Review to Performance Improvement of Die Sinking EDM Using Powder Mixed Dielectric Fluid

K.S. BANKER
Assistant Professor,
Mechanical Engineering Deparetment,
Shankersinh Vaghela Bapu Institute of Technology, Vasana
Gandhinagar. Gujarat (India)

S. P. PARMAR
Assistant Professor,
Mechanical Engineering Deparetment,
Shankersinh Vaghela Bapu Institute of Technology, Vasana
Gandhinagar. Gujarat (India)

B. C. PAREKH
Assistant Professor,
Mechanical Engineering Deparetment,
Shankersinh Vaghela Bapu Institute of Technology, Vasana
Gandhinagar. Gujarat (India)

Abstract:
Electrical discharge machining (EDM) is one of the non-traditional machining processes, based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. The performance of the process, to a large extent, depends on the Electrode material, Work piece material manufacturing method of the electrodes. A suitable selection of electrode can reduce the cost of machining. So in this paper Die- Sinker EDM using dielectric medium mixed with different types of powder for better improvement of MRR and TWR.

Key words: *Die -Sinker EDM, MRR, TWR*

1. Introduction

Electrical Discharge Machine (EDM) is now become the most important accepted technologies in manufacturing industries since many complex 3D shapes can be machined using a simple shaped tool electrode. Electrical Discharge Machine (EDM) is an important 'non-traditional manufacturing method' , developed in the late 1940s and has been accepted worldwide as a standard processing manufacture of forming tools to produce plastics moldings, die castings, forging dies and etc. New developments in the field of material science have led to new engineering metallic materials, composite materials, and high tech ceramics, having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. At the present time, Electrical discharge machine (EDM) is a widespread technique used in industry for high precision machining of all types of conductive materials such as, metals, Metallic alloys, graphite, or even some ceramic materials, of whatsoever hardness.

Fig. 1 Die sinking EDM

Electrical discharge Machine (EDM) technology is increasingly being used in tool, die and mould making industries, for machining of heat treated tool steel and advanced materials (super alloys, ceramics, and metal matrix composites) requiring high precision complex shapes and high surface finish. Traditional machining technique is often based on the material removal using tool material harder than the work material and is unable to machine them economically. An electrical discharge machining (EDM) is based on the eroding effect of an electric spark on both the electrodes used. Electrical Discharge Machine actually is a process of utilizing the removal phenomenon of electrical-discharge in dielectric. Therefore, the electrode plays an important role, which affects the material rate and the tool wear rate.

