A Review on The Effects of Powder Mixed Dielectric Medium In Electrical Discharge Machining

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Abstract- *In Electrical Discharge Machining, the dielectric fluid influences the machining rate and surface quality of the work piece. Flushing gaseous and solid waste from the spark gap and maintaining the dielectric temperature are the fundamental functions of the dielectric fluid. Tool Wear Rate and Surface Roughness are two examples of machining response parameters that may be improved by using different powder mixed dielectrics. To that end, this study examines the impact of powder addition on discharging characteristics as well as machining output metrics. Additional research was done on the performance of different powder materials when mixed with dielectric fluids to boost their conductivity and micro-hardness, as well as to reduce the Electrode Wear Rate (EWR). A comprehensive comparison of powder materials is examined in this study to better understand powder selection variables for future studies.*

Keywords- EDM, Dielectric, Solid Waste, Tool Wear Rate, Surface Roughness.

I. INTRODUCTION

Automobile, aerospace, and biomedicine are just a few of the industries that make use of EDM. It is during the EDM process that atoms in dielectric media are broken down, allowing them to become ionized and resulting in enough electrical sparks to melt and evaporate metal from the work piece [1]. These ions form an electrical contact between the tool and the work piece, resulting in a plasma state with a temperature range of 800^0K to 1200^0K in the generated area. Because of a plasma path collapse during the machining process, some of these elements become deposited on the machined surface when the process conditions are correct [2]. The MRR (Material removal rate), surface quality, and TWR (Tool wear rate) are all metrics used to assess the effectiveness of EDM processes. When it comes to the output characteristics, there are two types of input parameters: non-electrical and electrical [3].

Non-electric parameters include nozzle flush, work piece and tool rotation, reciprocating speed, and electrode lift time. However, electrical parameters such as discharge current, pulse off time, pulse on time, and discharge voltage supply are all examples of this. Tool wear, slow material removal rate (MRR), and adverse impacts on surface quality limit EDM's usefulness. Due to the varying spark characteristics, adding powder to the dielectric fluid in powder mixed EDM is a viable strategy for improving electrical discharge machining performance [4-7].

This research is centred on the manufacture of metal using electric discharge machining (EDM). Thermal materials' expansion is being measured according to the predetermined method. It is important to understand the phases of composite materials in order to understand the roles of each of the three states, such as solid, liquid, and vapour [8]. If an appropriate metal is distributed far enough, we may utilise the system's composition to evaluate our estimation. The status of the liquid phase enhances the infiltration strategy's performance. The matrix system is able to vary the method properties of distinct practices supported by the technology of the system based on the demands of the metals that are employed [9]. The approach of electric discharge machining is based on the metal matrix composition's components. An estimation of thermal expansion may be made based on the metal's strength and the many models available. The greater use of metal is a result of the diverse capabilities of the applications, which are described by the increased usage of metal. The function on metal demand is generated by the metal's average range. The fabrication of different metals is affected by the metal's characteristics. Using MMC, an evaluation of EDC's integration performance has been conducted [10-12].

Metal matrix composite is widely utilised

Metal matrix composites made of aluminium are very common. Aluminum metal matrix composites include aluminum-graphite composites, aluminum-beryllium composites, and others. Aluminum metal-matrix composites are increasingly being produced using the EDM method. EDM is regarded as the most widely used and most important non-traditional machining process and technique. Using Wire

EDM, Aluminum MMC production is maintained. Because of the importance placed on maintaining a consistent machining speed when using EDM, it is considered a cost-effective method [13].

EDM's performance on the MMC platform

Electric discharge machining analyses performance based on metal matrix composition parameters. During EDM, MMC's potential to impact the research strategy is generated. To demonstrate the process, a material's electrical characteristics are frequently referred to. Properties include current, polarity of the pulse, voltage, and the variable of various functions. In the EDM process, the measurement of the system amplifies the mechanisms that take place on the particles of metal. The metal qualities are improved as a result of the process's unique makeup.

Surface integrity of EDM

Electric discharge machining i.e. EDM surfaces are integrated to assess the system's functionality in terms of many aspects. Process efficiency may be improved by observing the functions of the various metal matrices. The EDM parameters provide a layer that reduces the entire system's functionalities. By employing EDM's diverse machining surfaces, it is possible to incorporate various aspects of a metal matrix. The surface components include a layer that is often used to transfer integration procedures.

