Electric Discharge Machining Process for advanced and hard materials: A start of art on Electrode wear

Presented by-

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Abstract

This review paper gives an insight of the different tool electrode materials, shapes that affects performance measures such as Tool Wear Rate (TWR), Material Removal Rate (MRR), Surface Roughness (SR) and Recast layer. These measures also get affected by the parameters such as Spark On-time (pulse on time or Ton), Spark Off-time (pulse off time or Toff), Arc gap (or gap), Discharge current (Ip) Duty cycle (τ) Voltage (V). It also discusses on the factors such Electrode rotation and Electrode speed and their effect on performance measures.

Key words: *EDM, Tool Wear Rate, Material Removal Rate, Surface Roughness, Duty Cycle*

1. INTRODUCTION

1.1. Background of EDM

The history of EDM dates back to the 18th century. In 1770, an English scientist, chemist, philosopher and political theorist named Joseph Priestley made many discoveries; He was the one who discovered that electrical discharge could erode metal. Another 173 years would pass before someone found a way to harness the power of electrical discharge for manufacturing purposes. B. R. Lazarenko and N. I. Lazarenko, two scientists in the Soviet Union, discovered in 1943 that submerging electrodes in dielectric fluid made it possible to control erosion from electrical discharge. This discovery resulted in the development of one of the world's first EDM machines. In the mid 1980s, the EDM techniques were transferred to a machine tool. This migration made EDM more widely available and appealing over traditional machining processes.

1.2. Theory of EDM

The electrical discharge machining (EDM) works on the principle of erosion of metals by spark discharges. The EDM is one of the most accurate manufacturing processes available for creating simple or complex shapes and the geometries within parts and assemblies of extremely hard materials (fragile) that are difficult to machine using conventional methods, as it works using electrical energy turned to thermal energy rather than cutting [1,2]. Consecutively, thousands of sparks per second are generated and each spark produces a tiny crater, in the material along the cutting path by melting and vaporization, thus eroding the workpiece to the shape of the tool [1,3]. The dielectric (nonconducting) fluid flushes out the chips and confines the spark [1,4]. Each spark produces a temperature between 8,000°C and 12,000°C [1,5] or as high as 20,000°C [1,6]. The size of microcrater depends on energy turned out by the spark generator pulsating direct current at 20,000 30,000 Hz [1,7].

2. WEAR BEHAVIOUR

2.1.

To decrease the tool electrode wear novel materials like electrical conductive boron doped CVD diamond (B-CVD) and polycrystalline diamond (PCD) can be used. Both materials offer high thermal conductivity and high melting point and therefore reduce the wear and enhance the relative removal rate in EDM [8,9,10].

2.2.

While Investigating the electro-discharge micro-machining of titanium super alloy, the researchers concluded that the Metal removal rate and tool-wear rate are found to increase monotically with the increase in peak current because of the higher discharge energy at higher value of Ip. Also MRR and TWR were found to increase when Ton increased from 1 to 10 μs. By seeing the SEM micrographs, it has been observed by the researchers that at lower range of Ip and Ton, the topographical condition of micro-holes is better and as Ip and Ton increase the micro-hole condition deteriorates. Thickness of the white layer formed on machined micro-holes increases sharply with increase in Ip and Ton.[11]

2.3.

Another investigation of the influence of machining parameters when machining tool steel using EDM in which Copper wlw electrodes with diameters 9.5,12 and 20mm were used in the EDM machining of AISI1045 tool steel at two current settings of 6.5 and 3.5A concluded that based on mrr of workpiece and the wear rate of electrode, the best performance was given by the electrode having the diameter 20mm at the current setting of 6.5A since this combination gives the highest mrr and lowest wear rate.[12]

2.4.

Some researchers showed that for a Ti-based solid solution carbonitride electrode under optimal conditions for the Ti-based electrode, the EWR was improved by 35.38%, , the machining time by 45.16%, and the entrance clearance by 17.19% compared to the EWR for a WC-Co electrode. The performance of Ti-based solid solution carbonitride was better compared to WC-Co for a micro-hole machining EDM process.[13]

2.5.

