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EFFECT OF THE COPPER ELECTRODE ON SURFACE ROUGHNESS DURING EDM: A REVIEW

Engineering

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ABSTRACT

Electrical Discharge Machining is a non-traditional machining process, used to machine material that is difficult to cut with conventional processes. The major problem during machining with EDM is quality of surface. The Surface Roughness is affected by varying the value of different parameters such as pulse on and off time, discharge current, duty cycle and polarity of electrode. The paper presents the effect of copper electrode on SR of different workpiece materials. Current and pulse on time is the responsible parameters for SR value. Cylindrical copper electrode gives better surface finish with positive polarity at low peak current value. The SR is not only affected by pulse off time, but other parameters also effect the SR..

INTRODUCTION

Electrical discharge machining (EDM) is one of the earliest non-conventional machining processes in which metal is removed by electric spark erosion process. It consumes the thermal energy to generate heat for vaporization and melting of metal. Generally in EDM tool is made cathode and work piece as anode. EDMing is done without any physical contact of workpiece and electrode. When the voltage across the gap becomes high it discharges through the gap in the form of the spark. Due to heat the positive ions and electrons are producing a conductive discharge channel. Plasma channel is created at this point when spark causing collisions between ions and electrons. Material removal occurs due to instant melting of the material as well as due to vaporization. The linear movement of electrode maintains the desirable gap with NC controlled mechanism to provide repeated sparks. Sometimes, the surface finish is decreased by temperature rise due to incomplete flushing of the debris material that generate crater on the surface [1-4]. The EDM process is same as conventional process except then a suitable electrode shape, size, material and NC precision controlled mechanism to feed the electrode towards workpiece. The EDM process is employed for making dies, tools, precision parts, intricate shapes, aerospace, aeronautics and the tough material that are not easily machined with conventional process like turning, drilling, hobbing etc. EDM performance is mainly dependent on different factors like as polarity, voltage, pulse duration electrode material, discharge current and flushing pressure of the dielectric medium. Choice of copper electrode is because it has low coefficient of thermal expansion, high electrical conductivity and high melting and vaporization temperature [5-6]. In poor flushing situations copper is highly resistant to DC arcing [7]. Addition of the powder in dielectric provide mirror like surface finish [8]. It is observed from the research work the copper electrode improves the surface finish at low peak current valu**e.**

COMPONENTS OF EDM

EDM is the process in which cutting of hard metals and alloys are possible without any physical contact between tool and workpiece. Selection of EDM tool is depends upon the tool shape, size and material of electrode and possibility of electrode rotation. Only conductive material of workpiece can be machined by EDM. The EDM setup consists of tank in which the dielectric fluid is filled. It removes the debris from machined surface. Electrode & workpiece submersed into the dielectric fluid. To control the movement of electrode and maintain the desirable gap the servo controlled mechanism necessary. It senses the electrode gap and commanded by servo system to obtain maximum material removal. The power supply is an important part of any EDM system. It transform the alternating current from the main utility supply into the pulse direct current (DC) required to produce the spark discharge at the machining gap. The DC pulse generator is responsible for supplying pulses at a certain voltage and current for specific amount of time**.**

EDM PARAMETERS

In EDM mainly two types of parameters are followed

1. Process Parameters 2. Performance Parameters

1. Process Parameters:-

The process parameters in EDM are used to control the performance measures of the machining process. Process parameters are generally controllable machining input factors that determines the conditions in which machining is carried out. These machining conditions will affect the process performance result, which are gauged using various performance measures.

A. Electrical Parameters

(i) Polarity (ii) Discharge voltage (iii) Gap Voltage (iv) Peak Current (v) Average Current (vi) Pulse on Time (vii) Pulse off time (viii) Pulse Frequency (ix) Pulse waveform (x) Electrode Gap (xi) Duty Factor

B. Non-Electrical Parameters

(i) Electrode lifts time (ii) Working Time (iii) Types of flushing (iv) Type of Dielectric

C. Electrode Based Parameters

(i) Electrode material (ii) Electrode size (iii) Electrode shape

2. Performance Parameters:-

These parameters measure the various outputs of the EDM machined workpiece.

(i) Material removal rate (MRR) (ii) Tool wear rate (TWR) (iii) Wear ratio (WR) (iv) Surface quality (SQ) (v) Surface roughness (SR)

SURFACE ROUGHNESS

Surface roughness is greatly affected by the friction, wear and tear of parts, heat transmission ability, light reflection, lubrication and coating etc. The appropriate process is required to maintain the high quality of surface finish. Researchers have carried the research work on SR by using different machining process. The SR mainly affected by electrode material, peak current and pulse on time [9].

The process parameters like as current, pulse on time and pulse duration was selected to investigate the SR. Different materials for workpiece selected were stainless steel 304 grade, mild steel and silver steel with copper electrode. The polarity of the tool was selected negative and positive with cylindrical cross section. It was conclude that machining of stainless steel 304 with cylindrical copper electrode using positive polarity gives better surface finish at low peak current and long pulse on time. Whereas, SR increases with increase in pulse duration and current during silver steel machining with centre flushing. At higher discharge current brass gives better surface finish as compared to copper and aluminium [10-12].

