Evaluation of Metal Removal Rate on Metallic Plates using EDM Process

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ABSTRACT

Electric Discharge Machining is an unconventional machining process that is used for cutting materials and intricate shapes that are difficult to cut by other conventional machines. This machining provides unique possibilities for machining many different materials. It is able to machine any material which has minimal electrical conductivity with a certain degrees of tool wear and heat influence. There are various machining parameters like depth of cut, time pulse, current frequency, lift time. This paper exhibits an experiment that is carried out to study the effects of the different parameters on metal removal rate on different materials like copper, brass and mild steel.

Keywords: Electric Discharge Machining (EDM), Metal Removal Rate (MRR), Metals, Machining parameters.

1. INTRODUCTION

EDM also commonly known as spark machining/arc machining is an electrical process where the current passes between the electrode and a work piece. The electrode and the work piece are separated by a dielectric liquid. The dielectric fluid acts as an insulator where voltage is applied to bring the process to its ionization point. Hydrocarbon oil is the most commonly used dielectric fluid for EDM process. There are many forms of this machining process such as die sinker, wire EDM, hole drilling and spark erosion, out of which the latter is the most common in use. The schematic diagram of spark erosion is shown in figure 1. A movable electrode moves with the help of power supply and thus when comes in contact with work piece, an ionization spark is produced due to the dielectric fluid and finally machining of materials takes place.

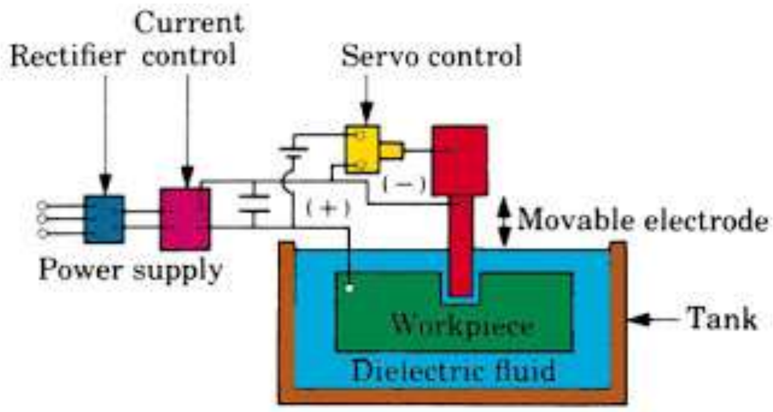

Figure 1: Working of Spark Erosion EDM.

This type of nontraditional process is more advantageous when compared to other process in terms of time, cost and finishing. The advantage of EDM is that it can cut hardened materials and exotic alloys by providing excellent surface finish. In spite of these, the principle advantages of this process are it is predictable, accurate and repeatable. This is used mostly for low volume productions with tight tolerances for airplanes and medical device industries. Unlike unconventional machining process, the EDM process removes substantial amount of material easily in less time and with more accuracy, thus leading to one of the most expensive process. Recently, Metal Removal Rate (MRR) is more significant parameter which is playing a major role in today's industries. So the user needs to select the parameters in such a way that needs of the customers are satisfied. In this paper, the characteristic behavior of copper, brass and mild steel are used to calculate MRR with different depths of cuts at constant speed and feed rate.

2. PROCESS PARAMETERS

Table1: Description of the work conditions

Work Condition Description	
ELECTRODE	Copper
WORKPIECE	Rectangular piece of 100x50x5mm
INPUT CURRENT	2-20A
PULSE ON TIME	1-100µs
GAP	1-20
DIELECTRIC FLUID	Spo oil
MATERIALS USED AS WORK PIECES	Copper, brass and mild steel

Table 2: Technical Specifications of the machine

Machine tool	400 x 250
Work tank	600x400x280mm
Work table size	400x250mm
Table traverse	250x170mm
Max workpeiece weight	100kg
Max work piece height	160mm
Max electrode weight	50kg
Z axis traverse	150mm
Types of table assembly	Needle roller bearing
No of T slots	3
T slot size	10mm
Least counter of vernier	0.005mm
Daylight	410mm
Shut height	260mm
Throat	320mm
Max working current	20+2amps
No of power setting	99x9
Min wear electrode	<0.1%

