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A STUDY ON THE IMPACT OF MAGNETIC FIELD ON EDM PROCESS

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ABSTRACT

Electric Discharge Machining (EDM) is an eccentric precision machining process which is extensively used. This process can be used for shaping of any electro-conductive material, especially difficult to machine materials. Pulse discharge occurs in the small gap between the tool and the work-piece. This extracts the unwanted material from the parent metal through liquefication and vaporization in presence of dielectric fluid. Researchers have tried to optimize this process by improving EDM process parameters such as electrical parameters, non-electrical parameters and tool based parameters with the objective of achieving higher Material Removal Rate (MRR) and lower Tool Wear Rate (TWR) without compromising on surface roughness. Some researchers have tried to influence the conventional EDM process with an external magnetic field and have found some positive results. Magnetic field assisted EDM is a comparatively new area of research and this approach has not been put to use on the large scale yet. This work is carried out with the objective of determining how different EDM performance parameters like MRR, TWR, surface roughness and over-cut are altered by the effect of a magnetic field.

Index Terms*— *EDM, Magnetic field

I. INTRODUCTION

EDM is an atypical machining process where material removal take place in the work-piece by ejection of controlled sparks from the tool when both, the tool and work-piece, are placed extremely close to each other, submerged in a weakly conductive dielectric medium such a paraffin, kerosene, EDM oil,etc. In this process the negative terminal of DC power source is connected to the tool and the positive terminal of the DC power source is linked to the work-piece. When the voltage across the gap is adequately increased to about 250V, dielectric fluid breaks down and plasma is produced between the tool and the workpiece. The extremely high temperature developed causes the work-piece material is vaporize thereby forming small craters. Repeating the process again and again the required shape is formed.

The dielectric fluid helps to wash away the debris from the machining gap and serves as a coolant for the process. Complex shapes and contours can be produced using this process. Since EDM is a precision machining process, the time involved in machining is high. The basic idea behind research carried out for EDM is to achieve higher MRR and lesser TWR at the same time not compromising on surface roughness. Several researchers have worked in this area to strike an optimum balance between these performance parameters. Some researchers have influenced conventional EDM process with the effect of a magnetic field and have obtained some positive results in regard with performance parameters.

In this work, the effect of magnetic field on performance parameters such as MRR, TWR, surface roughness and overcut have been studied and the mechanism behind these occurrences have been identified.

II. EFFECT ON MRR

Yan et al. (2008) influenced the plasma with electro-magnets found that the MRR increases with peak current and pulse duration and it reaches a maximum value at 20A peak current and 350µs pulse duration. When the electrical energy conducted into the machining zone was observed to be small when the peak current was less and it obtained a low MRR due to insufficient discharge energy. As the peak current increases, the energy dispatched to the machining zone was enlarged. The material removal mechanisms caused by melting, vaporization, and dielectric detonation were augmented, so the MRR of the magnetic force-assisted EDM increased with an increase in peak current. They also suggested that the effect of magnetic force helps in efficient debris removal from the machining zone, as efficient removal of debris improves performance parameters such as MRR.

Reza et al. (2012) studied the relationship of MRR on magnetic field assisted EDM with discharge energy. Discharge energy was considered in three levels namely; lower energy, middle energy and high energy levels. It can be found that the MRR has been increased by increasing the discharge energy. This is due to the transmittal of more thermal energy to the machining region in contrast to lower energy discharge. Therefore the MRR increases when the process moves from low energy to high energy regime.

Subramanian et al. (2012) inspected the effect of pulsed current on MRR of corrosion resistant stainless steel employing three different electrodes (Copper, copper-tungsten and graphite). It was found that as pulse current increases, the MRR also increases. This trend was followed in all three electrode material. The copper electrode yields the highest MRR followed by graphite and copper tungsten for stainless steel work-piece. The escalation of MRR with the increase in pulse current is because of the increase of spark energy that facilitates the action of melting and vaporization. This action results in the acceleration of impulsive forces in the spark gap and thereby increasing the MRR. It was found that there is a significant increase in MRR between the pulse current ranges 18 A - 30 A for all the three electrode materials compared to 6 A and 12 A. This is because of the higher pulse current that causes swift erosion of work material which has low hardness value.

Yan et al. (2009) found that the significant factors affecting MRR for magnetic field assisted EDM are machining polarity and peak current. It was found that when the cathode received more electrical discharge energy at long pulse duration while using negative machining polarity would generally increase the MRR. More electrical energy was conducted into the machining region within a single pulse upon increasing the peak current. Hence, more surplus workpiece materials were removed within a single pulse using large peak current and negative machining polarity.Rajukar et al. (2013) explained the concept of Lorentz force, a force experienced by the plasma when there is an interaction of electric and magnetic field which results in the confinement of the plasma leading to higher level of MRR.