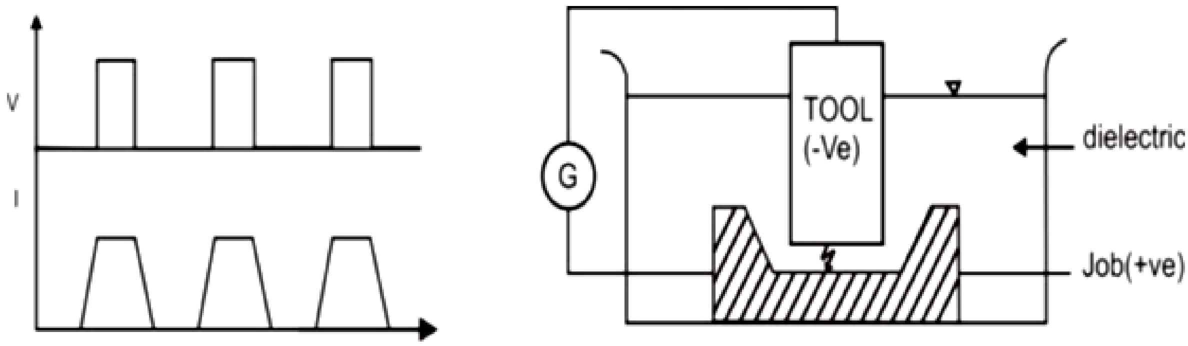

Fig. 2 Schematic representation of the basic working principle of EDM process

1.1 Electrical discharge machine process

In EDM, a potential difference is applied between the tool and workpiece. Both the tool and the work material are to be conductors of electricity. The tool and the work material are immersed in a dielectric medium. Generally kerosene or deionised water is used as the dielectric medium. A gap is maintained between the tool and the workpiece. Depending upon the applied potential difference and the gap between the tool and workpiece, an electric field would be established. Generally the tool is connected to the negative terminal of the generator and the workpiece is connected to positive terminal. As the electric field is established between the tool and the job, the free electrons on the tool are subjected to electrostatic forces. If the work function or the bonding energy of the electrons is less, electrons would be emitted from the tool (assuming it to be connected to the negative terminal). Such emission of electrons are called or termed as cold emission. The "cold emitted" electrons are then accelerated towards the job through the dielectric medium. As they gain velocity and energy, and start moving towards the job, there would be collisions between the electrons and dielectric molecules. Such collision may result in ionization of the dielectric molecule depending upon the work function or ionization energy of the dielectric molecule and the energy of the electron. Thus, as the electrons get accelerated, more positive ions and electrons would get generated due to collisions. This cyclic process would increase the concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap. The concentration would be so high that the matter existing in that channel could be characterised as "plasma". The electrical resistance of such plasma channel would be very less. Thus all of a sudden, a large number of electrons will flow from the tool to the job and ions from the job to the tool. This is called avalanche motion of electrons. Such movement of electrons and ions can be visually seen as a spark. Thus the electrical energy is dissipated as the thermal energy of the spark. The high speed electrons then impinge on the job and ions on the tool. The kinetic energy of the electrons and ions on impact with the surface of the job and tool respectively would be converted into thermal energy or heat flux. Such intense localized heat flux leads to extreme instantaneous confined rise in temperature which would be in excess of 10,000oC. Such localized extreme rise in temperature leads to material removal. Material removal occurs due to instant vaporization of the material as well as due to melting. The molten metal is not removed completely but only partially. As the potential difference is withdrawn as shown in Fig. 1, the plasma channel is no longer sustained. As the plasma channel collapse, it generates pressure or shock waves, which evacuates the molten material forming a crater of removed material around the site of the spark. Thus to summarize, the material removal in EDM mainly occurs due to formation of shock waves as the plasma channel collapse owing to discontinuation of applied potential difference. Generally the workpiece is made positive and the tool negative. Hence, the electrons strike the job leading to crater formation due to high temperature and melting and material removal. Similarly, the positive ions impinge on the tool leading to tool wear. In EDM, the generator is used to apply voltage pulses between the tool and the job. A constant voltage is not applied. Only sparking is desired in EDM rather than arcing. Arcing leads to localized material removal at a particular point whereas sparks get distributed all over the tool surface leading to uniformly distributed material removal under the tool.`

2. Powder Mixed EDM

The mechanism of PMEDM is totally different from the conventional EDM. A suitable material in the powder form is mixed into the dielectric fluid of EDM. When a suitable voltage is applied, the spark gap filled up with additive particles and the gap distance setup between tool and the work piece increased from 25-50 to 50-150 mm. The powder particles get energized and behave in a zigzag fashion. Fig 3. These charged particles are accelerated by the electric field and act as conductors. The powder particles arrange themselves under the sparking area and gather in clusters. The chain formation helps in bridging the gap between both the electrodes, which caused the early explosion.

2.1 EDM with Powder-Mixed in Dielectric Fluid

In the powder mixed EDM powder of different materials mixed in dielectric fluid. The floating particles impede the ignition process by creating a higher discharge probability and lowering the breakdown strength of the insulating dielectric fluid. As a result, MRR is increased, TWR is decreased and sparking efficiency is improved. Because conductive powders enlarge the gap distance and dispersing the discharges more randomly throughout the surface. Thickness of the recast layer is smaller and micro-cracks are reduced.

