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ANALYTICAL STUDY ON POWDER MIXED ELECTRICAL DISCHARGE MACHINING

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ABSTRACT
High dimensional precision products made from difficult-to-cut materials may be created via the use of “electric discharge machining” (EDM). When it comes to creating intricate forms and micro-apertures, the EDM process is the go-to. Since then, it has been inevitable. Fluid dielectricity has a significant influence when it comes to EDM functioning. In the past, dielectric fluids such as kerosene (or other hydrocarbon-based products) were routinely used in this operation. This paper explores the effects of incorporating powder into the dielectric fluid during an EDM. "Powder mixed electrical discharge machining" (PM-EDM) has emerged as a feasible solution for EDM performance improvement. As a result of this approach, the fluid's properties and the EDM process' performance are both altered by the addition of an electrically-conductive powder. Several machining parameters are used to manage the sophisticated PMEDM process. Each machining parameter has a distinct impact on the overall performance of the operation. In this article, electrical parameters and the performance of the process will be reviewed in great depth. Peak current, pulse on time, duty cycle and gap voltage, are a few examples of machining characteristics. This may be done by looking at the amount of material removed, the amount of tool wear, the wear ratios, and surface roughness.
KEYWORDS: Electronic Discharge machining EDM, Material removal rate, powder-mixed electrical discharge machining (PMEDM).

INTRODUCTION
Lightning has been identified in the industrial business as natural adaptation phenomena known as Electrical Discharge Machining (EDM). A spark is an electrostatic discharge that occurs when two electrically charged areas come into contact suddenly. As a result, dielectric liquid is used to separate charged electrodes separated by a gap distance, and a servo system is used to transfer one electrode to the other. Increasing the inter-electrode gap leads to a rise in electric field intensity, which eventually surpasses the dielectric strength at a certain distance. While discharging, the electrons and charged ions impact both electrode surfaces and generate heat and pressure sufficient to increase local temperatures over the boiling point of the superheated substance, preventing it from evaporating at these elevated temperatures and at high pressures. Since recently, powder-mix EDM (PMEDM) is one of the most sophisticated ways for improving EDM's performance capabilities. The dielectric fluid of EDM is combined with a fine powder of a suitable substance. Additive particles have filled the spark gap. The EDM process suffers greatly as a result of the addition of powder.

LITERATURE REVIEW
S SUNDRIYAL ET.AL (2021) It is one of the most modern hybrid technologies, gaseous assisted powder mixed near dry EDM (GAPMND-EDM), that enhances machining performance while also generating high-quality products with improved surface quality characteristics. These response measurements were material removal rate, surface finish micro hardness, residual stress, and residual stress. There was the greatest material removal rate (MRR 3.379 mg/min) when dielectric oxygen gas and graphite powder were combined, while the lowest surface roughness was obtained when dielectric argon gas and graphite additives were used (SR 1.11 m). The maximum micro hardness (MH) and lowest residual stress (RS) were achieved using a dielectric mix of zinc additions and argon gas.

THI-HONG TRAN ET.AL (2020) As a consequence of EDM's success, powder-mixed electrical discharge machining (PMEDM) has been proposed as an improvement. Optimizing PMEDM process parameters is crucial and time-sensitive. EDM procedures with SiC powder-mixed dielectric of hardened 90CrSi steel were studied using Taguchi and ANOVA techniques to discover the main parameters that impact surface roughness. Pulse current, time, time interval, and voltage were the PMEDM parameters selected for this experiment. The usage of SiC powder may be responsible for the decreased roughness of the surface. Traditional EDM with an ideal powder concentration of 4 g/L resulted in a 30% reduction in roughness. The research found that pulse-off-time and then powder concentration had the greatest impact on surface roughness. EDM parameters of 4 g/L powder concentration, 6 s pulse on time, 21 s pulse off time, 8 A pulse current, and a 4 V server voltage produced the optimum surface roughness.