III. EFFECT ON TWR

Yan et al. (2008) found that the TWR reduced upon increasing the pulse duration. The TWR became negative at 350µs pulse duration with both 15 and 20A peak currents. This can be attributed to the fact that increased pulse span at larger peak current will generate massive amount of pyrolytic carbon from kerosene dielectric that was used. The pyrolytic carbon could deposit on the electrode surface to form a protective layer, resulting in a negative TWR.

Subramanian et al. (2012) investigated the effect of pulsed current on tool removal rate on corrosion resistant stainless steel employing three different electrodes (Copper, copper-tungsten and graphite). It was suggested that tool wear is mainly due to high density electron impingement generated during machining from work and electrode materials. It was observed for copper tool, the TWR increases as the pulse current is increased due to its low melting point whereas for graphite and copper tungsten the TWR is less because of their high melting point.

IV. EFFECT ON SURFACE ROUGHNESS

Yan et al (2008) studied the relationship between pulse duration and surface roughness in magnetic-field-assisted EDM under various peak currents. They found that surface roughness increases with the peak current. Moreover, surface roughness first increased with pulse duration but after reaching a peak value, surface roughness was found to decrease. It was also observed that under large peak currents the surface roughness peaked at 160 µs pulse duration. During the EDM process, various sizes of discharge craters are generated on the machined surface due to melting and vaporization so the topography of the machined surface was irregular. The MRR increases when the peak current was fixed at a high level. Subsequently, large and deep craters were formed on the machined surface with a large surface roughness value. Hence the surface roughness increased with the peak current. In order to obtain a smooth surface it is necessary to work on lower levels of peak current.

Reza et al. (2012) illustrated the change in surface roughness with change in energy level. It was found that surface roughness increased with increase in discharge energy. This is due to the fact that large craters are formed when process moves to higher energy level and this increases the surface roughness. If low surface roughness is required it is advisable to work with lower energy levels.

Subramanian et al. (2012) investigated the effect of pulsed current on surface roughness on corrosion resistant stainless steel using three different electrodes (Copper, copper-tungsten and graphite). It was found that as pulse current increases the surface roughness also increases. The surface roughness value of copper electrode is amid graphite and copper tungsten. The surface roughness of graphite and copper are high due to the fact that higher MRR is followed by bigger and deeper craters. This produces low spark energy and pulse current which leads to the creation of small craters on the machined surface and thereby improving surface finish. Hence, formation of small craters results in good surface finish.

Yan et al. (2009) found that peak current was a factor affecting surface roughness in magnetic field assisted EDM. When the peak current was set at a high level, huge discharge energy would be dispatched to the machining region within a single pulse, hence the machined surface presented a larger crater size. This resulted in higher levels of surface roughness. It was suggested that if surface roughness was an important criteria, working on lower energy levels is necessary.

Ahsan et al. (2013) carried out experiments on EDM influencing it by an external magnetic field. It was found that introduction of magnetic field was useful only at lower energy levels with respect to surface roughness. This is due to the fact that at lower energy levels, the size of the crater formed is smaller and also it has lesser micro-cracks. The external magnetic field also helps in confining the plasma.

V. EFFECT ON OVERCUT

Subramanian et al. (2012) investigated the effect of pulsed current on diametral overcut on corrosion resistant stainless steel using three different electrodes (Copper, copper-tungsten and graphite). It was established that diameteral overcut is low at less pulse current and consequently the erosion is low. The copper tungsten electrode gives low and steady diameteral overcut for both materials at high pulse current. In contrast, graphite electrode yields the inferior dimensional accuracy which results in higher diameteral overcut for both materials at higher pulse current. The graphite results in large overcut due to its high spark dispersing effects. Overcut does not depend only on the pulse current but also on gap voltage and chip size.

Rajukar et al. (2013) explained how the plasma gets confined due to the effect of Lorentz force which occurs when there is an interaction of electric and magnetic field. The confined plasma leads to lower values of overcut while machining components in the presence of an external magnetic field.

VI. Conclusion

It is clearly seen that MRR is greatly influenced by the effect of magnetic field. MRR increases on the application of magnetic field. The confinement of the plasma because of the magnetic field is one of the main reasons. TWR reduces with the decrease in peak current and also with reverse polarity. Surface roughness improves with the application of magnetic field. The width of the crater formed is reduced and craters with less micro-cracks is formed. The confinement of the plasma also leads to lesser overcut.

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