International Journal of Advancements in Mechanical and Aeronautical Engineering – IJAMAE
Volume 1 : Issue 3 [ISSN 2372 –4153]
Publication Date : 30 September, 2014

Parametric studies for MRR and TWR using die sinking EDM with electrode of Copper and Brass

[Praveen Kumar Singh 1, Anshika gupta 2, Lalta Prasad 3, Ashiwani kumar4.]

Abstract— **The electrical discharge machining (EDM) is one of the latest non-traditional machining processes, based on thermoelectric energy between the workpiece and an electrode. In this machining process, the material is removed electrothermally by a series of successive discrete discharges between two electrically conductive materials (electrode and workpiece). The performance of the machining process depends on the material, design and manufacturing method of the electrodes. Usually, the machine manufacturer uses the standard workpiece and electrode materials to establish the EDM parameter settings. The present study focused on the effect of Copper and Brass electrodes on material removal rate (MRR) and tool wear rate (TWR) for AISI D2 tool steel by using Die-Sinker EDM. The current was varied from 4 to 10 amp, the voltage and flushing pressure were constant, the MRR for copper electrode was in the range of 4.8139 -22.6580 mm^3/min whereas the range of MRR for brass electrode was 7.2213-9.8203 gm/min. The trend of TWR as shown in results increases with current for both the electrodes. The effect of voltage on MRR and TWR for both the electrodes was analyzed. The MRR for copper electrode was continuously decreasing with voltage whereas MRR for brass don't follow any specific trend. The TWR for both the electrodes decreases with voltage. It has been observed that copper electrode is the best for machining AISI D2 tool steel by using Die- Sinker EDM.**

Keywords— **AISI D2 material, Die -Sinker EDM, MRR, TWR.**

I. *Introduction*

Electric Discharge Machining (EDM) is a non-traditional machining process in the sense that they do not employ traditional tools for metal removal and instead directly by means of electric spark erosion. The problems of high complexity in shape, size and higher demand for as removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process. The Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts. It is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. So it is one of the most popular non-traditional machining processes being used today. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive areas. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive [1, 2].

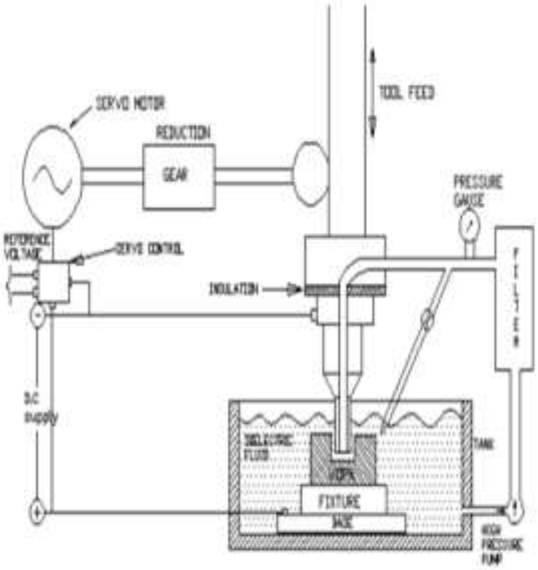
A. *Principal of EDM*

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Fig. 1.1 shows the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025 mm is maintained between the tool and work piece by a servo system shown in Fig 1.1. The tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/deionized water are very common type of liquid dielectric although gaseous dielectrics are also used in certain cases. The electric setup of the Electric discharge machining is shown in Fig. 1.1. The tool is made cathode and work piece is anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark. The positive ions and electrons are accelerated, producing a discharge channel that becomes conductive. It is just at this point when the spark jumps causing collisions between ions and electrons which create a channel of plasma. Such localized extreme rise in temperature leads to material removal. The material removal occurs due to instant vaporization of the material as well as due to melting. The molten metal is not removed completely but only partially [3, 4].

