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A REVIEW ON ELECTRIC DISCHARGE MACHINE PROCESS PARAMETERS

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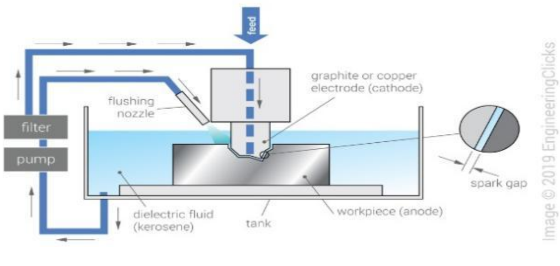
ABSTRACT:

The Electrical Discharge Machining (EDM) is one of the Modern non-traditional machining processes, Based on thermoelectric energy between the work piece and tool. The performance of the process, to a large extent, depends on the tool material, work piece material. A suitable selection of tool can reduce the cost of machining. The performance of EDM is find out on the basis of Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR), Radius of over cut(ROC). The important machining parameters of EDM which affecting on the performance parameters are discharge current, pulse on time, gap voltage. Full factorial design of experiments is used to conduct experiments and carried out with the help of a copper tool electrode and EDM Oil as a dielectric fluid by considering each parameter at three levels by varying the parameters current, pulse on time and gap voltage.In this research the process performance is measured in terms of Material Removal Rate (MRR) and tool wear rate. In this research finding the effect of Discharge current(A), Pluse on Time(μs), Voltage Gap(V) on machining of 420 Stainless Steel.

Keywords—Electric Discharge Machining, 420 Stainless steel, Material Removal Rate (MRR), Tool Wear Rate (TWR), Surface Roughness (SR), Radius of Overcut (ROC).

Introduction :

Electric Discharge Machining (EDM) is a non-traditional machining process that uses electric sparks to erode material from a workpiece. The sparks are generated between an electrode and a workpiece, which are submerged in a dielectric fluid. The dielectric fluid insulates the electrode and the workpiece, but it also conducts the electricity that creates the sparks. EDM is a versatile process that can be used to machine a variety of electrically conductive materials, regardless of their hardness or strength. This makes it a valuable tool for machining difficult to machine materials, such as hardened steels, titanium alloys, and ceramics. The EDM process is initiated when the voltage between the electrode and workpiece is raised to a high enough level. This causes a spark to jump between the two electrodes, which melts and vaporizes a small amount of material from the workpiece. The dielectric fluid flushes away the molten material, and the process repeats itself. The EDM process is characterized by its high precision and accuracy. It can be used to machine complex shapes and features that would be difficult or impossible to machine using traditional machining methods. EDM is also a relatively slow process, but it is often the only way to machine certain materials.



EDM Machine

Sinker EDM:

When the workpiece (anode) and the electrode (tool) in your machine are linked to the positive and negative terminals of the DC power supply, respectively, an electrical potential is created between them. Your machine's electrode and workpiece are fully submerged in the dielectric fluid, with the spark gap between their surfaces. As the machine's electrode gets closer to the workpiece, the electric field intensity in the spark-gap region eventually surpasses the dielectric fluid's strength. This causes the dielectric fluid to degrade and permits current to flow in the form of a spark from the electrode (tool) to the workpiece. Sparking causes the creation of a portion of the material from the work piece surface melts and evaporates due to intense electrothermal heat in the spark-gap zone (spark erosion).The dielectric fluid in your machine continuously flows, flushing away the tiny EDM chips and replenishing the spark-gap zone with clean, new dielectric fluid (with original properties) while your machine's DC pulse generator briefly pauses the current flow .A small area (where the distance between the electrode and the workpiece is the least) is where the spark energy is concentrated thanks to your machine's dielectric fluid. This is a never-ending circle.

Wire EDM :

Wire Electrical Discharge Machining (WEDM) is indeed a fascinating process that allows for precise cutting of conductive materials without direct contact between the electrode wire and the workpiece. The use of deionized water as a dielectric medium is crucial for flushing away the debris created during the machining process and for maintaining the gap between the wire and the workpiece.

