STUDIES FOR OBTAINING A SMALL HOLLE, RAPID EDM DRILLING MACHINE

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ABSTRACT

This paper studies the obtaining of an experimental rapid drilling machine, through EDM process for small holes. The best parameters such as peak current, pulse frequency, duty factor and electrode rotation speed were studied for best machining characteristics. An electrolytic copper rod 0.8 mm diameter was selected as a tool electrode. The experiments generate output responses such as maximum material removal rate (MRR) and the dependence with peak current, duty factor and electrode rotation, parameters. Finally, parameters were optimized for maximum MRR with desired surface roughness value and used for sizing the component for a better small rapid drilling machine.

Keywords: Fast drilling Electrical Discharge Machining, small holes.

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1. Introduction

Considered a last resort for drilling holes, Fast Hole Electrical Discharge Machining (EDM) Drilling is quickly becoming the standard method for producing small, tight tolerance holes. It is an extremely cost effective method for producing fast and accurate holes into all sorts of whether hard or soft conductive materials. EDM drilling operates on the principal of eroding material via the use of electric energy. [1]

There are many advantages of using fast EDM drilling versus conventional drilling:

-Some materials are too hard to drill using conventional methods. The EDM machine drills through almost any conductive material including carbide and hardened steel.

-Drills tend to bend in contact with the surfaces. To prevent this, additional fixtures and guide bushings must be used. With EDM drilling, the electrode never contacts the material being cut, thus eliminating the tool pressure normally experienced when drilling on curved or angled surfaces. [2]

-Deburring holes drilled by conventional methods can take longer than the drilling. EDM drilling creates no burrs. This burr-free drilling saves time and labor, and is especially crucial when difficult holes are being drilled. In addition, surface finishes are better. The smaller the hole, the more important a smooth surface is.

-Drilling holes with conventional methods is often extremely difficult if not impossible. EDM drilling is often the only practical method for producing such holes. As conventional drills enter or exit, they can break if torque is not carefully controlled. Small broken drills are often difficult to remove from the work piece, and time is wasted replacing broken drills and parts may have to be scrapped. With EDM drilling, torque does not exist since the electrode never contacts the piece. [3]

2. Method used

This method is based on trial and error improved results. The study is made on an experimental built machine, with a large domain of parameters adjustment. The goal is to obtain the best machining parameters resulting in maximum MRR.

Obtained parameters are used for proper choice and dimensioning of machine components for a better new machine potentially commercial type.

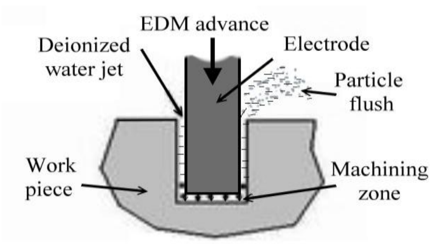

Fig. 1 *– EDM fast drilling process*

Holes were made in a 12mm plate of tool steel using a 0.8mm electrolytic copper full wire. Brass is also possible, coreless or multi-channeled [Fig. 2]

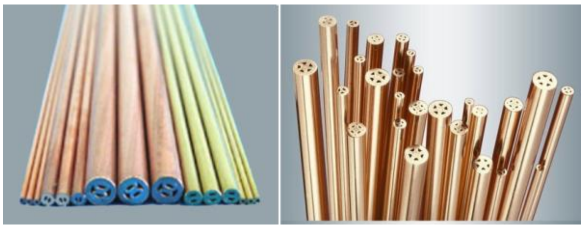

***Fig. 2 –** Examples of electrodes for drilling*

Before experimentation, the work piece faces were rectified to a good surface finish using a surface grinding machine. The bottom of the electrode rod is polished for best electric contact at every experiment.

The initial weight of the work piece was precise weighed using an accuracy digital scale. The work piece was connected to the terminals of power supply and clamped on the machine table. The dielectric fluid was flushed at a constant pressure in the gap between electrode and work piece. Holes of 12 mm depth were drilled in all the experiments. The time taken for machining each hole was recorded. At completion of each hole the work piece was removed from the machine, washed, dried, and weighted. The material removed rate was calculated using the following formula: [4]

$$MRR = \frac{\text{Initial weight of work piece - Final weight of piece}}{\text{Machining time}} \text{ mg/min} \quad (1)$$

3. Experimental results

The controllable variables chosen for the experimentation were peak current, pulse time-on and electrode rotation speed. Other factors such as gap voltage, (40 V), machine sensitivity, lift time, and flushing were kept constant during the experimentation. Table 1 shows the controllable parameters and actual values.