MODI, M. ET.AL (2019) Electro discharge machining (EDM) productivity of Nimonic 8OA alloy was studied in this work by using different powders. Despite their different thermo-physical characteristics, the research use chromium (Cr) and aluminium (Al) powders. When these powders were combined with dielectric fluid, the effect on surface roughness (SR), material removal rate (MRR), and machining process mechanism was studied. In addition to the volumetric percentage of powders, the size of molecules and their density as well as the electric resistance and heat conductivity of additives all had a substantial influence on the productivity of powder mixed-electro discharge machining (PMEDM).

HARDAHA RAJKUMAR ET.AL (2018) Electrical discharge machining (EDM) is a non-conventional machining method used to create very hard and complex geometric structures out of conducting material. EDM is an Electro-thermal method that utilises sophisticated metal removal processes via the creation of plasma channels between the tool and the work piece in a dielectric fluid. EDM has had a huge impact on the tool and die industry for many decades. The dielectric fluid has been infused with different particles in an attempt by many researchers to improve EDM performance. Further investigations in this subject have shown that mixing electrically conductive powder into dielectric fluid reduces the insulating strength and increases the spark gap between the tool and the work piece. This has resulted in better MRR and surface polish, as well as a more stable process.

PALLAVI CHAUDHURY ET.AL (2017) Raising quality standards at increased production levels need increasing the material removal rate while maintaining surface quality control. With its excellent surface quality and high mean residual roughness, Powder Additive mixed EDM revolutionises the machining industry (MRR). The effect of powder mixed dielectric on EDM machining has already been studied. This paper examined a number of different characteristics, including the maximum current, the kind of powder, and the concentration. The experimental data have been analysed using the Taguchi approach. The Orthogonal Array (OA) L9 is used to analyse seven components with three levels in this research. Using MINITAB 13 software, the experiment's findings were compiled and evaluated. The ideal parametric parameters for MRR have been confirmed by performing MRR confirmation tests.

EDM PROCESS

Despite the fact that EDM's material removal process is still debated, it is the most widely acknowledged and proven method of erosion. Electrical discharges occur between the tool and workpiece, which are immersed in a dielectric fluid, when a suitable electrical potential difference develops between the two electrodes. The cathode emits electrons as a result of the potential difference. Anode electrons clash with dielectric fluid on their race to the anode. This results in a breakup of electrons and positive ions. Between the electrodes, an ionised column of dielectric fluid molecules creates a spark. Because of the high temperature of the plasma channel, melting and evaporation of the electrode as well as the workpiece occurs, forming a crater on the work piece's surface. Flowing dielectric fluid washes off minute detritus from between the electrodes, causing the plasma channel to break down when the pulse is stopped. Likewise, a rough machined surface is generated by a sequence of crates on the workpiece's surface. As may be seen in Figure 1, a typical EDM set-up.

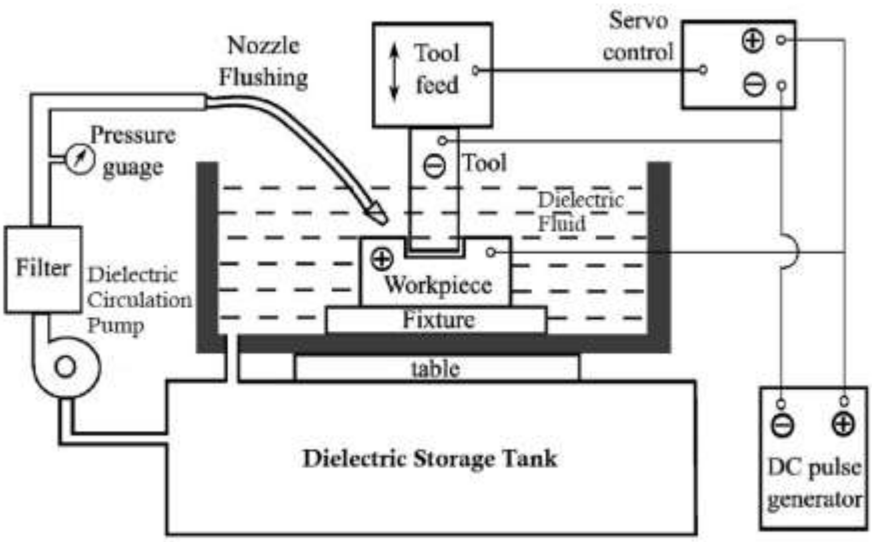

Figure1. EDM setup

"Mechanism of Material removal in EDM"