The utilization of three separate surfaces reveals the approach taken by appropriate techniques for performing the functions. Increased amount of enhancement requirements are influenced by the EDM surface integrity feature. Layers such as the recasting layer, heat affected zone (HAZ) layer, and conversion are all examples of machined surfaces. Depending on how much metal is utilised in the transmission method, the functions of the given layer form a decomposition factor. Recasting enhances the molten metal's surface area but does so at the expense of transmission efficiency.

Residual Stresses

It's common to find residual tension during electric discharge machining because of uneven solidification of the liquid metals. Failure or corrosion might result from these flaws if they are present during the tensile loading process. Cracks develop when the materials' ultimate strength is exceeded by the residual stress created during manufacturing. When a bridge collapsed suddenly in Belgium in March 1938, 1938, the designers were drawn to the residual stress caused by the bridge's massive framework. It was discovered that the collapse was caused by a welding operation that left residual stress, which manifested itself as a fracture.

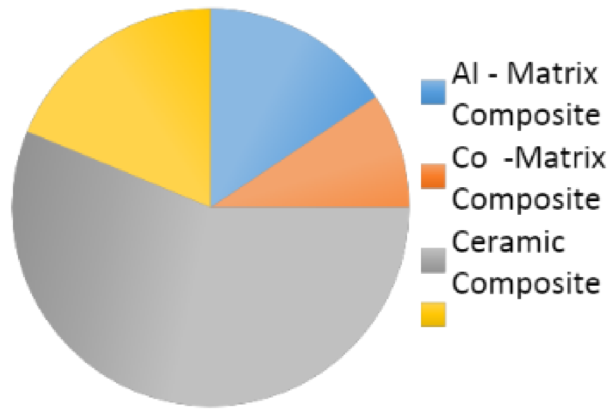

Figure 1. Metal matrix composites that have been machined using electric discharge [14]

The breakdown was caused by the expansion of the crack to the base metal. The same type of problems occurred with electrical discharge machining as they did with residual stress.

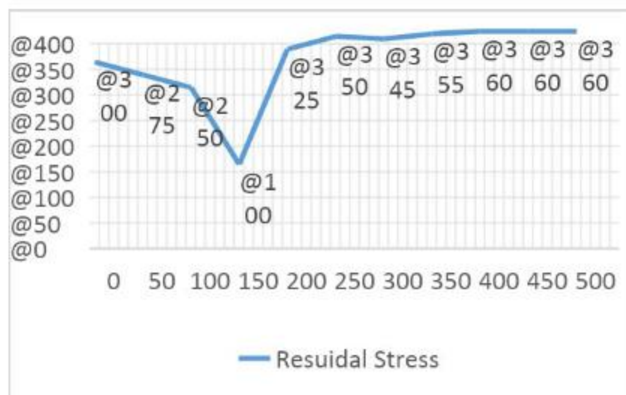

Figure 2. Residual Stress Variation [15]

Different powder material's effect in PMEDM

Graphite

One of the PMEDM tests found that adding 4 g/l of Graphite powder (10 m) to the dielectric fluid improved material removal by 60% and reduced tool wear by 15%. Graphite granules were added to the dielectric to boost the superalloy Co 605's micro hardness. Powder particles make up a significant amount of the machined surface. Micro-hardness in PMEDM is said to be affected by pulse on time, peak current, and polarity. For improved micro electrical discharge machining, Graphite particles were mixed with dielectric fluid. It has been shown that combining Gr with Dielectric in

PMEDM has increased the discharge gap, increased the MRR and decreased surface roughness[16].

Aluminum

EDM of Ti-6Al-4V enhanced the discharge gap and material removal depth by 30 percent at a powder concentration of 5 g/l, according to the study. However, the accuracy of the machined slit was impaired by the large overcut. To make the Al particles in the dielectric medium more uniform, surfactant was added to the dielectric. WC-Co workpieces may be machined more efficiently if aluminium powders are combined with mineral oil and the appropriate powder concentration is 17.5g/l. EWR decreased before rising when the aluminium powder concentration was reduced to a minimum of 15 g/l. Using aluminium powder in kerosene dielectric to machine A1 matrix materials enhanced Ra by 31.5 percent after 10 test cycles of blending [17].