PRAVEEN KUMAR SINGH, ANSHIKA GUPTA (RESEARCH SCHOLOR)
GBPEC Ghurdauri, Uttarakhand
INDIA

LALTA PRASAD , ASHIWANI KUMAR (ASSISTANT PROF.)
GBPEC Ghurdauri, Uttarakhand
INDIA

Fig.1.1 Set up of Electric discharge machining [5].



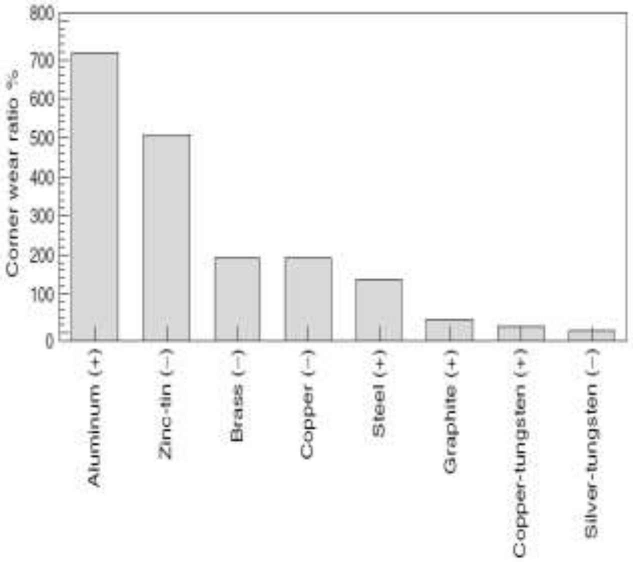
B. *Why COPPER electrode*

With development of the transistorized, pulse-type power supplies, electrolytic (or pure) Copper became the metallic electrode material of choice. This is because the combination of Copper and certain power supply settings enables low wear burning. The Copper is compatible with the polishing circuits of certain advanced power supplies. Due to its structural integrity, Copper can produce very fine surface finish. This same structural integrity also makes Copper electrodes highly resistant to Direct Current (DC) arcing in poor flushing situations. The Copper is frequently used to make female electrodes on a Wire EDM for subsequent use in reverse burning punches and cores in the Sinker EDM. The addition of 1-3% Tellurium to Copper improves its machinability to a level similar to Brass, eliminating the “gummy” properties normally exhibited by Copper when it is machined **[9]**.

C. *Why BRASS electrode*

Brass ensures stable sparking conditions and is normally used for specialized applications such as drilling of small holes where the high electrode wear is acceptable. In addition to the servo-controlled feed, the tool electrode may have an additional rotary or orbiting motion. Electrode rotation helps to solve the flushing difficulty encountered when machining small holes with EDM. The increase in cutting speed, the quality of the hole produced is superior to that obtained using a stationary electrode. Electrode orbiting produces cavities having the shape of the electrode. The size of the electrode and the radius of the orbit (2.54 mm maximum) determine the size of the cavities. Electrode orbiting improves flushing by creating a pumping effect of the dielectric liquid through the gap [7].

Fig. 2 comparative wear between many electrodes [7]



II. *Literature Review*

Cheke et al. [1] investigated that the wet and near-dry electrical discharge machining is used to achieve the high material removal rate (MRR) on oil hardened non shrinking steel. In near-dry EDM liquid and air mixture delivered through a tabular electrode instead of liquid dielectric used in Wet EDM. The L-9 orthogonal array was applied to investigate the effect of discharge current, pulse on time, gap voltage and pulse off time on material removal rate in wet and near-dry EDM. Pulse on time and discharge current are identified as a key factors for improving the MRR in wet and near-dry EDM. The comparative performance of wet and near-dry EDM has been made. During experiments it was found that the Wet EDM exhibits the advantage of good machining stability at high discharge energy which results in better MRR [1].

Simao et al. [5] investigated the surface modification by using EDM with powder metallurgy (PM) tool electrodes as well as powders suspended in the dielectric fluid. The experimental results were presented on the surface alloying of AISI H13 hot work tool steel during a die sink operation by applying partially sintered WC/Co electrodes operated in a hydrocarbon oil dielectric. The L8 fractional factorial Taguchi experiment was used to identify the effect of key operating factors on output measures. With respect to micro hardness, the percentage contribution ratios (PCR) for peak current, electrode polarity and pulse on time was very low [5].