Cryogenically treated copper electrode in additive mixed EDM, when analyzed by taguchi method affects TWR and WR in a positive manner. ANOVA analysis indicates that polarity, type of electrode, peak current, and dielectric contamination significantly affect both TWR and WR. Both TWR and WR are minimum with the use of cryogenically treated copper electrode.[14]. There is significant reduction of 58% in tool wear rate (TWR) for Tungsten electrode followed by brass and copper electrodes with 51% and 35%, respectively. Material removal rate (MRR) proportionally decreases with respect to decrease in TWR for all the three cryogenically treated electrodes when the shape of the electrodes are crystallite. Since tungsten microelectrodes are costlier, the remarkable improvement in tool life gave scope for future research in the application of cryogenics in MEDM.[15]. When a cryogenically cooled cylindrical brass electrode of 30 mm diameter is used for EDM the electrode wear reduces by about 10–16% compared to conventional electrode.[16]

2.6.

Micro-hole machining of carbide by electric discharge machining shows that while machining micro-holes in a carbide with copper tool electrode, positive-polarity machining should be used for better TWR. A tool electrode with a notch can improve the debris discharge. At high rotation speed, it is appropriate to use greater width for the notch of a single-side notch electrode.[17]

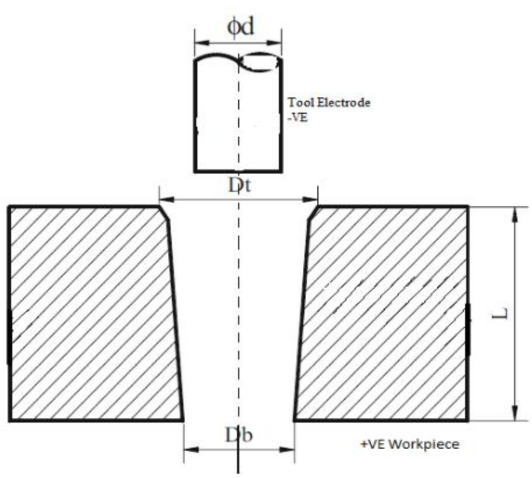

Fig.1 Schematic cross-sectional view of EDMed micro drilled hole. [11]

2.7.

Another tool material study [18,19] showed that the strength and harness of the carbide tool material increased under cryogenic temperatures. As result of material studies, it is recommended that the cutting tools, not the workpiece materials, be cooled. A new economical cryogenic machining approach has been developed. This approach uses a minimum amount of LN2 injected through a micro-nozzle formed between the chip breaker and the tool rake and assisted by the secondary nozzle for flank cooling. This cryogenic machining approach gives the best tool life compared with any machining method from current known sources.[18].

2.8.

When Cast Copper and Sintered Powder Metallurgy Copper (P/M Copper) have been considered as tool electrodes and Response surface methodology(RSM) has been used to analyze the parameters and analysis of variance (ANOVA) has been applied to identify the significant process parameters. It was observed that, for EN-8 material mean value of MRR is high (72.4 mm3/min) and low TWR value (12.73mm3/min) for Cast electrode compared with Sintered electrode. Considering die steel (D3) which has been machined by Cast electrode, the mean value of MRR is high and TWR is low compared with Sintered electrode.[20]. For Copper Tungsten Electrode as the peak current increases the TWR decreases till certain ampere and then increases. The long pulse duration causes the lowest TWR. Long pulse off time provides minimum TWR and the impact of pulse interval on TWR depends on peak current.[21]

4. CONCLUSION

The experimental investigations of the different tool electrode materials for micro-die sinking EDM, micro hole drilling, and CEDM showed good results with respect to wear and process behavior under process conditions of micro hole EDM. The B-CVD material showed better results with respect to wear behavior.[8]. While in case of titanium super alloy, the tool-wear rate increases monotically with the increase in peak current.[11]. The performance of Ti-based solid solution carbonitride is better compared to WC-Co for a micro-hole machining EDM process.[13]. While machining micro-holes in a carbide with copper tool electrode, positive-polarity machining should be used for better TWR.[17]. For Copper Tungsten Electrode as the peak current increases the TWR decreases till certain ampere and then increases.[21]

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