Tungsten

Surface modification is the most common usage for tungsten powder. Analysis of milling Tungsten powder with OHNS, D2, and H13 was conducted by researchers. At high plasma channel temperatures, scattered powder particles may react with carbon and improve the hardness of the aforementioned three work material ingredients by more than 100%. They were utilising an electrode made of brass and tungsten mixed dielectric to improve the micro hardness and surface quality [18].

Silicon

When compared to pure dielectric fluid, Molinetti and Amorim found that adding Silicon powder to dielectric (with a typical size less than 5 m) lowered Ra by a factor of 5 at peak currents of 2 A each. In the presence of silicon powder in a dielectric fluid, silicon particles can stick to the top layer at lower output currents, creating negative polarity, and this can alter the properties of the machined workpiece.. For EDM of AISI D2 with silicon powder with kerosene dielectric, the most important parameters and their impacts on powder mixed EDM are listed below: Silicon powder concentration and current were the most critical factors in determining material removal rate. Powder-mixed EDM with a Si powder concentration of 2 g/l improved material removal rate as well as surface roughness [19]. The dielectric employed a 2 g/l Si powder concentration (10m). Powder percentage was also lowered, showing that roughness improved for more tool areas after mixing 2g/l of Silicon powder into the dielectric, but only after that.

Silicon Carbide (SiC)

It found a 30 percent improvement in MRR and a little expansion of the machining zone when using Silicon carbide powdered in combination with kerosene as a dielectric. The MRR, on the other hand, barely changed at lower I. (1.5 A). When using a copper tool to machine Ti-6Al-4V with a dielectric (kerosene) and 25 g/l SiC powder, the maximum metal removal rate at tonne = 10 sec was achieved. For pulsed discharges, SiC powder has low heat conductivity and high electrical resistance, resulting in stronger explosion force and a deeper hole. The thickness of the recast layer was reduced by the addition of SiC, although Ra was unaffected. It observed that powder particles step down the discharge column to the point where they can reach the pool of molten material before solidification, resulting in a suspended particle-encrusted surface. Recast layer thickness was increased in hydrocarbon oil and water by using SiC powder. In contrast, when granules were mixed with water, this became more noticeable [20].

Titanium carbide

Titanium carbide powder coupled with gasoline and ultrasonic tool vibrations was discovered to be a crucial contributor to the improvement of Mg-Zn-Al machining characteristics. When the MRR was at its highest, the surface quality and TWR were also reduced. Fine-grain consolidation was achieved by transferring decomposed Titanium from the TiC-combined dielectric fluid to the surfaces of the MgZnAl alloys during solidification. In addition, the wear resistance and hardness of the machined surface were increased by alloying the outer layer of the work piece with some Titanium particles [21].

Titanium dioxide

It was discovered that rotary copper cutters may be used to machine H13 steel using kerosene-based TiO_2 powder (20 nm mean particle size). The centrifugal force cleared particles from the cutting zone when the rotation speed was raised to 200 rpm. Plasma channel bubbles generated at speeds greater than 200 rpm, reducing the MRR. A maximum of 1 g/l of Titanium dioxide particles was added to the dielectric fluid to boost the pace at which material was removed from the machining gap [22].

Copper

Applied to dielectric fluid, copper powder has no influence on tool wear, surface roughness, or material removal rate because of its high density.

Chromium

Chromium powder concentration of 0.5 cm3/l, t_{on} = 25s, applied in dielectric considerably decreased TWR and enhanced MRR by nearly 50 percent. An EN-8 machining process was used, with a dielectric made of Cr powder. Increasing the particle concentration to 6 g/l and increasing the current to 8 A significantly improved the MRR. They used RSM methods for parametric analysis of TWR and MRR [23].

Manganese

Manganese particles with an average particle size of less than 10 m were used to enhance the machining surface attributes of AIDI H13 metal. Just by adding Manganese to the dielectric, surface irregularity was reduced by a factor of two and workpiece surface toughness was raised by 35 to 40 percent [24].

