Analysis of Different Tool Material On MRR and Surface Roughness of Mild Steel In EDM

Mr. V.D.Patel*, Prof. C. P. Patel **, Mr. U.J. Patel***
*(M.tech (cad/cam) U.V.Patel collage of engginering ,Mehsana, Gujarat)
** (Department of Mechanical, ganpat University, Mehsana
***(M.E (cad/cam) L.D. Engineering collage of engineering, Ahemedabad,gujarat)

***Abstract*-- In this study, experiments were performed to determine parameters effecting surface roughness (SR) along with structural analysis of surfaces with respect to material removal parameters. Experimental work was conducted on Mildl steel with copper, brass and graphite as tool electrodes with kerosene oil as dielectric fluid. The data compiled during experimentation has been used to yield responses in respect of material removal rate (MRR) and SR. Detailed analysis of structural features of machined surface was done by using Scanning Electron Microscope (SEM) and optical microscope to understand the mode of heat affected zone (HAZ), which alternatively affects structure of machined workpiece and hence tool life. While investigating electric discharge machining (EDM) surface by micrographs, it was observed that molten mass has been removed from surface as ligaments and sheets. In some cases, it is removed as chunks, which being in molten state stuck to surface. All three specimens machined by different electrodes showed different pattern of HAZs.**

Keywords: Electric discharge machining (EDM), Metal removal rate (MRR), Surface roughness (SR)

I. INTRODUCTION

Electric discharge machining (EDM) has widespread applications for manufacturing dies and tools to produce plastics moldings, die casting, and sheet metal dies etc[1][2]. Implementation of EDM process will awaken manufacturing engineers, product designers, tool engineer and metallurgical engineers about unique capabilities and benefits of this process[3]. In US, 4-fold increase in number of EDM machines installed in industry was observed during 1970-80. EDM can be used for machining of high precision of all type of conductive material (metals, alloys, graphite, ceramics etc.) of any hardness. In EDM process[4-8], material removal from workpiece is done by means of a series of electrical discharges. This paper presents work on machining by EDM for Mild steel.

II. METHODOLOGY

Workpiece material was Mild steel, which has following chemical composition: c 0.095, si 0.251, mn 0.490, p 0.011, s 0.014, fe 98.977%. Copper electrode (cu 99.986 , p 0.011, fe 0.003%), brass electrode (sn 0.368, zn 39.124, pb 3.397, fe 0.447, ni 0.127, sb 0.122, cu 56.181%) and aluminium electrode (al 97.455, si 0.88, cu 0.384, mg 0.673, zn 0.07, fe 0.035, ti 0.019, mn 0.496%) were used under following experimental conditions: sparking voltage, 120 V max; discharge current, 10.93,17.18 & 24.48 A; on time, 10, 20, 50, 100 , 500 μs; servo system, automatic; and electrode polarity dielectric, kerosene. All electrodes (diam, 14mm) were machined in cylindrical shape on a lathe machine (make: HMT). Work materials were machined (20 mm X 20 mm X 10 mm) on shaper machine. Each piece was hardened and tempered to obtain hardness of 58 HRC

III. RESULTS

3.1Material Removal Rate in EDM

MRR increases with increase in discharge current for all three electrodes (Fig. 1,2,3). However, in case of brass and copper, it decreases after some limit, due to pulse energy increases as the current increases. MRR does not observe linearity with pulse energy, may be due to the possible losses of thermal energy by conduction to surrounding material and dielectric fluid. An increase in current beyond certain limit for a given electrode area and material has adverse effect on MRR(Fig. 1,2,3). Moreover, this can lead to arcing. In these experiments, maximum current limit was 24.48 A. Electrical conductivity and thermal conductivity of Mild steel material are found to decrease with dispersed loading. At a current of 10.93 A, material removal rates has been higher for aluminum. However, at higher levels of current, wear rate of aluminium increases and causes some machining problems, which further reduce MRR. Copper shows good response in metal removal rate toward high values of discharge current, due to increase in thermal conductivity and electrical conductivity of copper. Brass shows good response in surface finish with all values of current as compared to other electrodes. Workpiece particles, which are eroded from the surface to form craters, get accumulated at rims of respective craters. Higher amount of heat is generated at higher currents and long discharge durations, which increases craters size. An increase in gap voltage causes an increase in MRR for given parameters, because pulse energy increase with gap voltage. Maximum

