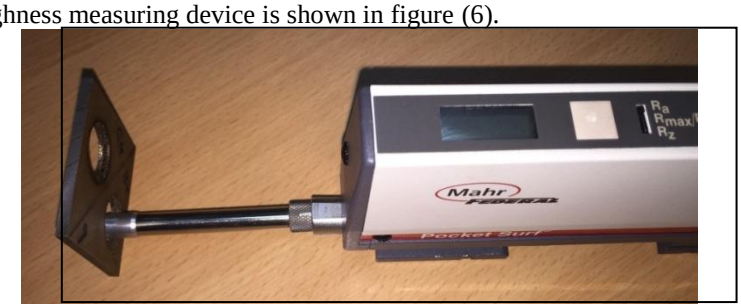

Fig.6 : Automatic digital POCKET SURF EMD-1500.

To find diameter error of hole used Micrometer, Complete Unit Set, 14-17mm Range, accuracy 0.005 mm Three jaw hole measurements is shown in figure (7) and to find error with use the equation below.

Diameter error (ED)(mm) = Hole diameter(mm) -- Electrode diameter(15mm)

Fig.7 : Micrometer used for hole.

DESIGN OF EXPERIMENTS

To determine effect of cutting parameters for EDM, 9 experiments have been used on L9 Orthogonal Array (Level-3, Factor-3) for each copper and brass electrode Gap, Current, Pulse On Time are input cutting parameters to the common output measures like Surface roughness and diameter error. In addition, electrode materials are also considered to recognize their effect on these process . Table(3) shown machining parameters .

Table.3: The machining parameters.

No	Machining parameters	Symbol	unit	Levels		
				Level 1	Level 2	Level 3
1	Pulse on time	T_{on}	µs	50	100	150
2	Gap	G	mm	1	3	6
3	Current	I_p	A	20	30	40

RESULTS, ANALYSIS AND DISCUSSIONS

Effect of Electrode Material on Surface Roughness (Ra)

Copper and brass as electrodes provide the following results Table (4) for surface roughness on various current conditions. The results obtained are plotted in Figure (8) And figure(9) for copper and brass Surface roughness (Ra) increases with increasing the current (Amp) And decrease with increasing pules on time and Gap. Copper is found to provide the finest surface finish followed by brass with a close margin at all values of the current.

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Table.4 : The Ra and Ed for copper and brass .

No	Pulse on time Ton(µs)	Current I_p(A)	Gap G(mm)	Ra For copper	Ra For brass	Diameter Error for copper	Diameter Error for brass
1	50	20	1	2.81	3.56	0.375	0.445
2	50	30	3	2.95	3.85	0.289	0.395
3	50	40	6	2.83	3.66	0.205	0.365
4	100	20	3	2.22	3.15	0.095	0.175
5	100	30	6	2.61	3.50	0.185	0.215
6	100	40	1	3.01	4.51	0.135	0.205
7	150	20	6	2.23	3.42	0.101	0.125
8	150	30	1	2.59	3.77	0.205	0.215
9	150	40	3	2.69	3.61	0.315	0.455

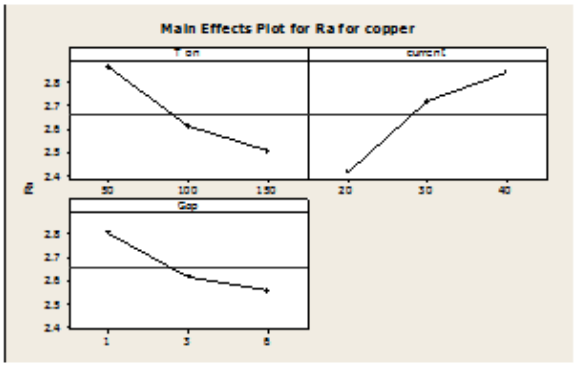

Fig.8 : The Effect of current, pulse on Time and Gap Gap on (Ra) using copper electrode.

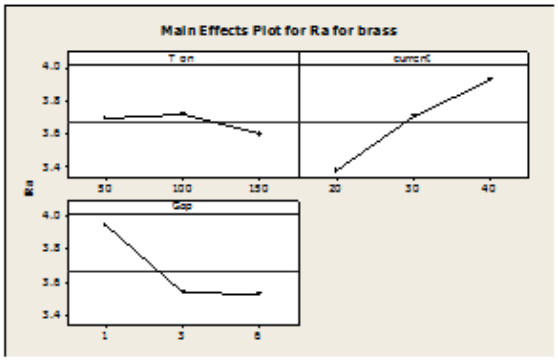

Fig.9 : The Effect of current, pulse on Time and on (Ra) using Brass electrode.

Effect of Electrode Material on Diameter Error (Ed)

Table 4 shows the results achieved for diameter error (Ed) at the stated cutting conditions. The results obtained are plotted in Figure (10) and figure (11) copper as an electrode is found as the best electrode for all values of the current. copper if found to provide the least values of diameter error among all the electrodes closely followed by brass And decrease with increasing pules on time and Gap. It can also be seen that the difference between Ed (copper) and Ed (brass) increases slightly at higher values of the condition.

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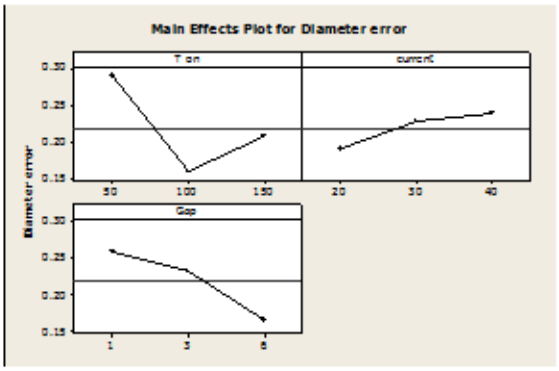

Fig.10 : The Effect of current, pulse on Time and Gap Gap on (Diameter error) using copper electrode.

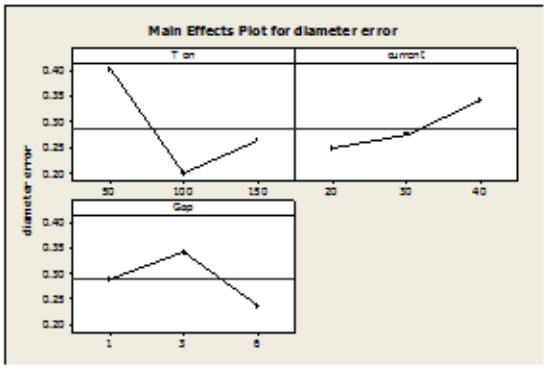

Fig.11 : The Effect of current, pulse on Time and on (Diameter error) using Brass electrode.

CONCLUSION

Two electrode materials namely Copper and brass are taken to study the influence of electrode material on quality of blind holes machined via EDM (die sinker). Three current conditions, i.e., 20 amp, 30 amp and 40 amp are taken for the study on workpart AISI H13 whereas surface roughness, diameter error are taken as the dimensions of quality. Following conclusions are drawn after the research work;

• Copper provides the best surface finish for blind holes among the electrodes closely followed by brass.

• Copper is found to be the best electrode material for dimensional accuracy. the least values of the error (diameter error)From the results obtained, it can be deduced that copper as an electrode provides the most suitable values overall for most of the stated performance measures among all the electrodes.

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