***Table 1.** Controllable parameters*

Parameters	Notation	Levels				
		-2	-1	normal	1	2
Current [A]	I	2	4	6	8	10
Pulse on time [μs]	t_{on}	20	40	60	80	100
Electrode rotation [rpm]	N	0	100	200	300	400

The experiment design consists of 16 experiments by combining process parameters and their levels [Fig. 3]. Random selection of parameters minimalized error and exterior influence.

The experimental design matrix and output responses values are shown in Table 2.

***Table 2:** Output responses values*

	Parameters			
No.	I	ton	N	MRR
1.	2	40	200	1.34
2.	2	60	200	1.63
3.	4	40	100	5.55
4.	4	60	200	6.41
5.	4	80	300	8.58
6.	6	60	200	16.32
7.	6	20	200	15.96
8.	6	60	400	20.8
9.	6	60	0	10.62
10.	6	100	200	16.83
11.	8	80	100	24
12.	8	80	300	28.51
13.	8	40	300	31.25
14.	8	40	100	24.72
15.	8	60	300	29.41
16.	10	60	200	39.63

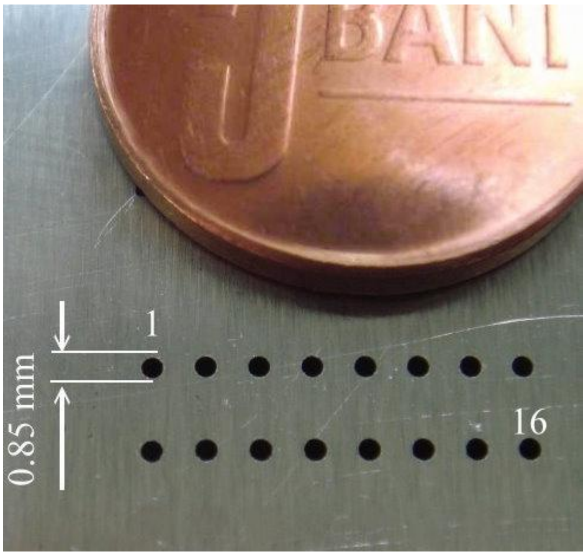

***Fig. 3 –** Experimental obtained holes.*

4. Conclusions

The effect of current at different pulse on-time the MRR increases with the increase in current. MRR varies almost linearly with the current. At pulse on time 60 μs, MRR increased from 1.63 to 39.63 mg/min as current is increased from 2 A to 10 A.

The effect of pulse on-time and MRR at same electrode speeds is insignificant. For electrode speed at 200 rpm, and 6A, MRR is increased from 16.32 mg/min to 16.83 mg/min as t_{on} increased from 60 μs to 100 μs. The short pulses cause less vaporization, whereas long pulse causes the plasma channel to expand. The expansion of the plasma channel causes less energy density on the work piece, which is insufficient to melt or vaporize the material [5].

The effect of electrode rotation on MRR for various currents causes the MRR increase as the electrode speed increases dependent of the current values. The improvement of MRR is due to better flushing condition. At 6 A current, increase in MRR is from 10.62 mg/min to 20.8 mg/min when electrode speed increased from 0 rpm to 400 rpm. It shows that the electrode speed is more significant at low current settings because the debris is finer and less concentrated at low current values and the increase in electrode speed resulted in effective removal of debris. But at high current, the MRR is more and the debris is larger and more concentrated.

The excessive concentration of debris and large size can result in bridging the gap between the electrodes and subsequent short-circuiting reduces the percent increase in MRR.

If require close tolerance, small holes, EDM drilling is the technology to utilize. By reducing the discharge energy, holes can be polished.

This machine can be use it to drill precise holes in medical and dental instruments, but its uses are varied and include drilling holes in turbine blades, fuel injectors, cutting tool coolant holes, hardened punch ejector holes, plastic mold vent holes, and starter holes for wire EDM.[6]

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