The ability to use thin electrode wires with diameters as small as.004 to.012 inches (.10mm to.30mm) enables intricate and precise machining, making WEDM a valuable tool in various industries, especially for parts with complex shapes or hard-to-machine materials. The process's non-contact nature also helps minimize the risk of tool wear and allows for high-precision machining without distortion of the workpiece or the electrode wire's path.

Literature survey :

Krishnan, [1] The paper investigates the optimization of Electrical Discharge Machining (EDM) parameters using the Factorial method, focusing on material removal rate (MRR), electrode wear rate (EWR), and surface roughness (SR). Current (I) was identified as the most influential parameter affecting the output responses, followed by Pulse on Time (Ton) and Pulse off Time (Toff). Grey relational analysis was utilized to determine the optimal parameter levels for the multiple output responses. Experimental tests were conducted, and the results indicated that the optimal parameter set for MRR was I = 6 A, Ton = 120 µs, and Toff = 30 µs, while for EWR and SR, the optimal values were I = 2 A, Ton = 120 µs, and Toff = 90 µs, and I = 2 A, Ton = 60 µs, and Toff = 30 µs, respectively. The study provides valuable insights into EDM machining optimization and highlights the significant impact of input parameters on the output responses.

Dr. U Ashok Kumar's [2] research focused on investigating the Die Sinker EDM Process Parameters on Inconel 625 alloy using copper and graphite electrodes. The study aimed to optimize the Material Removal Rate (MRR) through Taguchi L9 orthogonal array experimentation. The results indicated that the Current parameter had the highest contribution to MRR, followed by Time ON and Flushing Pressure. The literature review included references to studies on the machining performance and optimization of various superalloys, including Inconel 625, using electrical discharge machining techniques.workpiece used in this paper is samples of Inconel 625 steel with dimensions of 180 mm x 150 mm x 10 mm thickness.the tool used for machining the Inconel 625 workpiece is a copper electrode and a graphite electrode.

Prof. K.S.Kamble, Mahesh Dalvi, and Rahul Chavan conducted [3] research on Electrical Discharge Machining (EDM) focusing on the machining characteristics of Inconel 925. The literature review highlighted the importance of EDM in machining hard materials and the use of Taguchi method for experimental design. The study aimed to analyze the effect of input parameters like voltage, current, and pulse on time on Material Removal Rate (MRR) and Tool Wear Rate (TWR). The results showed that round electrodes exhibited less wear compared to square electrodes in EDM, emphasizing the significance of electrode shape in the machining process.The workpiece material designated in this paper is Inconel 925.The tool selected for the study in this paper is copper, which is submerged into a dielectric liquid the EDM process.

Sadagopan P et al**.** [4] He evaluated the influence of different types of dielectrics by taking the tool as cylindrical copper electrode with a nominal diameter of 4 mm. The work piece material selected is Al 6063 alloy with a cylindrical rod of 28 mm and length 15 mm and dielectric as bio-diesel, transformer oil, and kerosene, on material removal rate (MRR), electrode wear rate (EWR),and surface roughness in electrical discharge machining (EDM) of Aluminium Alloy 6063. The experimental results showed that bio-diesel outperformed transformer oil and kerosene in terms of MRR, TWR, and surface finish. The study found that the current "IP" had the maximum effect on MRR, while pulse on time "TON" had a considerable effect, and pulse off time "TOFF" had the least influential effect on MRR when using bio-diesel as the dielectric.

S. Dewangan et al. [5] The final results and conclusion of the study are that an optimal condition of EDM process parameters of Ip= 1A, Ton (pulse on time) = 10µs, Tw (working time of tool) = 0.2s, and Tup (tool lifting time) = 1.5s has been determined to improve surface integrity aspects after EDM of AISI P20 tool steel. The study found that pulse current (Ip) and pulse-on time (Ton) are directly proportional to white layer thickness (WLT).The study found that the pulse current (Ip) is inversely proportional to SCD, indicating that a higher pulse current leads to a reduction in surface crack density.