MRR obtained for work material are as follows: copper, 1.45 gm [10 µs, 23.48 A]; brass, 0.7 gm [200 µs, 23.48 A]; and aluminium, 1.48 gm [20 µs, 23.48 A]. MRR increases (up to 20 µs) with increase in discharge duration, and beyond certain pulse on time (Fig. 1,2,3) it starts decreasing. For copper and aluminium, it increases slightly between 10 and 20 µs. Thereafter, it decreases up to 200 µs for brass and aluminum.

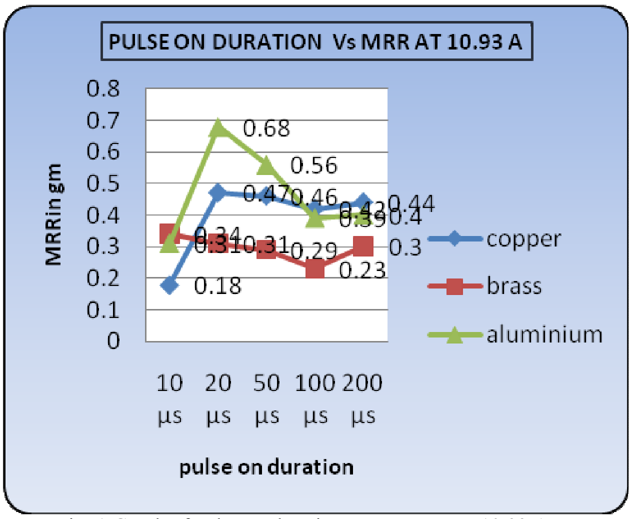


Fig: 1 Graph of pulse on duration verses MRR at 10.93 A

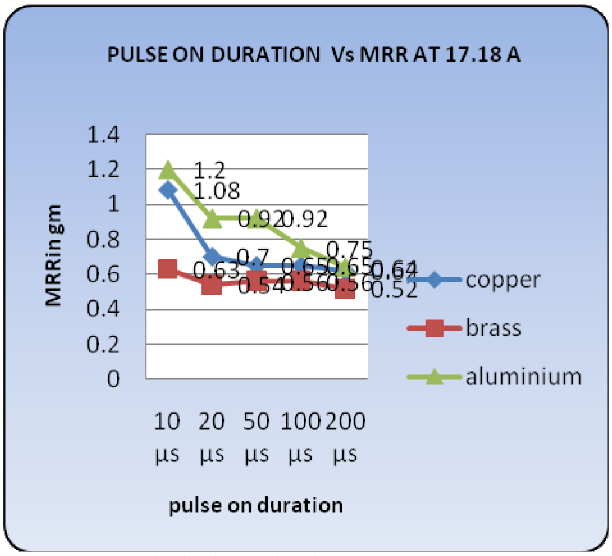


Fig: 2 Graph of pulse on duration verses MRR at 17.18 A

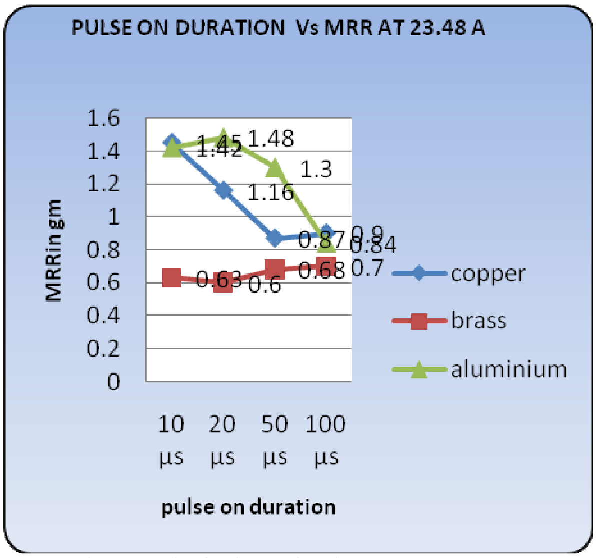
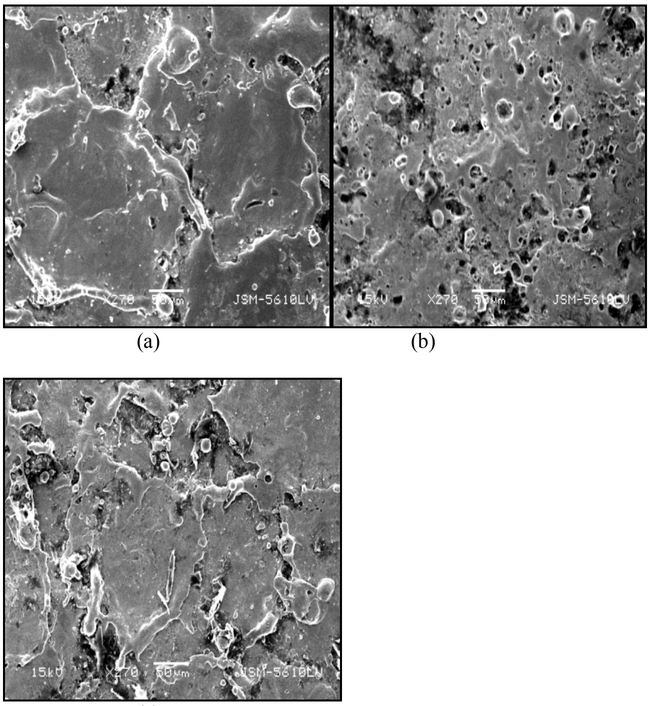


Fig: 3 Graph of pulse on duration verses MRR at 23.48 A

It is presumed that spark energy released into inter electrode gap acts as an instantaneous disc heat source at low discharge durations incident thermal energy does not penetrate deep into work material, which produces shallow craters, therefore, low MRR. Further, work particles, which came out during EDM process after erosion, did not get effective expulsion due to lack of turbulence. Therefore, these particles remained in crater and hindered pace of erosion. At high discharge duration, melted particles smeared over EDM surface and interfere with discharging process leading to reduction of MRR and deterioration of surface quality. Surface produced by EDM process at large currents is rough. SR increases with increase in discharge current.SR of aluminum is more than copper followed by brass.

