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# A Review on Current Research Trends in Micro- EDM

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**Abstract**

The rapid trends in production caused the emergence of mini and mild merchandise with an boom in engineering applications. Micro-EDM is particularly used in the intangible operations to manufacture the favored product to be produced. In current years, many kinds of research have been done to improve the overall performance of micro-EDM. This article gives a assessment of studies activities done as a part of the Partial Administrative Organization process. The outcomes of insulating fluid, pulse and ultrasound vibrations, which play a critical role within the overall performance of precision machinery manufacturing for EDM, are highlighted in this article. Additionally, attempts through many researchers to manufacture a high-upward push microstructure structure the use of micro-EDM have been discussed. Therefore, the standard assessment of this paper will offer a better expertise of the numerous contributions of powerful implementation / implementation. The assessment also makes a specialty of optimizing various parameters the use of distinct methods, together with Taguchi, ANN, grey relational analysis, and an difficult to understand logical control system.

**Keywords:** Micro-EDM, Dielectric, Pulse-Duration, Ultrasonic Vibration, MRR, Tool Wear Taguchi Method, Fuzzy Logic Control System.

## Introduction

Electric discharge mechanism (EDM) is one in all the maximum extensively used unconventional substances removals. The EDM method removes the metal with the aid of unloading the cutting-edge from a pulsating DC strength source through a skinny area among the electrodes between the device and the workpiece. An insulating liquid fills the distance between the electrode and the element becomes localized ionization at the point where the distance among the electrode is narrower. This will increase the drift of electrons within the electric area, ensuing in high collision motion and inflicting evaporation. When extra electrons are collected in space, the resistance drops and generates a excessive power spark. Sudden electricity produced reasons the room to evaporate. Recently, for the manufacture of precision parts, it's miles important to maintain the bottom arrangement for mechanical / thermal deformation. This name to resist the intensity of the spark (in phrases of modern-day density, frequency and associated characteristics) which ends up in partial administrative organization.

Micro-EDM is much like the EDM combination principle, as the processing mechanism is based on an electrical thermal manner that is predicated on discharge through an electrical insulator to offer warmth on the surface of the component. The radius or radius of the plasma channel substantially distinguish between micro and overall EDM. The general plasma volume in the overall management machine is more through several orders than the radius of the plasma channel. Constant voltage and continuous distinction at some point of the discharge method inside the overall EDM, however, in

micro-EDM, the present day and voltage difference varies. Pulse turbines which include mono RC pulse discharge are used in partial EDM type and RC relaxation is used in overall EDM device

The blessings of micro-EDM are that the part will now not be difficult to mechanical deformation, since there may be no bodily contact between the tool and the component, accordingly getting rid of vibrations and vibration troubles and allowing `` very small or thin components without mechanical strength. " It has the potential to fabricate complex shapes with high-quality precision and the system for making any conductive material no matter its hardness. It has become one of the maximum essential methods to manufacture precision parts with exceptional precision and incredible freedom to layout at a low installation cost. The current micro-EDM technology used for manufacturing micro-features can be categorized into 4 one-of-a-kind types:

- Micro-wire EDM, where a wire diameter down to 0.02mm is used to cut through a conductive work piece.
- Die-sinking micro-EDM, where an electrode with micro-features is employed to produce its mirror images in the work piece.
- Micro-EDM drilling, where micro-electrodes (of diameters down to 5–10m) are used to ‘drill’ micro- holes in the work piece.
- Micro-EDM milling, where micro-electrodes (of diameters down to 5–10 m) is employed to produce 3D cavities by adopting a movement strategy similar to that in conventional milling.

Despite the wide variety of experimental effects that illustrate the potential of those progressed processes, they are still now not broadly used. Available machine equipment and system houses are still no longer reliable enough because they are now not widely used. The main issues restricting or restricting the micro-EDM utility and imparting some particular solutions defined in these articles.

Figure 1 shows the schematic diagram of the laboratory evolved partial EDM system utilized by Kim et al. (2006). The automation gadget especially includes precision feeding mechanism by way of servo control, X-Y operating degree, operating tank and ultrasonic vibrator. In order to reduce the effect of vibrations at the part and feeding stages, the running tank has polymer supports. The working tank with the workpiece is positioned at the XY stage of the favored feed strokes and the primary shaft (chuck type) is set up at the fifth groove of the Z level. Kerosene has been used as an insulating fluid and the RC circuit has been used as an electrical source.