Figure 2 depicts the process of removing material via EDM. During the ignition phase, two electrodes that are not in touch are subjected to a considerable voltage differential. As the electrode goes closer to the workpiece, the inter-electrode gap electric field grows until it reaches the dielectric breakdown voltage. Between the Tool and Workpiece's closest points, the discharge is most likely to occur. If the previously described gap is determined to have debris or impurities, this might change. Dielectric ionisation causes currents to flow across the plasma channel, which lowers the voltage of the plasma The electrodes are continually assaulted with ions and electrons, resulting in a constant heating of the workpiece, which in turn leads in an intense heating of the workpiece. A little puddle of molten metal developed on the electrodes as the discharge current flowed. Molten metal evaporates very immediately. The molten metal pool grows in size as the plasma channel widens (see Figure 2(iv)). As soon as the voltage is turned off, the plasma channel begins to contract due to pressure from the neighbouring dielectric. A tiny hollow is produced on the workpiece's surface when the molten metal pool is driven into the dielectric (Figure 2v). Melting metal is used to eliminate the tiniest particles, which freeze and become trash. The inter-electrode gap is used to eliminate the dirt from the discharge area. After a spark, the gap expands, bringing the electrodes closer together and causing the next spark. Additionally, a workpiece surface is re-created by hundreds of comparable electric discharges occuring in different locations.

In order for the molten metal to cool down quickly and form exceptionally high temperatures, a recast layer forms on the surface. Corrosion resistance, wear resistance, and fatigue strength are all reduced in this layer due to the presence of microcracks. After milling, it is critical to restore the surface's integrity. Poor surface quality, low surface integrity, and low productivity limit the adoption of the EDM technology in industry, despite its ability to machine any electrically conductive material. In an attempt to improve the overall effectiveness of EDM, researchers have developed new and improved techniques. These include Rotary EDM, Ultrasonic EDM, Powder-Mixed EDM (PMEDM), Near-dry EDM, and Magnetic Assisted EDM.

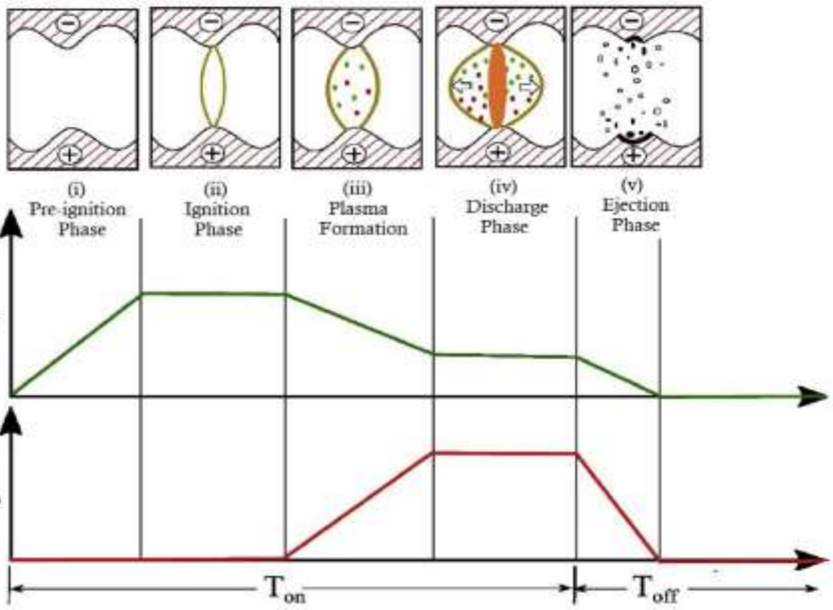

Figure 2 "Mechanism of Material removal in EDM"

DIFFERENT TYPES OF EDM TECHNIQUES

Electronic dance music (EDM) has a wide variety of subgenres. Sinker EDM, Wire EDM, and Fast Hole Drilling EDM were the three primary kinds of EDM techniques analysed in this study. Workpieces and tools are submerged in a dielectric liquid, and frequent sparks between them erode the material, causing it to deform. A pulsed spark is produced when dielectric fluid travels through a gap between an electrode and a work piece. Figure 3 depicts the EDM process's fundamental operating principle.

