Original Research Paper

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STUDY ON THE EFFECT OF BRASS AND COPPER ELECTRODES DURING ELECTRIC DISCHARGE MACHINING OF INCONEL 718 USING NANO PARTICLES MIXED DIELECTRIC FLUID.

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ABSTRACT Electrical Discharge Machine (EDM) parameters have a significant influence on machining characteristic like material removal rate (MMR) and tool wear rate (TWR). Inconel 718, which is widely used in the Medical, Marine, Architectural and food processing industries, is used as a work material. The tool electrode materials used are brass and copper. Experiments are conducted using face centered central composite design to determine the effects of process parameters like current rate, pulse on time, pulse off time and concentration of titanium carbide nano particle in dielectric fluid. Based upon the experimental outcomes, the effect of brass and copper electrodes during electric discharge machining of Inconel 718 using nano particles mixed dielectric fluid was investigated.

KEYWORDS : Electrical Discharge Machine (EDM), Brass and Copper Electrode, Titanium Carbide Nano Particle, Material Removal Rate (MRR), Tool Wear Rate (TWR).

INTRODUCTION

Electrical Discharge Machining (EDM) is an electro-thermal unconventional machining process, where electrical energy is used to produce the electrical spark and the material removal generally occurs due to the thermal energy of the spark. The newly developed concepts make use of non-conventional energy sources like noise, light, mechanical, chemical, electrical, electrons and ions. Harder and complex machining materials, finds broader application in aerospace, nuclear engineering and other industries due to their high strength to weight ratio, hardness and heat resistance performance. Large advances have been made in the past little years to increase the material removal rates and at present, non-traditional machining processes have achieved nearly unlimited capabilities except for volumetric material removal rates. As the metal removal rate increases, the cost efficiency of operations also increase, which lead to usage of nontraditional machining process.

The electrical discharge machining process is employed widely for making tools, dies, precision parts, aerospace, aeronautics etc. Thus, the EDM process became automatic and unattended machining method. The process uses thermal energy to generate heat which melts and vaporizes the work piece by ionization inside the dielectric medium. The electrical discharge creates impulsive pressure by dielectric explosion to take away the melted material. The total removed material can be successfully controlled in order to produce complex and precise machine components. Though, the melted material is not flushed away completely, the remaining material gets re solidified to form a discharge crater. Due to this, the machined surface has micro cracks and pores caused by rise in high temperature which also reduces the surface finish. Many published studies considered the surface finish of machined materials by EDM as in Harpreet Singh et al., 2012.

The important parameters of the EDM process like material removal rate (MMR), tool wear and tool wear ratio are widely used for machining high strength steel, tungsten carbide and hardened steel as discussed by Prabhu et al. in 2010. When the two parts are brought together within a minimum gap, the electrical strain is discharged and a spark jumps across the gap. Anywhere it strikes, the metal gets heated up to a larger amount that it melts. As discussed by Nikhil Kumar et al., 2012, at higher level of current, wear rate of aluminum increases and causes some machining problems, and further reduces the MRR. Copper shows good response in metal removal rate towards high values of discharge current, due to increase in thermal conductivity and electrical conductivity. Brass also shows good response in surface finish with all values of current as compared with other electrodes.

Particles of the workpiece, which gets eroded from the surface to form craters, get accumulated at the rims of respective craters as discussed by Patel et al., 2011. In a new hybrid material removal process named powder mixed EDM (PMEDM), a suitable metal powders such as Aluminium, Copper, Silicon etc. are mixed into the dielectric fluid. The added powder particles fill up the spark gap and increases the spark gap. These high electric field energies the powder particles. These conductive particles at different places under sparking area bridges the gap between tool electrode and work piece material as discussed by Mohammad Yeakub Ali, et al., in 2012. The mechanism of PMEDM is fairly special from conventional EDM in the sense that a fine powder of some suitable material is mixed with the dielectric fluid. The powder particles lead to a series of discharges in the gap. The electrically conductive powders widen the discharge gap by reducing the insulating strength of dielectric as discussed by Atpal Singh, et al., in 2012. The objective of present research work is to study the effect of brass and copper electrodes during electric discharge machining of Inconel 718 when using nano particles mixed dielectric fluid with material removal rate, tool wear rate as the output responses.