In EDM, the processing performance in the gadget depends on situations winning in the area between the two poles which include the electric capacity in area, the beam current, the spark frequency and the related properties. These are controlled by the dielectric state and the nature of the distance among the electrode (the presence / absence of debris). In this context, the literature evaluate of micro-EDM expands understanding regarding treatment properties, the significance of system parameters on performance, and the utility of new capabilities inclusive of superposition of ultrasound vibrations, buffer type, including existing water, as well as new materials consisting of lined electrode and anesthetic . However, a few uncertainties arise due to feasible corrosion, embrittlement due to using water; the importance of the frequency and amplitude of the vibrations for the specified performance and the performance of the magnetic field in the electric area is not clear.

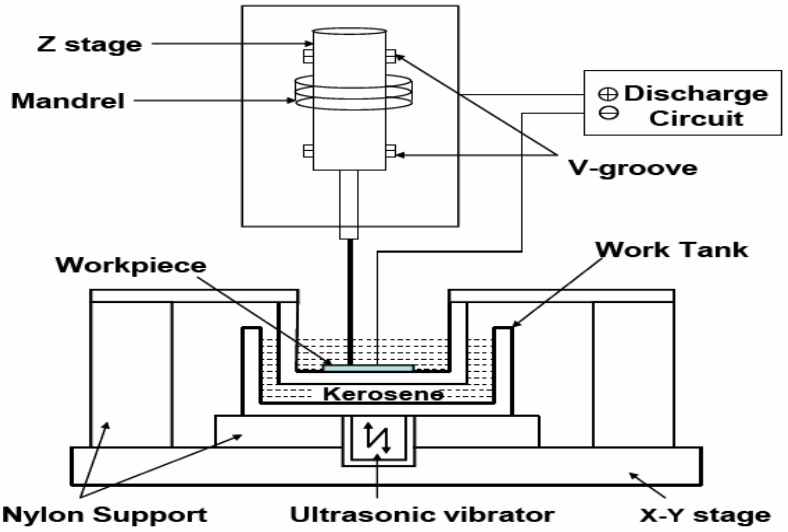


Figure 1: A schematic diagram of hybrid micromachining system [1]

Consequently, the review conferred within the article focuses on the result of material fluids, pulse properties and ultrasound-induced vibration from the conductor on instrument performance in terms of fabric removal rate (MRR), instrument wear and surface integrity. The illustration conjointly includes producing a high ratio, an impact and system, numerous output parameters like MRR, tool wear, and surface roughness. It conjointly focuses on numerous improvement techniques like Taguchi technique, relative grey analysis, artificial neural network (ANN) and symbolic logic management (FLC) performance. Applications and future directions for micro-EDM also are highlighted. Details are conferred within the following section "Various Issues" in Micro-Edm

Figure two shows the bone diagram of the precise parameters moving the machining performance of the partial EDM. during this study, numerous analysis associated with these parameters is highlighted to get high MRR, low TWR and sensible surface end.

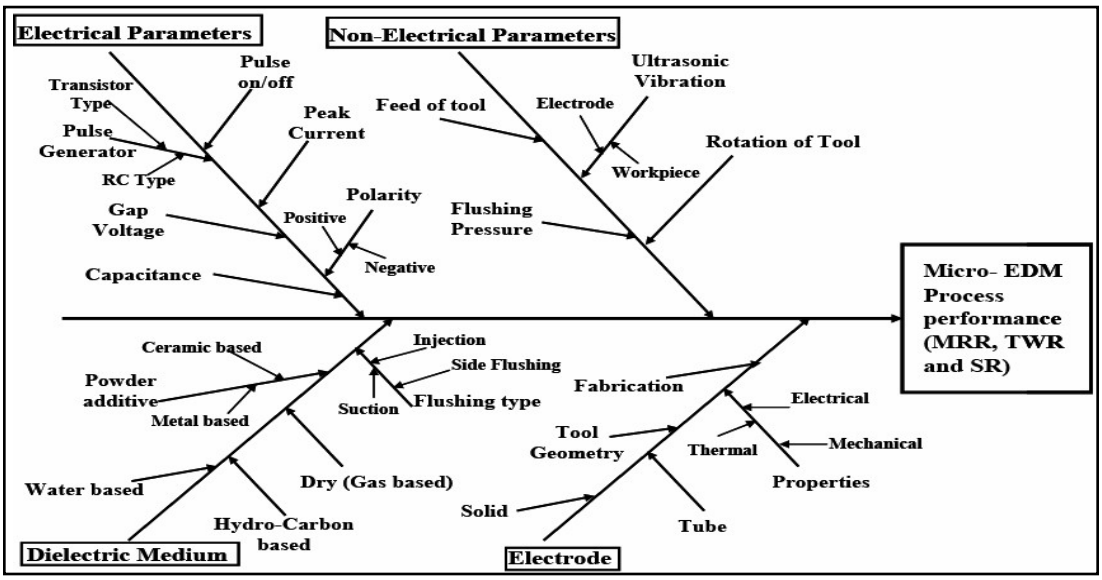


Figure 2: A fishbone diagram of selected parameters of micro-EDM [6]

Micro-EDM has demonstrated to be one of the maximum widely used production processes due to its versatility in numerous fields. Since the demand for micro-EDM is excessive, many forms of research are needed to beat standards, and new technologies should be applied to use them extra effectively.

