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Investigating the Effect of Brass Electrode on Inconel 718 on Electrical Discharge Machine

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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. Experiments are conducted using face centered central composite design.

***Keywords:* -** MMR, TWR, EDM and Inconel-718.

1. Introduction

EDM as a process was introduced over since fifty years; it is a developing technology has led to increases in both cutting speeds and component accuracy. Developing in the beginning tool making industry sector of mould tools and push tool. Electrical Discharge machining method is now mainly found within fabrication developed, automobile companies and aerospace company, technical and therapeutic industries. In large number of industrial applications of EDM already existing market and they are simply waiting to be discovered and implemented.

It will enlarged in use of EDM in manufacturing will continue to grow and diversify though both a combination of awareness and process knowledge. In production there will always be a need to find a better way to make incredible, Electrical Discharge machining will support the drive to quality cost and delivery. Awareness of Electrical Discharge machining will provide the ability to design parts that are not possible or cost effective to produce by any other method. The viewpoint of machining complex shapes in hardened or exotic materials will continue to attract engineers and designers to produce more challenging parts and profiles.

2. Literature Review

Analyses and finalized that Die- Sinker EDM using copper and graphite electrode can be used for optimizing Performance parameters and reducing cost of manufacturing and also found that a silver 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 MRR and TWR [1]. Characteristics such as material removal rate (MRR), tool ear rate (TWR), overcut (OC), taper ness and machining time (MT) during micro-machining of through holes on Ti-6Al-4V super alloy employing de-ionized water based dielectric other than conventional hydro-carbon oil i.e. kerosene and also the result shows that MRR and taperness of micro-hole is improved and TWR is reduced employing B4C powder than pure dielectric[]. Surface topography and recast layer formed during micro-hole machining by micro-EDM has also been investigated based on optical and SEM micrographs[2].

Machining the En-19 tool steel by using U-shaped copper electrode perform on electrical discharge machine. Where Diameter of U-shaped electrode, Current and Pulse on time are taken as process input parameters and material removal rate, tool wear rate, Overcut on surface of work piece are taken as output parameters. A set of eighteen experiments (Taguchi design) were performed on electronica make smart ZNC electric discharge machine and relationships were developed between input and output parameters.The study indicates that, MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically. In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool. In the case of over cut the most important factor of discharge current then diameter of the tool and no effect on pulse on time[3].

Tungsten Carbide ceramic using electro-discharge machining (EDM) with a graphite electrode by using Taguchi methodology. The Taguchi method is used to formulate the experimental layout, to analyses the effect of each parameter on the machining characteristics, and to predict the optimal choice for each EDM parameter such as peak current, voltage and pulse duration and interval time [4]. It is found that these parameters have a significant influence on machining characteristic such as metal removal rate (MRR), electrode wear rate (EWR) and surface roughness (SR). The analysis of the Taguchi method reveals that, in general the peak current significantly affects the EWR and SR, while, the pulse duration mainly affects the MRR. Experimental results are provided to verify this approach [5].

The effect of different materials on surface roughness produced and also helped for choosing right type of electrode material for specific purpose has investigated to reveal the effects of various process parameters of WEDM like pulse on time (TON), pulse off time (TOFF), gap voltage (SV), peak current (IP), wire feed (WF) and wire tension (WT) on material removal rate of hot die steel (H-11) using one variable at a time approach and also the optimal set of process parameters has also been predicted to maximize the material removal rate [6].

Experiment and found that the electrode negative polarity performs very well EDM-3 gives higher Material Removal Rate (MRR). Both powder electrode (EDM-3 and EDM-C3) give the better MRR and EWR more than solid electrode. And concluded that the suitable duty factor is 11%. The Surface Roughness (SR) of copper-tungsten gives the best when current peak intensity not over 20 amperes [7].

The process performance of electrical discharge machining with powder metallurgy tool electrode during the machining of hastelloy using positive polarity. Where current and voltage are taken as process input parameters and material removal rate, tool wear rate, percentage wear rate, surface roughness are taken as output parameters. A set of ten experiments were performed on electronica make smart ZNC electric discharge machine and relationships were developed between input and output parameters. Presented a hybrid optimization approach for the determination of the optimal process parameters which maximize the material removal rate and minimize surface roughness & the tool wear rate. The input parameters of electrical discharge machining considered for this analysis are pulse current (Ip), pulse duration (Ton) & pulse off time (Toff). The influences of these parameters have been optimized by multi response analysis. The designed experimental results are used in the gray relational analysis & the weight of the quality characteristics are determined by the entropy measurement method. The effects of the parameters on the responses were evaluated by response surface methodology, which is based on optimization result comparative analysis of the performance of copper and aluminum electrodes for machining stainless steel and carbide. It was found that MRR (material removal rate) increases with increase in current and voltage, but MRR is higher during machining of stainless steel than that of carbide. During machining carbide, electrode wear and corner wear were higher than those during machining stainless steel. Wear of copper electrodes was less than that of aluminum electrodes. Volumetric wear ratio i.e., the ratio of the material removed from the work to the same removed from the electrode decreases with increase of current or voltage. That means, comparatively more material is removed from the electrode than that removed from the work. Investigations on work surface finish show that aluminum electrodes produce smoother surface than copper electrodes during machining of both stainless steel and carbide. The surface was found to be smoother on carbide than on stainless steel [8].