Surface finish	0.8µ Ra
Connected load	Kva2
Servo system	DC stepper
Power supply	3 phase,415v AC. 50Hz

Table 3: Specifications of Dielectric Tank

Dielectric Tank	
Dielectric capacity	150litres
Filter element	10micron paper filter
Dielectric pump motor rating	1HP 3Ø
Total weight	700kg
Machine dimensions	1130x1040x1800mm

Table 4: Physical Properties of Brass, Copper and Mild Steel

Metals used	Brass	Copper	Mild Steel
Density g/cm^3	8.96 g/cm^3	7.85 g/cm^3	8.470 g/cm^3
Melting range ^0c	1,085 °C	1510°C	900 to 940 °C
Specific heat J/gm. K	0.385	0.502	0.380
Resistivity ohm.m	1.724×10^{-8}	15×10^{-8}	5.9×10^{-8}
Temperature coefficient ($1/^0C$)	4.29×10^{-3}	6.6×10^{-3}	1.5×10^{-3}

Table 5: Parametric values used for the experimentation

Resistance (ohms)	Duty Cycle (T)	Impulse Current (amps)	Bi -impulse Current (amps)	Sparking Time (secs)	Lift Time (secs)	Gap (v)
63	9	10	3	2	2	10

3. EXPERIMENTATION

The experiment is carried out on ElectronicaC-425 EDM setup. Brass, Copper and Mild steel are used as work material with copper electrode and spo oil as dielectric oil. The machining is conducted using different process parameters like peak current, pulse on time, pulse off time, gap, sensitivity, resistance, duty cycle, impulse current, bipulse current, spark time, lift time. The MRR is evaluated for each cutting condition by measuring the amount of material removed and the time taken for the material removal. Machining experiments for determining the metal removal rate is carried out by setting voltage in the range of 120-200v, the discharge current in the range of 6.0 to 18.0A, the pulse duration in the range of 30-90µs, and the gap between the electrode and work piece in the range of 1-20.

Figure 2: Electronica C-425 EDM MACHINE

Figure 3: Dielectric Fluid Tank

Figure 4: Machining of the metals

Metal removal rate is usually expressed as cubic millimeter per minute (mm^3/min),

$$MRR = \frac{\text{WEIGHT BEFORE MACHINING} - \text{WEIGHT AFTER MACHINING}}{\text{TIME TAKEN FOR MACHINING}} * 1000$$

Achieving an efficient MRR is not simply a matter of the right machine settings. It also involves direct energy dissipated in the EDM process. This energy can be dissipated in three ways, in the work piece, in the gap and in the electrode.

Figure 5: Copper metal after machining

Figure 6: Brass metal after machining

Figure 7: Mild Steel after machining

4. RESULTS

Table 6: Result analysis of the metals after the machining

CASE	Material	Weight of metal before machining (gms)	Weight of metal after machining (gms)	Time under machining (mins)	Material Removal Rate (MRR) (mm^3/min)	Depth of machining (mm)
I	Brass	277	276	20	50	0.17
	Copper	274	273.8	20	10	0.030
	Mild Steel	220	219	20	50	0.29
II	Brass	276	271	120	41.66	1.25
	Mild Steel	219	213	120	50	1

5. CONCLUSIONS

The work has been carried out to measure the metal removal rate by machining Mild steel, Brass, Copper with Electric Discharge Machining using a copper electrode. Based on the results presented herein, it can be concluded that the impulse current and the time affects the metal removal rate. Following are the observations that are analysed while performing the experiment.

- Material removal rate is determined with different depth of cuts for copper, brass and mild steel.
- It is observed that mild steel has the highest material removal rate and depth of cut followed by brass.
- Copper has the lowest material removal rate owing to poor electrical conductivity.
- The MRR is indirectly proportional to the time take for the machining process.
- Minimum electrode wear rate takes place at a current gap of 6A and gap 18
- The MRR for copper material using copper electrode is very less due to the straight polarity.

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