Desilva and Fernando [8] carried out the work on comparative analysis of milling of copper and graphite electrodes for EDM and identifying machine capabilities. In this work a tool (cost calculator) is developed to be used on the shop floor for a plastic injection mould manufacturing company for the comparative analysis of Copper and Graphite electrode of EDM. They recommend that the use of the cost calculator reduce the cost and time for producing electrodes and provides the flexibility to change the values fed in the calculator may be customize for ready use by any other tool shop[8].

The performance of the manufacturing process depending on the Electrode material, Work piece material, and manufacturing method of the electrodes as reported by Nikhil et al. [9]. A suitable selection of electrode can reduce the cost of machining. Copper and graphite electrode are used for optimizing Performance parameters and reducing cost of manufacturing. finally it is found that a graphite electrode give better performance in certain characteristics but the cost become high for machining so keeping in mind cost and other some characteristics a graphite electrode is more suitable than Copper electrode in case of both (Material Removal Rate)MRR and (Tool Wear Rate)TWR [9].

III. Experimental Set-up

For this experiment the whole work can be down by Electric Discharge Machine, model ELECTRONICA C-3822 (die-sinking type) with servo-head (constant gap) and positive polarity for electrode was used to conduct the experiments. A constant voltage (40V), flushing pressure (20 kg/cm^2) and Ton, Toff setting was 30 and 9 respectively. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94°C) was used as dielectric fluid. Experiments were conducted with positive polarity of electrode. The pulsed discharge current was applied in various steps in positive mode.

In this experiment using AISI **D2 tool** steel material this D2 tool steel material is high Carbon, high Chromium tool steel alloyed with Molybdenum and Vanadium. The workpiece material composition is given in table below.

Table 2-composition of D2 material

Element	C	Mn	Si	Cr	Ni	Co	V	Fe
Composition Weight (%)	1.5	0.3	0.3	12	0.3	1.0	0.8	Remaining

