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Current Research Trends in Electrical Discharge Machining : A Review

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ABSTRACT

One of the most widely utilised non-conventional exact material removal procedures is electrical discharge machining (EDM). Hard metals can be moulded using the electrical discharge machining (EDM) method, which uses arc erosion to create deep, intricately formed holes in all types of electroconductive materials. Between the work piece and the electrode, there is a tiny space where erosion pulse discharge takes place. By melting and vaporising the undesired material, this separates the parent metal from the unwanted stuff. The objectives of this new study are the same: to reduce tool wear and achieve enhanced surface quality while reducing metal removal rate. This study discusses the scientific work done from the beginning to the invention of die-sinking EDM, Water in EDM, and dry Electric discharge machining and powder-mixed EDM are also used. in the last ten years. Additionally, a brief description of the EDM research plan going forward is included.

Keyworks : EDM , Process Parameters, Review

I. INTRODUCTION

The production of dies and moulds has made extensive use of electrical discharge machining (EDM), a non-traditional approach of machining. Additionally, surgical components and parts for the aerospace and automobile industries are finished with it. This method was created in the late 1940s and relies on repeatedly electrically discharging an electrode tool against the work piece while it is submerged in a dielectric fluid to remove material from a part. Until the gap is closed, the electrode is advanced nearer the workpiece. Small enough to allow for a high enough impressed voltage to ionise the dielectric . The term "short duration discharges"created in a liquid dielectric gap that divides the tool from the work piece. Electrical discharges from the tool and work piece have an erosive action and remove the substance . EDM does not directly make contact with the work piece, which prevents mechanical strains, chatter, and vibration issues from occurring during machining.

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However, the assessment of current EDM research trends described in this study focuses on research on machining techniques, such as ultrasonic vibration, dry EDM machining, EDM with powder additives, and EDM in water, as well as modelling methods for forecasting EDM performances.

II. Types of EDM

There are basic two types of EDM

2.1. Die Sink EDM:

The workpiece and electrode for EDM, also known as cavity type EDM or volume EDM, are submerged in an insulating fluid, most frequently oil or another dielectric fluid. The workpiece and electrode are both linked to an appropriate power source. An electrical potential between the two components is created by the power supply. Dielectric breakdown in the fluid creates a plasma channel and a little spark jumps when the electrode reaches the workpiece. These sparks often occur one at a time because it is extremely rare that multiple sites in the inter-electrode area will all have the same local electrical properties at the same time. Numerous sparks occur between the electrode and the workpiece, seemingly at random points. The machine lowers the electrode automatically so that the process can proceed without interruption when the base metal erodes and the spark gap subsequently widens. A few hundred thousand sparks are produced every second, with the setup parameters carefully regulating the actual duty cycle.

2.2. Wire EDM:

In this type of machining heat from electrical sparks, a thin, single-strand metal wire (often brass) and de-ionized water, which is used to transmit electricity, enable the wire to cut through metal during the machining process, also known as spark electrode machining (Spark EDM). While the workpiece is submerged in a tank of dielectric fluid, commonly deionized water, a thin single-strand metal wire, normally made of brass, is fed through it. Typically, plates up to 300mm thick are cut with wire-cut EDM, and strong metals that are challenging to process with other techniques are utilised to manufacture punches, tools, and dies.

III. Dry Machining

The tool electrode in dry EDM is shaped into a thin-walled pipe. The pipe is used to supply high-pressure gas or air. The gas's duties include cooling the inter-electrode gap and clearing away debris from the gap. Yu et al[3] investigation into the method's ability to work cemented carbide materials included a comparison of the machining properties of oil EDM milling and oil die sinking EDM. They discovered that oil die sinking EDM requires less time to machine the same shape.

Dry EDM should be more practical in actual production, however, as oil die sinking takes time to produce electrodes.

3.1. EDM in water

Research over the last 25 years has involved the use of pure water and water with additives. Hydrocarbon oil can be replaced by water as a dielectric. The strategy is used to encourage a safer workplace and improved health while using EDM. This is due to the fact that hydrocarbon oil, like kerosene, will breakdown and release hazardous vapour (CO and CH_4).[4]

3.1.1 Pure water

According to Konig and Siebers [5], the working medium has an impact on the removal procedure. They claimed that the working medium has a long-lasting impact on the removal procedure. As a result, the erosion process in water-based medium has higher thermal stability and can be achieved even under extreme circumstances, allowing for significantly bigger increases in the removal rate. The specific boiling energy of aqueous media is around eight times larger than that of traditional oil-based dielectrics, and boiling phenomena take place at a lower temperature level.

3.1.2 Water with additives

Leao and Pashby [6], some studies have looked into the viability of adding organic compounds such ethylene glycol, polyethylene glycol 200, 400, 600, dextrose, and sugar to demonised water conditions to enhance performance and enable considerably bigger improvements in the removal rate. The specific boiling energy of aqueous media is around eight times larger than that of traditional oil-based dielectrics, and boiling phenomena take place at a lower temperature level.

From the above it is concluded that Hydrocarbon oils can be replaced by water-based dielectric because it is safe for the environment. When comparing water-based dielectric performance to hydrocarbon oil, it is evident that surfaces treated in distilled water function better.

IV. Modelling

Numerous input variables have an impact on the EDM process.To forecast the results of the process, primarily the surface finish, tool wear, and MRR, a variety of approaches are used, including dimensional analysis, artificial neural networks, and heat modelling.

4.1.Artiificial Neural Network

Gopal and Rajurkar made an effort to model the EDM process using ANNs [7]. The 9-9-2 size back propagation neural network was developed with machining depth, tool radius, orbital radius, radial step, offset depth, pulse on-time, pulse off-time, and discharge current as the input parameters. Experiments were conducted to verify the validity of the ANN model, and it was found that the ANN model produces faster and more accurate results.

4.2. Other Methods

T. A. El-Taweel [8] used the powder metallurgy technique to explore the relationship between process parameters in EDM of CK-45 steel and innovative tool electrode materials such as Al-Cu-Si-TiC composite products. Peak current, dielectric flushing pressure, and pulse on time are taken into account as the process input factors in this study, and process performances like MRR and TWR were assessed. Utilizing response surface methods, the analysis was completed. It was discovered that the peak current had the greatest impact on both the MRR and TWR, whereas the dielectric flushing pressure had little bearing on either response.

The effects of process parameters and their interactions, including voltage, pulse on time, current, and pulse off time, on the material removal rate (MRR) in stainless steel (304) as the workpiece, were examined by Raj Mohan et al. [9].The Taguchi technique was used to determine the ideal cutting parameters, and the signal to noise ratio (S/N) and analysis of variance (ANOVA) were employed to examine the influence of the parameters on MRR. It was determined that pulse current and pulse on time are the two most important significant elements that influence the MRR.

Process factors including discharge current, pulse-ontime, and duty cycle were explored by Manabhanjan Sahoo et al. [10] for their effects on process performance metrics such metal removal rate (MRR) and electrode wear rate (EWR). In a die sinking EDM, experiments are carried out on tungsten carbide using a copper electrode. The Response Surface Methodology was used to create a mathematical model and find empirical links between the process parameters and responses.

V. Conclusion

In recent years, EDM has significantly improved the machining process. EDM is one of the most widely used machining technologies because it can work with hard materials and complicated pieces. EDM technology is still vital due to its contributions to industries like cutting new hard materials. The goals for each and every method used in the EDM process are the same: to improve working conditions, the ability of machining performance, the quality of the output product, and the development of methods for processing new materials.

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