Modern industries face the challenges of advanced materials which includes super alloys, composites and ceramics that are difficult to perform with the machine, with high accuracy, and surface excellent coupled with a better manufacturing cost. These issues may be overcome via the partial administrative business enterprise process. The foremost subject of micro-EDM is the manufacture of inkjet nozzles, high-side proportions and nozzles, gasoline injector spray nozzles, and dies for extrusion, beverages and small fuel fields, medical needles and semiconductor industries inclusive of electro needles. (Spiral electrodes). Micro-EDM has additionally made its presence felt in new regions inclusive of MEMS, medical and surgical instruments. It has also become well-known for its capacity applications inside the pharmaceutical industry, ports for biomedical devices, microfluidic engines, navy affairs, the aerospace and car industries, warmth exchangers, small gears, and microsites - robots, precision robotic fingers and infinite stages may be made and perforations die, etc. The Micro-EDM process have to be continuously reviewed so that it will compete and meet the necessities of destiny core machines.

- In recent years, a new technique is introduced to use micro-EDM with the electrically non-conductive material. One material such as SiN4 is proved to be good. However, research is necessary to use the non- conductive materials in the micro-EDM process.
- Researchers recently discovered that the functions of the dielectric liquid can also be achieved with different gases.

**Literature Review**

Following papers have been reviewed to understand current research trends in micro-EDM.

| SN | Author | Process review | Output parameter | Benefits/conclusion |
|---|---|---|---|---|
| 1 | N. B. Gurule, S. A. Pansare | Potentials of Micro- EDM | 1.Material Removal of Micro-EDM 2.2D and 3D Machining by micro-EDM 3.Tool Electrode Manufacturing and Wear in Micro-EDM 4. Basics of Micro-EDM process 5. application of Micro-EDM | This paper is helpful to fabricate the micro-EDM setup for the purpose of experimental research work. It is observed that micro-holes are the most simple and widely used micro products that can be successfully manufactured by using micro-EDM. |
| 2 | D.T. Pham∗ S.S. Dimov, S.Bigot, A.Ivanov, | Recent developments and research issues | 1. Handling of electrodes and parts 2.Electrode and workpiece preparation 3. EDM process & measurement 4. Sources of errors I. Machine errors | This paper has given an overview of the main issues affecting the performance and limiting the application of micro-EDM Tolerance, Efficiency Techniques |

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| | K. Popov | | II. Jigs and fixtures<br>III. Electrode dressing<br>IV. Electrode wear | |
| 3 | Norliana Mohd Abbas, DariusG. Solomon, Md. Fuad Bahari | A review on current research trends in electrical discharge machining (EDM) | 1.Ultrasonic vibration, dry EDM machining, 2.EDM with powder additives and 3.EDM in water 4.Modeling techniques | The ultrasonic vibration method is suitable for micromachining, dry machining is cost-effective, EDM in water is introduced for safe and conducive working environment, EDM, with powder additives is concerning more on increasing SQ, MRR and tool wear using dielectric oil and EDM modeling is introduced to predict the output parameters which leads towards the development of precise and accurate EDM performance. |
| 4 | K.takahata, N.shibaike H.guckel | High aspect ratio WC- Co Microstructure produced by the combination of LIGA and Micro EDM | Fabrication of microstructure by LIGA (**Li**thographie, **G**alvanoformung, **A**bformung) and Micro EDM | A new microfabrication process which combines with LIGA and micro EDM has been developed. We can fabricate microstructure by using suitable bulk materials and various purposes. |
| 5 | Qingyu Liu, Qinhe Zhang, Min Zhang, Jianhua Zhang | Review on size effects in micro electrical discharge machining | Careful research and precise attention must be given to size effects in micro EDM. Size effect information especially benefits the machining speed and machining precision of micro EDM. | The performances of micro EDM differs significantly from that of macro EDM due to side effects. This paper is the first to comprehensively define the size effects in micro EDM and to further establish three categories of side effects as related to material microstructure, processing parameter, and thermal conduction |