Dielectric Categories

Hydrocarbon oil based Dielectric

Die-sinking EDM continues to use mineral and lubricating oil, hydrocarbon oil dielectrics, and kerosene as dielectrics. In die-sink EDM, hydrocarbon oil is more effective than distilled water because it produces fewer spark gaps, allowing for more precise form fabrication. Hydrocarbon oils are superior than water dielectrics because they do not corrode, are easier to filter, and have a higher ageing resistance.

Water Based based Dielectric

In electrical discharge machining, DI water is commonly used as a dielectric medium for the formation of micro-holes. Material removal rate and surface characteristics are improved by machining in DI water rather than kerosene, but machining accuracy suffers. Using a Cu electrode with negative polarity results in 0% electrode wear while machining with DI water, tap water, and a mixture of tap distilled and tap water in a 3:1 ratio[25].

Gaseous Based based Dielectric

EDM typically makes use of dielectrics like oxygen and air. There is less danger and contamination from other dielectrics when using them instead. When ordered correctly, these dielectrics behave like other dielectrics. Additives like glycerine can help enhance gaseous dielectrics.

Powder Mixed Dielectric

It is important to note that PMEDM performance is affected by powder parameters such particle composition, size, and concentration. The optimal powder concentration should be selected in order to improve performance attributes and reduce discharge inconsistency. Powder thermo-physical parameters, notably particle density and electro-thermal conductivity, have a significant impact on the PMEDM discharge process.

Powder Parameters

PMEDM performance is affected by the powder's concentration, composition, and dimension. In order to maximise performance and avoid discharge instability, the optimal powder ratio should be chosen. Extraction and dielectric type are influenced by the powder's properties.

Powder Particle Size

Granular particle size is emphasized as a vital powder feature in the PMEDM process in order to produce the best outcomes. Particle sizes between 70 and 80 nanometers resulted in lowest discharge gap rise, highest material removal rate and lowest tool wear rate, according to a study. The highest surface quality was achieved while increasing the thickness of the recast layer.

Powder Particle Concentration

EDM's task stability and efficiency are enhanced by using the proper particle concentration during the manufacturing process. Powders' qualities dictate the appropriate concentration for a desired outcome. When concentrations are elevated above what is necessary due to the presence of additional powder particles equal to debris particles, this leads to unstable machining, short circuits, and arcs. Debris accumulation, on the other hand, is frequently blamed for sparking. Surface deterioration is caused by settling and bridging of excess particles in the discharge gap.

II. CONCLUSION

One of the most effective modern machining processes for removing high-hardness conductive materials is Electric Discharge Machining. This approach isn't extensively used because of its poor surface roughness quality and sluggish rate of material removal. Since it tends to create high surface characteristics in a short period of time, PMEDM looks to be one approach for getting over these limits. Various powder material and dielectric fluid combinations have been tested by researchers since the debut of powder-mixed EDM. It's still a complicated process to select the best additive powder materials, due to factors like machined scale, electrical and non-electrical components, additive powder impact, tool and work piece material. An in-depth examination of powder mixed Electric Discharge Machining, the most important powder features, and a detailed review of various powder materials were all covered in this paper. In light of the reviewed studies, we may draw the following conclusions:

- The most often utilised powder particles are aluminium and graphite, since they improve the surface and machining qualities.
- Any time Titanium, Titanium Carbide and Aluminum are employed in the machining of other metals, the surface modification is evident.
- Adding MoS_2 and Gr granules, which improve lubricity, was a no-brainer.
- Powder components like Cu and shattered glass have little effect on machine efficiency, however Cu powder can be used to modify surfaces.
- The bulk of study has employed powder ratios of less than 20 g/l and nanoparticle sizes of 1 to 55 m or 20 to 150 nm.

III. FUTURE SCOPE

Powder characteristics such as form and size, concentration of powders, fatigue life, micro hardness, micro structure, corrosion resistance, and resistance to wear must be studied in depth. Because nano particles powders mixed with dielectrics have superior suspension, the results of this combination must be studied. The majority of the time, dielectric fluid storage tanks are described as having a flat base in the literature. Various tank bases must be studied because they affect powder particle settlement at the corners and the bottom of the base of dielectric tank's base.

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