Angelos P et al. [6]The evaluation showed that the evaluated the material removal rate (MRR) in electrical discharge machining (EDM) experiments by taking tool as rectangular copper electrode with dimensions of 38 × 23 mm and the work piece was two rectangular blocks of aluminium alloy Al5052 and the dielectric fluid used was a low viscosity hydrocarbon mineral oil (Castrol SE FLUID 180).The results showed that the MRR is strongly dependent on the nominal machining power, particularly the pulse on current, while the effect of pulse-on time on MRR is not clear. The interaction between machining parameters, such as pulse-on current and pulse-on time, was found to be more complicated.

L. Li, X. Cheng et al. [7] He evaluated the machining characteristics of Inconel 718 by Sinking-EDM and Wire-EDM. The study used Inconel 718 as the workpiece material. For the Wire-EDM experiments, a 250 µm diameter brass wire electrode was used, and the EDM cuts were conducted in de-ionized water as the dielectric fluid. In the Sinking-EDM experiments, two different electrodes were used for comparison: the traditional Cu electrode and the newly developed Cu-Sic electrode. The Cu-Sic electrode was fabricated by electro-deposition.The results indicated that the Cu-Sic electrode for Sinking-EDM had better performance in terms of material removal rate (MRR), surface roughness, and electrode wear. Additionally, they found that the high toughness of Inconel 718 contributed to the absence of microcracks on the EDM surface. For more detailed information, please refer to the full article.

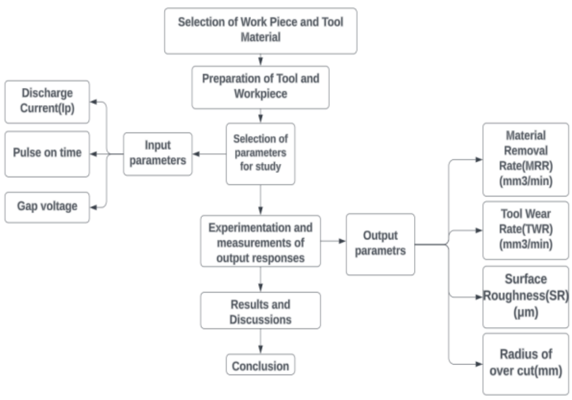
Janak B. Valaki & Pravin P. Rathod. [8] Elucidated the analysis, under the influence of control parameters, Waste Vegetable Oil (WVO) demonstrated higher Material Removal Rate (MRR) in Electric Discharge Machining (EDM) compared to kerosene, attributed to factors like increased current values and intensified ionization state. WVO also exhibited higher Electrode Wear Rate (EWR) due to improved oxidation and conductive discharge channel. In terms of Tool Wear Ratio (TWR), WVO outperformed kerosene with better TWR up to 9-A current and demonstrated superior performance in terms of current, gap voltage, Ton, and Toff, showcasing its potential as a viable dielectric fluid for EDM under various conditions.

Balbir Singh et al. [9] evaluated the influences of process parameters on material removal rate (MRR) improvement in the machining of Aluminium Alloy 6061/10%SiC composite using ZNC electrical discharge machining (EDM) process. Work piece used in this paper Aluminium alloy 6061 reinforced with 10% Sic particles varying in size from 20µm to 40 µm. Tool used in this paper Electrolytic copper electrode with a diameter of 12 mm and a length of 120mm.Dielectric fluid used in this paper Pure Kerosene Oil. The results of their study include the mathematical relations between process parameters and MRR, as well as the actual vs predicted effects of current, pulse on time, pulse off time, and gap voltage on MRR. Additionally, the study includes SEM micrographs of the recast layer across the surface machined in Simple EDM and PMEDM.