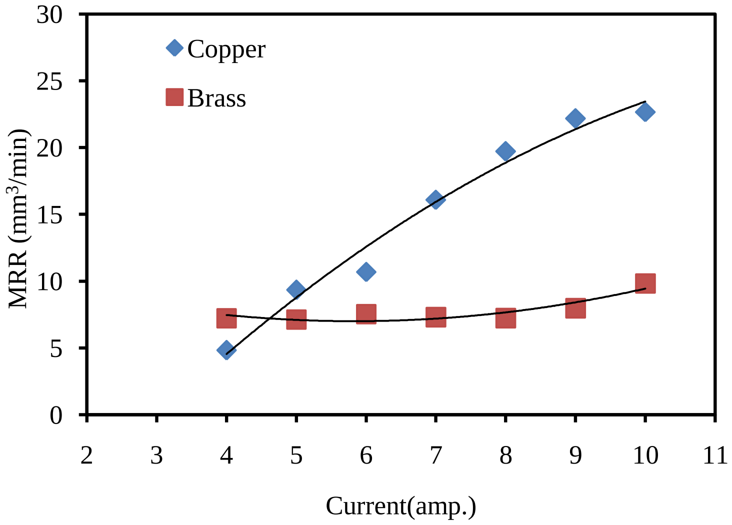
A. Calculation of MRR and TWR

$$MRR = \frac{W_{wb} - W_{wa}}{t \times \rho}$$

$$TWR = \frac{W_{tb} - W_{ta}}{t}$$

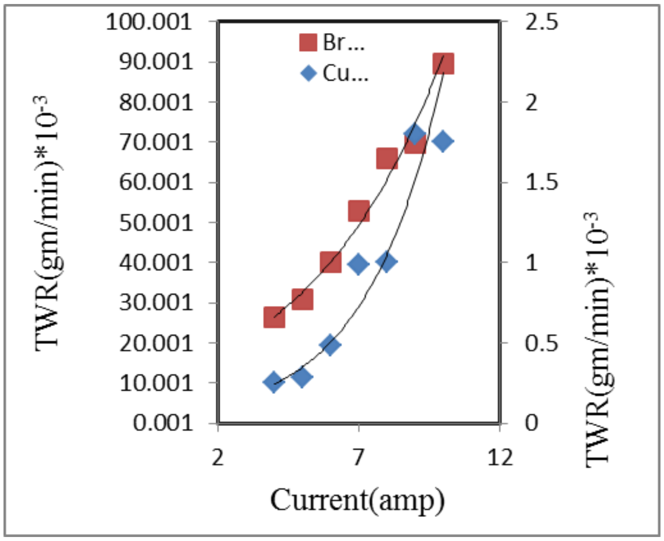
Where
Wwb = Weight of the workpiece before machining
Wwa = Weight of the workpiece after machining
Wtb = Weight of the tool before machining
Wta = Weight of the tool after machining
t = Machining time
ρ = Density of the work material (7.7 x 1000 kg/m3)

Graph 1. Comparison of MRR using electrode of Copper and Brass



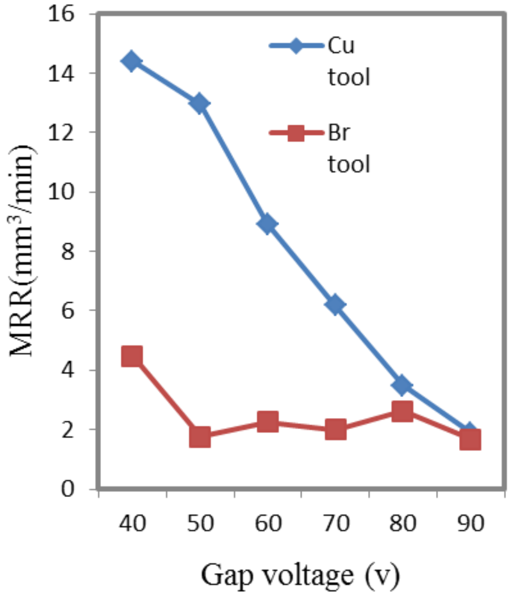
Graphical representation of variation in MRR of Copper and Brass electrode upon variation in applied current and significant increase in MRR of both Copper and Brass electrodes is observed. The graph depicts that MRR of Copper increases from 4.8139 to 22.6580, whereas MRR of Brass increases from 7.2213 to 9.8203.This shows colossal increase in MRR of Copper electrodes in comparison to Brass electrodes.

Graph 2. Comparison of TWR using electrode of Copper and Brass



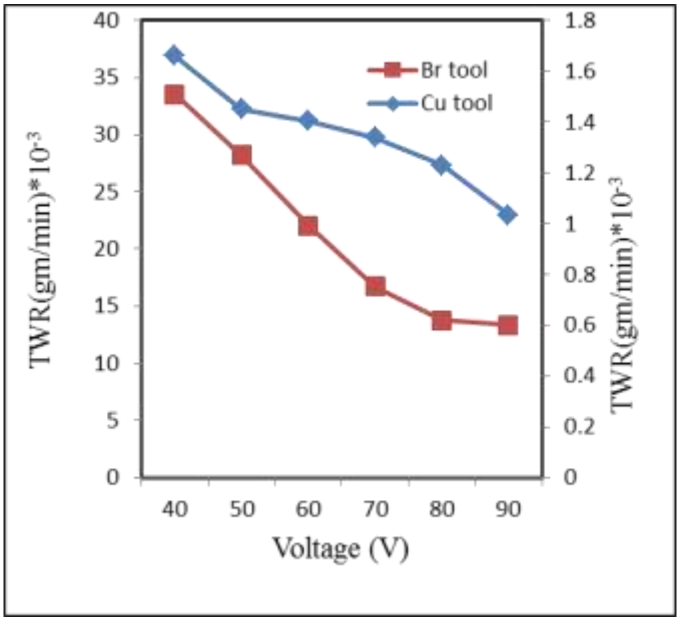
Graphical representation of TWR with respect to applied current depicts the high TWR of Brass in comparison to Copper. TWR of Brass is depicted on the left ordinate axis and TWR of Copper on the right ordinate axis. Copper possess TWR from 0.25 to 1.75 upon changes current from 4 amp to 10 amp. Whereas Brass possess TWR from 09.385 to 89.4 in the same range of current.