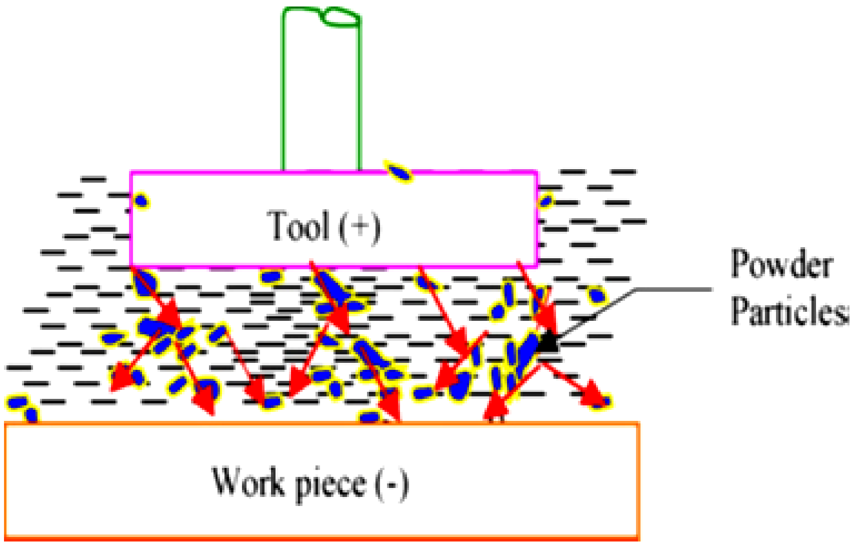

Fig.3 Principle of powder mixed EDM

Consequently, the corrosion resistance of the machined surface is substantially improved. It can also be occluded by Kansal in 2007 that PMED holds a bright promise in application of EDM, particularly with regard to process productivity and surface quality of work piece. During review of literature it is observed that most of the research works using powder mixed dielectric focus on improving the process parameters such as material removal rate MRR, TWR and surface roughness. Early years the study of the impact of such machining on surface modification began. For achieving surface modification by powder-mixed dielectric and inverse or reverse polarity arrangement is universally recommended. Some of the powders that have already been used are Ni, Co, Fe, Cr, Cu, Ti, C (graphite), Si, Sic and Mo with quoted grain sizes between 1µm and 100 µm. When abrasive powders such as Sic and alumina were mixed in the dielectric to improve the material removal rate. Such a process has been named PMEDM in which machining efficiency can be significantly increased by selecting proper discharge parameters. Jeswani conducted experiments with addition of 4g/l of fine graphite powder in the dielectric and found that MRR improved by 60% and electrode wear ration reduced by about 15%.

In recent year Prihandana presents a new method that consists of suspending micro-MoS2 powder in dielectric fluid and using ultrasonic vibration during m-EDM processes. The results show that the introduction of MOS2 Micro powder in dielectric fluid and using ultrasonic vibration significantly increase the material removal rate and improves surface quality fig 4. By providing a flat surface free of black carbon spots.

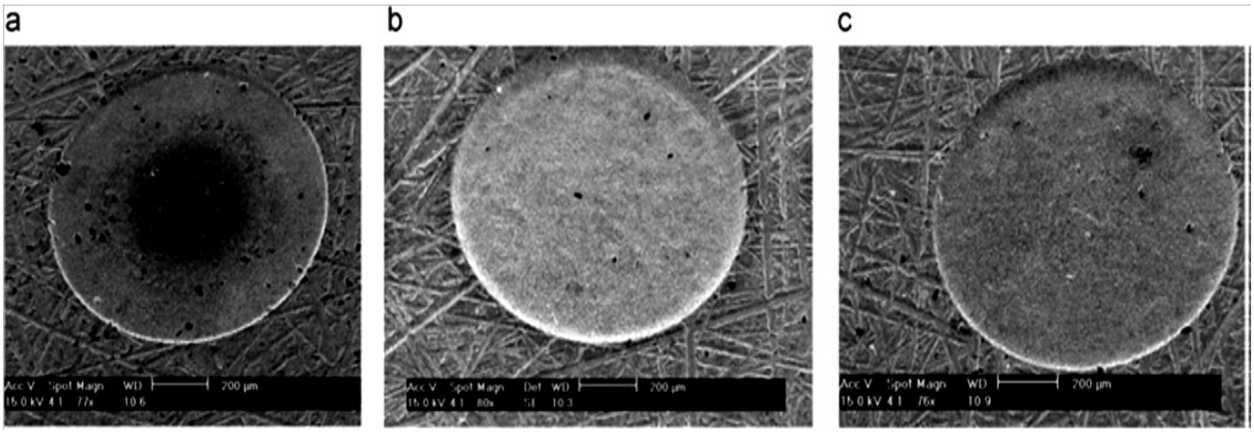

Fig. 4 Microstructures of Cu–W surfaces with brass as the tool electrode, obtained by m-EDM process using (a) Pure Dielectric (b) MoS2 concentration of2g/l (c) MoS2 concentration of 5g/l

Kun Ling Wu and other researchers explore the influence of surfactant on the characteristics of electrical discharge machining process on mold steel. In this study, particle agglomeration is reduced after surfactant molecules cover the surface of debris and carbon dregs in kerosene solution. Debris is evenly dispersed in dielectric to improve the effects of carbon accumulation and dreg discharge and reduce the unstable concentrated discharge. The EDM parameters, such as peak current, pulse duration, open voltage and gap voltages are studied. The experimental results show that after the addition of 30 g/l to dielectric, the conductivity of dielectric is increased. The machining efficiency is thus increased due to a shorter relay time of electrical discharge. When proper working parameters are chosen, the material removal rate is improved by as high as 40-80%.

3. Conclusions and Future Trends

Because of EDM enormous improvement in machining process has been achieved in recent years. The capability of machining intricate parts and difficult to cut material has made EDM as one of the most popular machining processes. The contribution of EDM to industries such as cutting new hard materials make EDM technology remains indispensable. The review of the research trends in EDM in water and EDM with powder additives is presented. In each topic, the development of the methods for the last 25 years is discussed and noticed much work in PMEDM rather than by using water as dielectric fluid.

Most of the available research works on powder mixed dielectric have studied the impact of such machining on MRR, surface roughness and TWR etc. with normal polarity. The study of the impact of this method on surface modification has been taken up by very few researchers.

Less work has been reported using powders of important alloying elements such as manganese, chromium, molybdenum and vanadium in the dielectric medium. Likewise, some of the important die steel materials such as OHNS die steel, molybdenum high speed tool steels and water hardening die steels have not been tried as work materials.

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