Venkatesan S. [10] Implemented the study on the Electric Discharge Machining (EDM) performance of Ti6Al4V Alloy explored the influence of distinct process parameters. Negative polarity demonstrated an 18% lower Material Removal Rate (MRR) than positive polarity, a trend supported by previous research. MRR increased with powder particle concentration in the dielectric fluid, energizing particles and reducing spark gap. Tool Wear Ratio (TWR) increased with powder concentration until a saddle point, then sharply declined. Ra, a measure of surface quality, decreased at negative polarity, with an optimal powder concentration range of 5 g/l to 10 g/l. The TOPSIS technique identified the optimal combination as a discharge current of 10 A, gap distance of 3 mm, negative polarity, and an unmixed dielectric medium, validated through sensitivity analysis.

Hamid Baseri et al. [11] The results of this study show that higher spark energy leads to an increase in MRR, TWR, and SR. Adding TiO2 Nano powder into the dielectric also reduces the resistivity of the gap, which increases MRR. Increasing the tool rotational speed increases TWR, but decreases SR. Adding TiO2 Nano powder into the dielectric increases TWR, but decreases SR. Applying a magnetic field has a positive effect on MRR, increases TWR, and decreases SR.It was found that the magnetic field had a positive effect on MRR by aiding in the expulsion of eroded particles from the machining gap, leading to improved process stability and increased MRR. However, the magnetic field was observed to increase TWR due to a reduction in ignition delay time, and it also improved surface quality and reduced SR by expelling debris from the machining gap.

METHODOLOGY :



The experiments were conducted on Electronica S-ZNC Sinker EDM with a capacity of 12V/20W as the maximum input rating as shown in the Fig. 3.1. The operating tank of the machine has a volume of 800mm x 500mm x 350mm. Check that the EDM machine is properly adjusted and in good working order. 420 Stainless steel was selected as the work piece, with dimensions 50mm x 50mm x 10mm as shown in the Fig. 3.2. Make sure that the work piece have a smooth, flat surface, are clean, and are free of impurities. A cylindrical copper rod was selected as a tool electrode with nominal dimensions of ⌀12mm and a length of 100mm.. Before starting the machining process, weigh each tool and work piece. Insert the tool electrode securely in the tool holder of the EDM machine. Using appropriate clamps or fasteners, secure the work piece to the EDM machine's worktable. To prevent movement during machining, provide perfect alignment and strong clamping. Electrol EDM oil was selected as dielectric fluid for machining in the EDM machine. Ensure the fluid is properly directed into the working tank via flushing nozzle. Fill the dielectric tank of the machine with the prepared fluid, ensuring that it covers the work piece and electrode. Begin the experiment by using the first set of EDM parameters. Start the EDM machine and start the machining operation, making sure the electrode approaches the work piece properly and paying attention to the tool-electrode distance and spark erosion. For every machining process the machining time was taken as 10 minutes. After the first set's machining procedure is completed, remove and gently clean the tool and work piece, and weigh the tool and work piece as shown in the Fig. 3.5. Continue with the following parameter combinations, adjusting the discharge current, pulse-on-time, and voltage gap levels . Throughout the experiments, make sure to keep the machining conditions and work piece preparation techniques consistent. Analyze the data and note down the values to find correlations between input parameters and the output responses.

Conclusion :

In this study, the effects of discharge current, pulse-on-time, voltage gap, on the Material Removal Rate (MRR), Tool Wear Rate (TWR), Surface Roughness (SR), and Radius of Over-Cut (ROC) when machining 420Stainless Steel is investigated using EDM oil as dielectric fluid and copper as tool.

1. An increasing trend in MRR is observed with increase in the discharge current and pulse-on-time but decreased with increasing voltage gap.
2. The TWR also increased with increasing discharge current and pulse-on-time. The SR increased with increasing discharge current and pulse-on-time but and increasing voltage gap.
3. The ROC is decreased with increasing current and pluse on time until when it reaches to peak point then ROC is increased after the peak point.
4. The results also suggest that EDM is a viable process for machining this material, as it can achieve high MRR with good surface finishes.

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