Graph 3. Comparison of MRR using electrode of Copper and Brass.



Graphical representation of variation in MRR of Copper and Brass electrode upon variation in applied gap voltage and significant decrease in MRR of both Copper and Brass electrodes is observed. The graph depicts that MRR of Copper decrease from 14.3939 to 1.6840, whereas MRR of Brass decrease from 4.4740 to 1.6840.This shows colossal decrease in MRR of Copper electrodes in comparison to Brass electrodes.

Graph 4. Comparison of TWR using electrode of Copper and Brass



Graphical representation of TWR with respect to gap voltage depicts the high TWR of Brass in comparison to Copper. TWR of Brass is depicted on the left ordinate axis and TWR of Copper on the right ordinate axis. Copper possess TWR from 1.66 to 1.0342, Whereas Brass possess TWR from 33.55 to 13.33 in the same range of voltage.

B. *Conclusion*

The tests were performed with Copper and brass by taking the entire parameter constant except of current and voltage in die sinking EDM. The individual effect of current and voltage is analyzed.

1-In case of current MRR by Copper is better than Brass. And TWR of Copper is less than Brass.

2- In case of voltage MRR by Copper is better than Brass. And TWR of Copper is less than Brass.

References

[1]. Cheke P. R, Khedekar D. S, Pawar R. S, M. S. Kadam "*comparative performance of wet and near-dry edm process for machining of oil hardened non sinking steel material*", International journal of mechanical engineering and technology2012,vol. 3(2),pp. 13-22.

[2]. Ho K.H., Newman S.T. "*State of the art electrical discharge machining (EDM)*", International Journal of Machine Tools & Manufacture2003,vol 43,pp. 1287–1300.

[3]. Kumar S, "*Status of recent developments and research issues of electrical discharge machining*", International Journal of Latest Trends in Engineering and Technology 2013, vol.2 (3), pp.242-248.

[4] H.C. Tsai, B.H. Yan, F.Y. Huang. "*EDM performance of Cr/ Cu based composite electrodes*", International Journal of Machine Tools & Manufacture2003, vol. 43 (3),pp. 245–252.

[5]. J. Simao , H.G. Lee, D.K. Aspinwall, R.C. Dewes, and E.M. Aspinwall. "*Workpiece surface modification using electrical discharge machining*",

International Journal of Advanced Technology & Engineering Research 2003,vol.43, pp.121–128.

[6]. Joshi A, kothiyal P. "*Investigating effect of process variable on MRR in EDM by using Taguchi parameter design approac*h", International Journal on Theoretical and Applied Research in Mechanical Engineering2012, vol. 1(2),pp. 54-59.

[7]. Information on http://www.azom.com sited at December.

[8]. Desilva K., Fernando M. "*comparative analysis of milling of copper and graphite electrodes for edm and identifying machine capabilities"* ,International journal of general engineering and technology 2012, vol. 1(2),pp.35-46.

[9]. Kumar N, Kumar L, Tewatia H, Yadav R. "*comparative study for MRR on die-sinking edam using electrode of copper & graphite*" , International Journal of Advanced Technology & Engineering Research 2012, vol. 2(2), pp.170-174.

About Author (s):

[Praveen kumar singh received the B.Tech. degree in Mechanical Engineering from College Of Engineering And Technology , Moradabad. pursuing M.Tech. degree in Production Engineering from GBPEC Pauri Uttarakhnd. His research areas include Advance Manufacturing Process.]