Copper electrode was used to carry out the SR, considering process parameters such as pulse on and off time, peak current and duty factor. The materials selected for workpiece were EN 8 alloy steel, AISI 4340 and AISI 420 steel. It was brought out that; copper electrode was the superior in surface finish as compared to aluminum during machining of EN 8 alloy steel. Whenever, in AISI 4340 steel case SR increase with current value and vice-versa. SR does not affected by pulse off time. Machining of AISI 420 was done with square section 10x10 mm copper electrode and concluded that current is the most significant factor for SR value. SR was increased with pulse on time at all value of current [13-15].

Optimization of process parameters pulse on and off time, peak current and duty factor was done to investigate the SR. Steel 2714 maraging steel and AISI H13 tool steel were used for machining with copper and graphite. Pulse on time mostly affects the SR for both electrode materials. When applying smaller pulse on time with positive polarity the size of the particle and crater formed was small that leads to better surface finish. The SR also increases with pulse on time, duty factor and current [16-18].

The effect of different electrode material like copper, graphite, copper infiltrated graphite and copper tungsten were noticed during machining. The process parameters current and polarity was selected for machining of 316L, 17-4 PH steel and Ti6Al4V titanium alloy. It was examined that copper tungsten provides good surface finish at higher value of current for 316L and 17-4 PH steel. Whereas, at high current value copper and graphite gives greater SR. During titanium alloy machining better SR obtained with copper infiltrated electrode [19-20].
The current, pulses on time and duty factor were the parameter to obtain the SR. Machining was done with copper and copper infiltrated graphite electrode on INCONEL-718 using EDM. It was concluded that due to increase in current and duty factor the spark intensity increases that reduced the surface finish with copper electrode. Surface roughness was decreased by increasing pulse on time that directly reduced the spark intensity. It was seen that pulse on time and current inversely affects the surface smoothness i.e. when current and pulse on time was highest, the surface roughness found to be maximum [21-22].

Shyam Lal et al. [23] investigated the effect of wire EDM using Taguchi method. The peak current, pulse on and off time was selected for machining of metal matrix Al-7075 alloy. It was seen that SR increases with increase in current and pulse on time but decreased with increasing the pulse off time. Omer Eyercioglu et al. [24] investigated the machining characteristics DIN I. 2080 cold working tool steel during small hole EDMing with Φ2 mm single hole brass electrode. Discharge current, pulse on and off time were chosen the parameters. The flushing pressure, rotation of electrode and polarity were taken as constant. Better surface finish could be obtained with stability of machining that increase the dimensional accuracy. Rough surface was obtained with higher discharge current because due to formation of bigger molten metal crater on the workpiece. Hesam Shahali et al. [25] planned the experiments as per Taguchi L 18 regression analysis and carried out the wire EDM machining with brass. The effect of process parameters discharge power, time off and voltage on surface integrity while machining DIN 1.4542 alloy (16.5% Cr and 4.5% Ni). It was noticed that with reduction of discharge power minimizes the SR.

V Vikram Reddy et al. [26] investigated the SR of PH 17-4 stainless steel. Taguchi method was used for conducting experiments with L9 orthogonal array by choosing EDM process parameters, namely, peak current, surfactant concentration and graphite powder concentration. It was concluded that peak current has most significant effect on EDM process performance. C Cogun et al. [27] conducted an experimental investigation to determine the effect of powder mixed dielectric on SR during EDM process. The machining tests were conducted by using a copper electrode with graphite boric acid powder (H3BO3) mixed kerosene dielectric and prismatic steel. It was found that increasing pulse time increases surface roughness for both graphite and H3BO3 powder mixed. Mixing of graphite powder into the kerosene dielectric significantly improved surface quality. Y-F Chen et al. [28] optimized the EDM parameters using Taguchi method. The process parameters was selected peak current and pulse duration. The effects on the machining characteristics of EDM parameters for processing ZrO2 ceramic with copper and aluminium were explored extensively in this work. It was brought out that peak current and pulse duration significantly affected SR.

CONCLUSION

The paper presents the effect of the copper electrode material on the surface roughness using EDM process. The parameters studied are pulse on time, pulse off time, current, duty factor and polarity to optimize the parameters to achieve better surface finish. The following conclusions are drawn:

- Cylindrical copper electrode with positive polarity gives better surface finish at low peak current and long pulse on time.
- Better SR is achieved at low current and low pulse duration with negative polarity of tool.
- Cooper electrode provides better SR then aluminium in all cases of pulse on time and current.
- The SR achieved with smaller value of pulse on time and higher discharge current is better. Current is the most significant factor for SR when machining is done by copper and copper tungsten electrode.
- Brass gives good quality of machined surface at higher discharge current value in comparison of copper and aluminium.
- Stability of the machining increases the dimensional accuracy when machining with single hole brass electrode. That tends to improve the surface finish.

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