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|---|---|---|---|---|
| 6 | S.Mahendran D.Ramasamy | Micro-EDM overview and recent developments | Principles, recent developments, parameters for Material removal rate and the tool wear rate | The paper focuses on the principal of micro-EDM, the types of EDM processes, dielectric fluid, electrodes, fuzzy logic, piezo-actuated tool feed control, material removal rate(MRR) and the tool wear ratio(TWR). This paper is essential if or the new development in the research for the micro- EDM machine. |
| 7 | M.P. Jahan M.Rahman Y.S.Wong | A review on the conventional and micro-electro-discharge machining of tungsten carbide | Developments in electro-discharge machining of tungsten carbide are grouped broadly into conventional EDM of tungsten carbide, micro-EDM of tungsten carbide and current research trends in EDM and micro-EDM of tungsten carbide | Future advancement in the area of EDM and micro- EDM of tungsten carbide will continue towards understanding the fundamental science and engineering of the process as well as broadening the application of the process for the industries. |
| 8 | Mehdi Hourmand Ahmed A. D. Sarhan Mohd Sayuti | Micro-electrode fabrication processes for micro-EDM drilling and milling: a state-of- the-art review | This paper extensively describes and compares various smicro-electrode and micro-tool fabrication processes in order to produce precise micro-products | This paper extensively reviews micro-EDM process as well as various micro-electrode and workpiece materials, dielectrics, and micro-electrode fabrication and measurement processes that have been used by previous researchers. Moreover, the advantages and disadvantages of various micro- electrode fabrication processes are discussed |
| 9 | A. Kadirvel*, P. Hariharan, and S. Gowri | A review on various research trends in micro-EDM | Focuses on the optimization of Various parameters using different methods viz., Taguchi, ANN, grey relational analysis and fuzzy logic control system. | The review focuses on recent research trends to improve the output parameters such as MRR, TWR and surface analysis to obtain precise and accurate micro-EDM performance |

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| 10 | Sinan Filiz, Caroline M. Conley, Matthew B. Wasserman, O. Burak Ozdoganlar | An experimental investigation of micro-machinability of copper 101 using tungsten carbide micro-endmills | The experiments were conducted on an ultra- precision miniature machine tool. Tungsten carbide micro-endmills with 254 mm diameter were used to create full-immersion cuts (slots). The effect of increased wear on the cutting forces, surface roughness, and burr formation was also analyzed | This paper presented an experimental investigation of micro-machinability of OFHC pure copper (101) in terms of tool wear, cutting forces, surface roughness, and burr formation. |

**Conclusions**

The review focuses on recent research trends to improve the output parameters such as MRR, TWR and surface analysis to obtain precise and accurate micro-EDM performance. Thus, there is a number of issues remains to be solved in order to successfully implement micro-EDM in industries. These include the influence of dielectric fluids, pulse characteristics and ultrasonic vibration on machining parameter.

- Many researchers proved that the water-based dielectric is more suitable, however further research is required to overcome hydrogen embrittlement, explosion, and corrosion in the material.
- Also, an incremental variation of the spark intensity with the depth of drilling can be a solution for producing defect constrained high aspect ratio structure/hole.
- The shorter pulse-on duration is preferable to make accurate machining with higher removal rate and lower TWR, though; pulse-off duration will be a key factor in sustaining the process.
- RC type pulse generator proves to be better in producing a smoother surface, especially for high aspect ratio structure. Electrode rotation can assist better surface texture in micro-EDM.
- The uses of diamond either as a coating or as polycrystalline status have been cited. However, the stability aspect is not illustrated.
- Application of magnetic field needs further study from the point of sustaining (undisturbed) plasma channel in the dielectric.
- When assigning process tolerances for micro-EDM all aspects of the process, such as the type of electrode grinding, type of positioning and duration of the operation, should be considered. All these activities will accumulate errors, which should be taken into account.
- Grain size can not only influence the minimum machinable size of the microrod, but also the machining speed and surface roughness. Both the thermal conductivity and melting point of the grain boundary are lower than those of the grain, due to high solute concentration, therefore, the micro EDM performances change with grain size (volume fraction of grain boundary,) and the variation tendency depends on the material.

- The tool electrodes used in micro EDM and wire EDM are small in diameter, and thus susceptible to process force and residual stress during spark discharge. Vibration and deflection of electrodes impair machining precision and limits the minimum machinable size.
- The MRR and TWR of the workpiece show monotonous rising trends as voltage and peak current increase during conventional EDM process, however, during micro EDM with low voltage and/or current, the MRR, and TWR show abnormal trends dependent on the other processing parameters.

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