EXPERIMENTAL METHOD

The EDM set-up used in this experimental study is M100 model die sinking EDM machine manufactured by Electronica Machine Tools. It uses Kerosene as the dielectric fluid. The primary benefit of using kerosene is that it has very low viscosity and gets flushed away easily. The selected work piece material is Inconel 718. Each experiment was performed for fix time period using two different types of electrodes brass and copper. A separate dielectric chamber was developed and a pump combined with a pressure-regulating valve is used to circulate titanium carbide nano particles in kerosene. Input process parameters are current, pulse on time and pulse off time. The material removal rate and tool wear rate are evaluated by using an electronic balance machine.

RESULT AND DISCUSSION

Analysis of Material Removal Rate:

Figure 1 shows the relation between current and the MRR of work piece. It is found that the increasing current leads to increase in MRR. When using copper electrode, the MRR gets increased at 5A, thereafter decreases at 10A, and again increases faster at 15A current. With increase in powder concentration, it increase the discharge energy and each individual spark removes metal from the work piece and thereby MRR gets increased. The value of MRR increases with increase in peak current as discussed by Narender Singh, et al., in 2012.

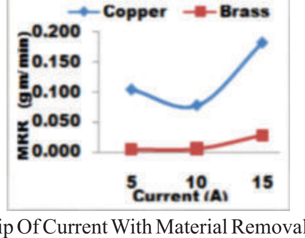

Fig. 1 Relationship Of Current With Material Removal Rate

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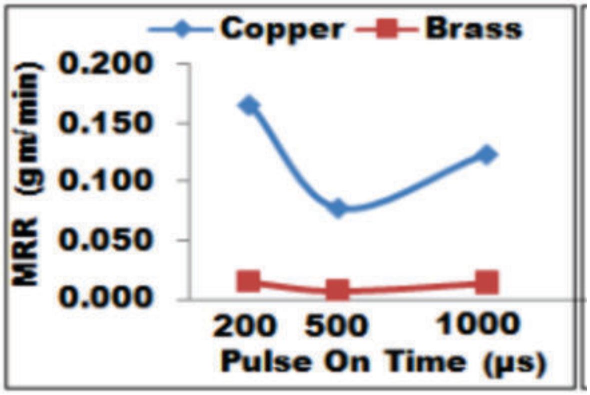

Fig. 2 Relationship Of Pulse On Time With Material Removal Rate

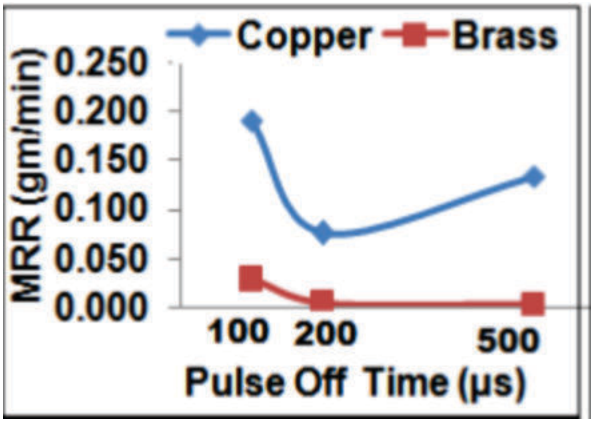

Fig. 3 Relationship Of Pulse Off Time With Material Removal Rate

When using brass electrode, MRR gets improved at 15A. Copper electrode gives a better MRR when compared with the brass electrode. Influence of pulse on time in MRR is shown in figure 2. When using the copper electrode at a pulse on time of 200 µs, MMR gets increased and then slightly decreases with the increasing pulse on time. Figure 3 shows that the increase in pulse off time from 100µs to 500µs, the MRR gets decreased for both copper and brass electrodes. The pulse off time is the time needed for the return of insulation in the working gap of dielectric at the end of every discharge period as discussed by Kumar, et al., in 2007. At short pulse off time, MRR is a smaller amount. This is due to the fact that during tiny pulse off time, the possibility of arcing is very high, since the dielectric gap between the work piece and electrode cannot be flushed away correctly. The debris particles at rest gets waited in discharge gap and results in arcing. Due to this, MRR decreases as discussed by Saha, et al., in 2009.