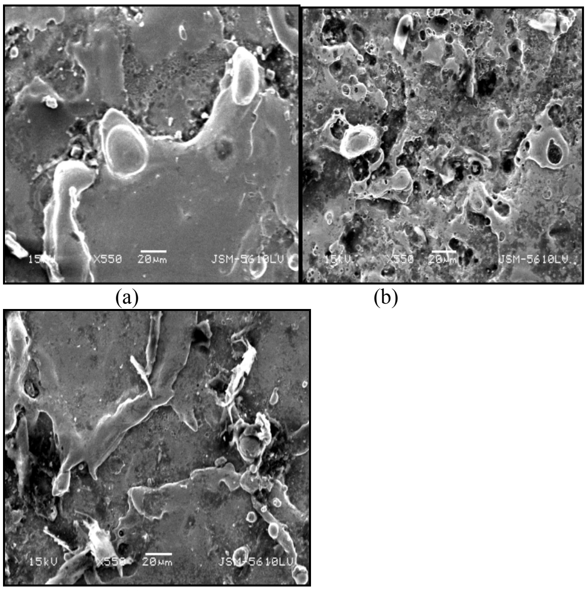
IV STRUCTURE ANALYSIS OF EDMED SURFACE

Analysis of EDMed surface of copper, brass, aluminum at 10.93 A, using scanning electron microscope (SEM), indicates that surface has undergone melting followed by washing out of molten substance (Fig. 4,5). However, because of non- uniform transfer of heat on workpiece, differential removal of molten metal can be seen (Fig. 4,5). Presence of ligaments and spherical features, which are in charged state in SEM micrograph, indicate that, during course of flushing, molten has come as ligament in the initial stage, and further gets broken into number of droplets. The droplets are being flushed away, thus exposing of fresh surface for removal of mass in the tool steel.



(a) (b) (c)

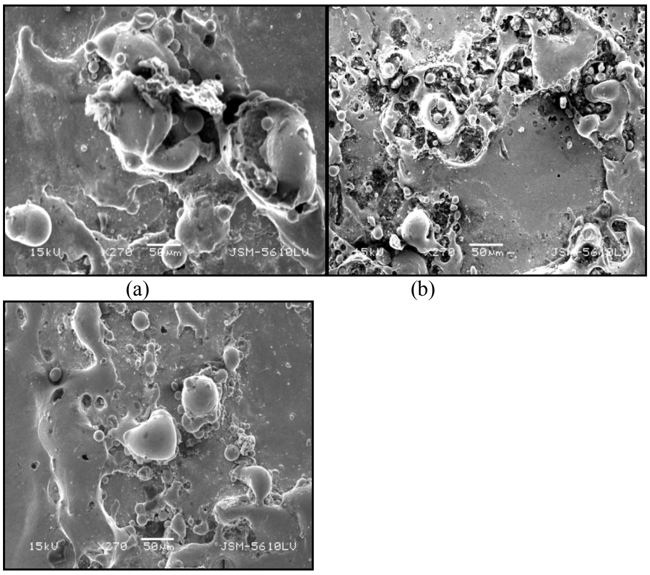
Fig:4 SEM of EDMed surface of 50 µm SEM Current 10.93 A and 10 µs (a) aluminium, (b) brass, (c) copper



(a) (b) (c)

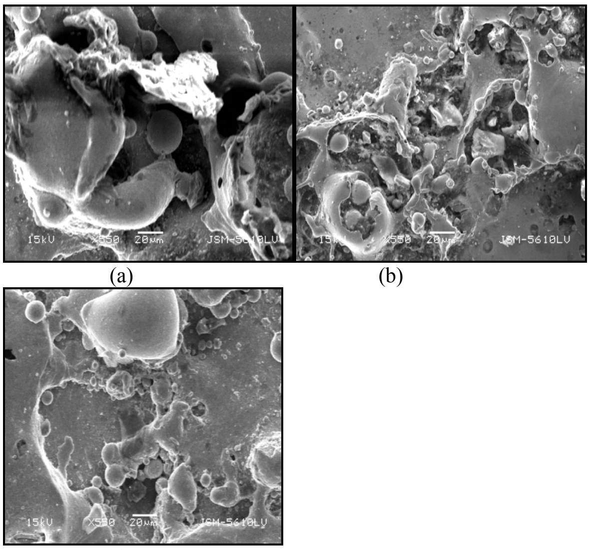
Fig:5 20 µm SEM Current 10.93 A and 10 µs (a) aluminium, (b) brass, (c) copper