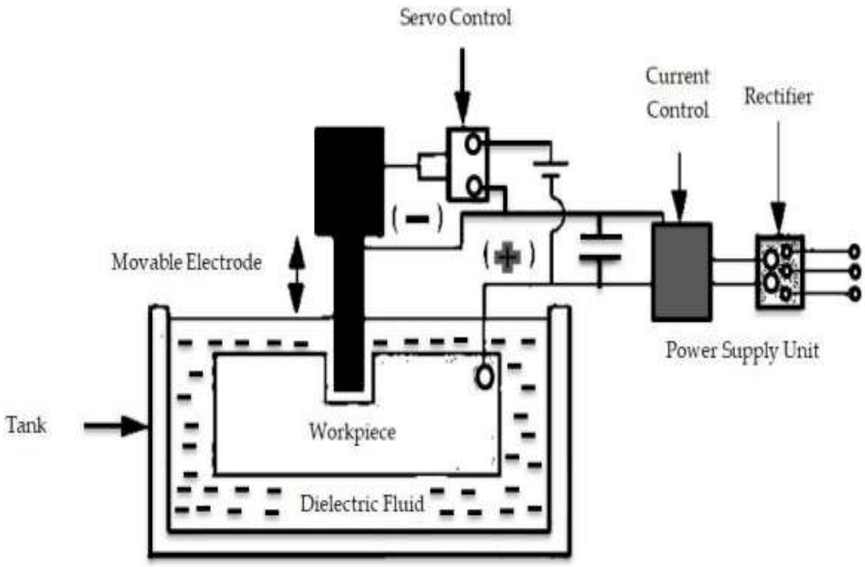

Figure 3 "Schematic representation of the basic working principle of electrical discharge machining"

VARIOUS POWDERS USED IN EDM

When it comes to EDM, there are six different types of dielectric fluid-mixed powders to choose from: micro-powders made of aluminium, silicon, chrome, graphite, and silicon carbide. EDM makes use of these particles. They all have different qualities that make them suitable for different machining scenarios. A wide range of properties is required to meet the needs of these powders. For EDM operations, Table 1 summarises the general composition of widely and recently used materials (powders) as well as their physical characteristics.

Table 1 "Commonly used powders in powder-mixed EDM (PMEDM) and their physical properties"

Material	Density (g/cm3)	Electrical Resistivity (W-cm)	Thermal Conductivity (W/m-K)
Aluminum (Al)	2.70	2.89	236
Graphite C	1.26	103	3000
Chromium (Cr)	7.16	2.6	95
Copper (Cu)	8.96	1.71	401
Silicon (Si)	2.33	2325	168
Nickel (Ni)	8.91	9.5	94
Silicon Carbide (SiC)	3.22	1013	300
Titanium (Ti)	4.72	47	22
Tungsten (W)	19.25	5.3	182
Alumina (Al2O3)	3.98	103	25.1
Boron Carbide (B4C)	2.52	5.5 105	27.9
Carbon nano tubes (CNTs)	2.0	50	4000
Molybdenum Disulfide (MoS2)	5.06	106	138

CONCLUSION

EDM is one of the most prominent unconventional manufacturing technologies for creating high-strength, hard electrically conductive material. PMEDM is an enhanced EDM process that has a promising future and solves the EDM method's shortcomings. Different powder materials and dielectrics combinations have been tested by many researchers.

- Different concentrations of conductive particles, according to the findings, may increase the rate of material removal in EDM.
- Input parameters such as peak current, pulse on and off duration, duty cycle, voltage, discharge current, tool angle, powder concentration, nozzle flushing and grain may be modified to optimise the rate of material removal and the change in SR.
- The researchers' key findings state that adding particles into a dielectric medium increased SR and improved MRR.

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