Comparative analysis of the performance of copper and aluminum electrodes for machining stainless steel and carbide. It was found that MRR (material removal rate) increases with increase in current and voltage, but MRR is higher during machining of stainless steel than that of carbide. During machining carbide, electrode wear and corner wear were higher than those during machining stainless steel. Wear of copper electrodes was less than that of aluminum electrodes. Volumetric wear ratio i.e., the ratio of the material removed from the work to the same removed from the electrode decreases with increase of current or voltage. That means, comparatively more material is removed from the electrode than that removed from the work. Investigations on work surface finish show that aluminum electrodes produce smoother surface than copper electrodes during machining of both stainless steel and carbide. The surface was found to be smoother on carbide than on stainless steel [9].

3. Selection of Tool Material

The choice of the electrode depends upon the performance criteria require to increase (MRR, surface roughness machining immovability) and also depends upon high hardness, harden rate of high work, presence of abrasive carbide particle, hardness and strong tendency to weld the tool to form build up edge in the required model. Because of wide area applications in various fields, it is better to know the properties of Inconel-718 with EDM.

4. Selection of Work Material

Inconel 718 is a High Strength, Temperature Resistant (HSTR) Nickel based super alloy and it elevated toughness. It is expansively used in aerospace applications such as gas turbines, flight motors, spacecraft's equipment, pumps and tooling. Inconel-718 is difficult to machining the material for their pitiable thermal properties, high robustness and hardness, present period it has highly abrasive carbide particles and strong tendency to weld to the tool to form build up boundary. In this bond wide area of applications in various fields and better to know the behavioral properties of Inconel-718 with EDM.

4.1 Inconel 718 Nickel Chromium Alloy

Inconel 718 is a Nickel-Chromium alloy creature precipitation hard enable and having high creep- rupture strength at high temperatures to about 700°C (1290°F). It has higher strength than Inconel X750 are better mechanical properties at lower temperature than Nimonic 90 and Inconel X-750.

5. Experimental Details

In the Experiment work, since three factors, each with three levels were selected as controllable variables, a three factor three level central composite rotatable design was selected for conducting the experiments. The actual and coded parametric values for each parameter are listed in Table. Therefore, the experimental design consists of 20 (8+6+6=20) experimental runs.
The equipment used to perform the experiments is a die sinking EDM (Electronica-M100 MODEL) machine. The selected work piece material for the research work is Inconel 718. The tool electrode material used is brass. The brass electrode was the negative polarity and the specimen was the positive polarity. The dielectric fluid was of titanium carbide nano particle suspended in kerosene. During EDM, the primary parameters are current, pulse-on time, and pulse-off time. The work pieces were weighed before and after each experiment using an electric balance with a resolution of 0.001mg to determine the value of metal removal rate was measured from the weight loss.

6. Results and Discussion

6.1 Analysis of Current Vs MRR and TWR

Fig. 1 Relationship of current with MRR and TWR

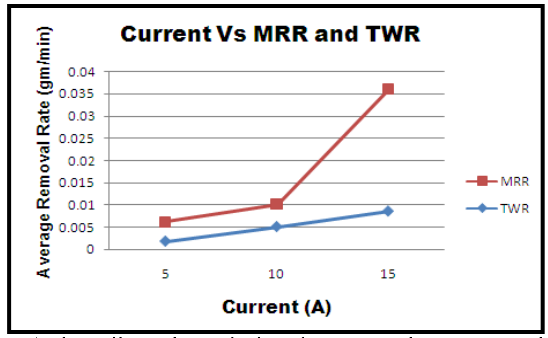

Fig. 1 describes the relation between the current density and the tool wear rate. As shown in diagram the elevated current produce stronger spark with more thermal energy and results in more electrode wear Thermal conductivity of copper is about 3 times higher than that of brass. Heat is more dissipated into the electrode causing less electrode wear when compared with the copper electrodes. It can be completed that thermal conductivity is an important factor that reduces the electrode wear. The influence of the input process parameters like current, pulse on time and pulse off time on the process responses, such as MRR and TWR were analyzed. When using brass electrode, MRR gets improved at 15A. Copper electrode gives a better MRR when compared with the brass electrode

6.2 Analysis of Pulse on time Vs MRR and TWR

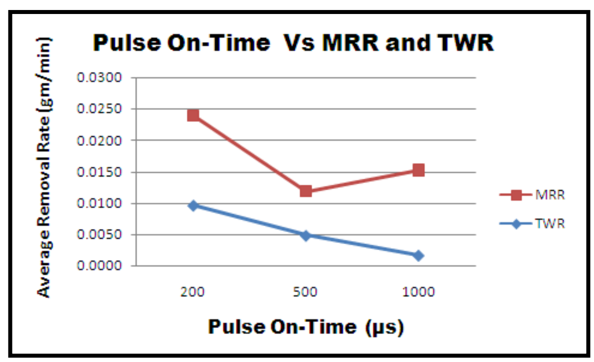

Fig. 2 Relationship of pulse on time with MRR and TWR

Influence of pulse on time in MRR and TWR is shown in fig. 2 describe 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. When using the copper electrode at a pulse on time of 200μs, MMR gets increased and then slightly decreases with the increasing pulse on time.

Figure 2 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. 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 particle at rest gets waited in discharge gap and results in arcing. Due to this, MRR decreases as discussed.

7. Conclusion

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

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