However, all particles are not washed and they remain as sticking because particles partially are in molten state during course of flushing. Since phenomenon involves very high amount of heat transfer on the surface followed by rapid quenching during course of flushing, a proper balance between energy and its transfer is required. It may lead to formation of cracks (Fig. 4 a). Analysis of EDMed by copper electrode indicates that molten mass is being removed either by sheet formation or by ligament formation (Fig. 5 c). Molten mass has come out from surface as chunk, which gets stuck to surface because of its existence in partially liquid condition (Fig. 5 a & b). Contour in and around the surface indicates that a proper removal, which may lead to smooth surface, has not taken place. Bigger size of droplets sticking to the surface also indicates that proper and fast removal of molten metal from surface has not occurred (Fig. 5 b & c). SEM diagram of surface EDMed by aluminum electrode indicates that top surface remains hot while in solid state, while bottom portion is in liquid state. Existence of volcanic features indicates that liquid has come out from the bottom, as heat flows inside the substance. (Fig. 7 a & c) Eroded surface is full of debris of ligaments and spherical type. Ligaments in aluminium are bigger as compared to copper and brass. Non-uniform distribution of heat leads to volcanic eruption of surfaces where craters and cracks can also be seen at surface. The formation of cracks is due to thermal miss match(Fig. 7 c). Size of holes varies (1-15 µ). Chilling effect on top of surface is faster as compared to removal of molten metal9-12. Plasma, which is being set up by this electrode, melts to higher extent, thus providing a thicker molten mass, which could not get removed by flushing liquid. When heat from surrounding areas penetrates into molten thicker mass, it leads to volcanic eruption of the surface.



(a) (b) (c)

Fig:6 50 µm SEM Current 23.48 A and 200 µs (a) aluminium, (b) brass, (c) copper



(a) (b)

(c)

Fig:7 20 µm SEM Current 23.48 A and 200 µs (a) aluminium, (b) brass, (c) copper

V Conclusions and discussion

For high discharge current, aluminum and copper electrodes show highest MRR, whereas brass gives good surface finish and normal MRR. SEM of EDM surface indicates that molten mass has been removed from surface as ligaments and sheets, and also as chunks, which get stuck to surface due to molten state. Aluminum electrode machined specimen shows volcanic eruption and cracks, due to non-uniform distribution of heat on work surface. All specimens machined by different electrodes show different pattern of HAZs. In case of aluminium electrode, HAZ is deeper as compared to brass and copper.

VI REFERENCES

1. Pandey P C & Jilani S T, "Electrical machining characteristics of cemented carbides, *J Mater Process Technol*" **116** (1987) 77-88.

2. Payal H S & Sethi B L,"Non-conventional machining processes as viable alternatives for production with specific reference to electric discharge machining", *J Sci Ind Res*,**62**(2002) 678- 682.

3. Singh S, Maheshwari S & Pandey P C, "Some investigations into the electric discharge machining of hardened tool steel using different electrode materials", *J Mater Process Technol*, **149** (2004) 272 277.

4. Heuvelman C J, Horsten H J A & Veenstra P C, "An introductory investigation of the breakdownmechanism in electro-discharge machining", *Annals CIRP,* **20** (1971) 43-46.

5. Jain V K, Batra J L & Garg A K, "Computer aided process planning (CAPP) for electric discharge machining (EDM)", *J Mater Process Technol,* **48** (1995) 561-568.

6. Abdulkadir E & Ekmekci B, "Remarks on surface integrity of electric discharge machined surfaces"; A state of art review, in *Proc 11th Conf on Mach Design & Prod* Turkey.

7. Crookal J R & Khor B C, "Electro discharge machined surfaces, in *Proc 15th MTDR Conf*(Macmillan,) "331-338.

8. "Saito N, Mechanism of electric discharge machining, in *Japan Soc Proc Eng"*, **vol 1**

9. Pandey P C & Verma V K, "Machinability of cemented carbide when machined electrically", in *Proc 12th AIMTDR Conf* (IIT, Delhi) 21-26 December 1986.

10. Payal, H S, "*Experimental and analytical study of electrical discharge machining (EDM) process",* Ph D Thesis, Thaper Institute of Engineering and Technology, Patiala, India, 2006.

11. Luis C J, Puertas I & Villa G, "Material removal rate and electrode wear study on EDM of siliconcarbide" *J Mater Process Technol,* **164/165** (2005) 889-896.

12. Marafona J & Chousal J A G, "A finite element model of EDM based on joule effect", *Int JMachine Tool & Manuf*, **46** (2005)1-8.