Analysis of Tool Wear Rate

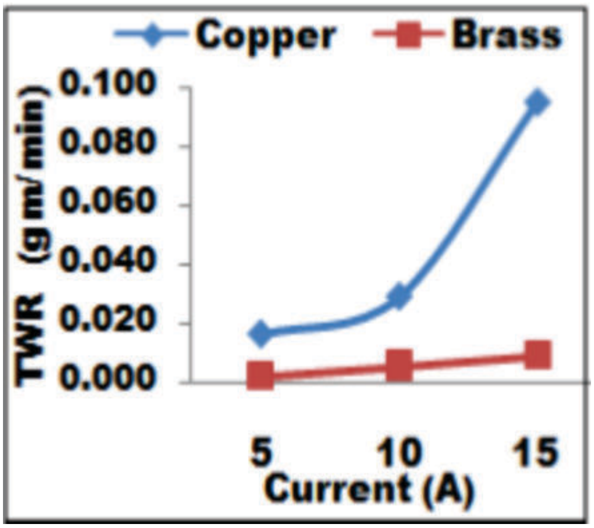

Fig. 4 Relationship Of Current With Tool Wear Rate

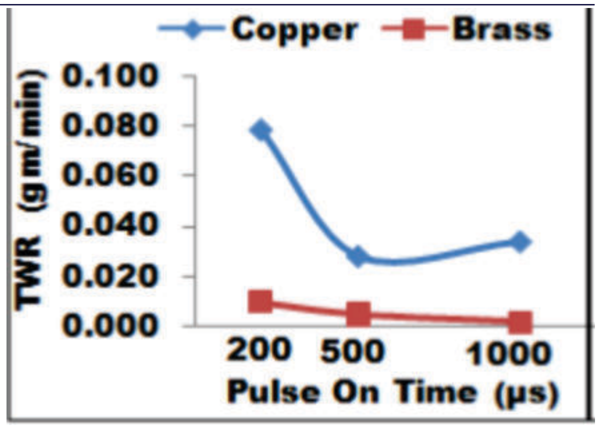

Fig. 5 Relationship Of Pulse On Time With Tool Wear Rate

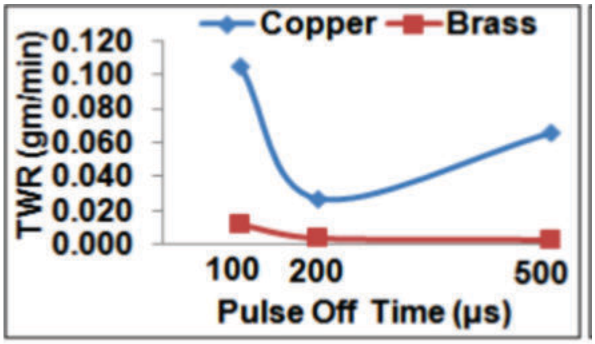

Fig. 6 Relationship Of Pulse Off Time With Tool Wear Rate

Figure 4, describes the relation between the current density and the tool wear rate. As shown in figure, higher current produces stronger spark with more thermal energy and results in more electrode wear. Thermal conductivity of copper is about 3 times higher than that of brass. Heat is more dissipated into the electrode causing less electrode wear when compared with the copper electrodes. It can be concluded that thermal conductivity is an important factor that reduces the electrode wear. It is shown in figure 5, that increase in pulse on time from 500 µs to 1000 µs, the tool wear rate decreases for both copper and brass electrodes. It can be observed in figure 6 that, electrode wear is less than increasing pulse off time. The outcomes of experiments shows that the brass electrode undergo less wear compared with the copper electrodes.

CONCLUSION

In this paper, Analysis of machinability studies of Inconel 718 in PMEDM process has been carried out. Titanium carbide nano particle are mixed in EDM dielectric fluid. The results of the investigation are as follows.

1. Material removal rate gets increased with the increasing current.
2. Tool wear rate slightly gets increased by the increasing current.
3. With increase in pulse on time, material removal rate gets slightly decreased.
4. Metal removal rate is better when using copper electrode at all the values of current, pulse on
   time and pulse off time when compared with the brass electrode.
5. Tool wear rate of brass electrode is lesser than the copper electrode.
6. Maximum material removal rate was obtained for both electrodes at a current density of 15A.
7. The material removal rate gets increased when mixing nano powders in the dielectric fluid
   when compared with the conventional EDM process.
8. This is due to the higher thermal conductivity and melting point of copper compared with the
   brass.

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