

Recent Developments in Wire EDM: A Review

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Abstract

Wire Electrical Discharge Machining is a controlled machining process which is used to manufacture geometrically intricate shapes with great accuracy and good surface finish that are difficult to machine with the help of conventional machining processes. WEDM is now growing as an important process in various fields; work has been done to use the technology for fabricating micro components. In this paper a review of the recent work has been done. Some properties and parameters that effects the machining performance of WEDM are also discussed.

Keywords

WEDM, Coated Electrodes, Multilayered Electrodes, Surface Finish

I. Introduction

Electrical Discharge Machining, commonly known as EDM is a non-conventional machining method used to remove material by a number of repetitive electrical discharges of small duration and high current density between the work piece and the tool. EDM is an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. In EDM, since there is no direct contact between the work piece and the electrode, hence there are no mechanical forces existing between them. Any type of conductive material can be machined using EDM irrespective of the hardness or toughness of the material.

II. Principle of EDM

The principle of Electrical Discharge Machining (EDM), also called electro discharge or sparks erosion machining, is based on the erosion of metals by spark discharges. We know that when two conducting wires are allowed to touch each other an arc is produced. If we look closely at the point of contact between two wires, we note that a small amount of metal has been eroded away, leaving a small crater. In this process the material is removed from the work piece due to erosion caused by rapidly recurring electrical spark discharge between the work piece and the tool electrode. There is a small gap between the tool and the work piece. Both the work piece and tool are submerged in dielectric fluid, commonly used are EDM oil, deionized water, and kerosene.

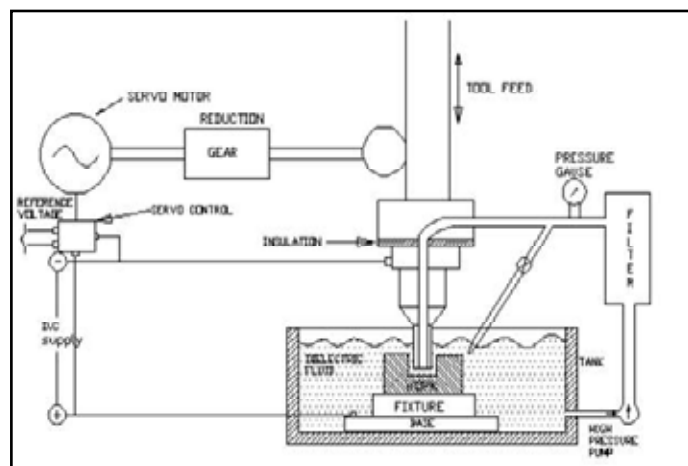


Fig. 1: Schematic Diagram of EDM [1]

III. Types of EDM

Basically there are two types of EDM: Die-sinking EDM and Wire-cut EDM.

A. Die-sinking EDM

Die-sinking EDM, also known as Volume EDM or cavity type EDM consists of an electrode and a work piece which is submerged in an insulating fluid such as oil or other dielectric fluids.

B. Wire-cut EDM

Wire-cut EDM or Wire EDM (WEDM), also known as Spark EDM is mostly used when low residual stresses are required, as it does not needs high cutting forces for removal of material. In this type of EDM the cutting is done with the help of a fine diameter wire which acts as an electrode [1].

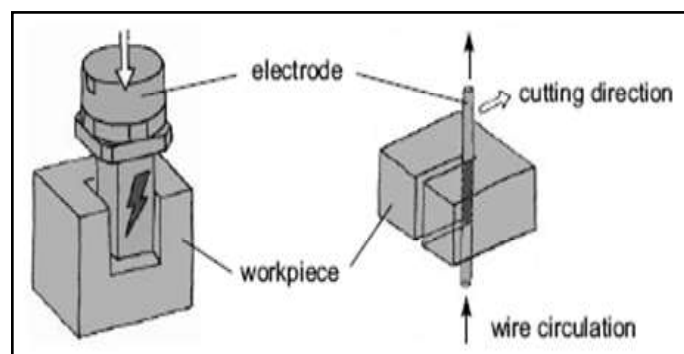


Fig. 2: Die Sinking & Wire Cut EDM Process [1]

WEDM is an electro thermal, nontraditional machining process, where electrical energy is used to generate electrical spark and material removal occurs due to thermal energy of spark. The spark is generated between the tool electrode and the work piece. Certain gap is maintained between tool electrode and work piece. A dielectric liquid is made to flow through the gap constantly; the material removed is flushed out of the gap with this flowing dielectric liquid [2].

In today's competitive world the demand is increasing for high speed machining with good quality of surface finish in tight tolerances, Wire Electrical Discharge Machining (WEDM) can serve the purpose. WEDM is an indispensable machining technique for producing intricate shapes on different types of conducting materials.

IV. Recent Developments in Wire EDM

Enormous Research has been done during the last few years in the field of wire EDM, to increase metal removal rate, tool life, surface finish and to minimize the time consumed for the process etc. some of the recent developments are discussed here.

For high speed cutting and highly accurate machining a wire electrode should have physical properties such as high conductivity, tensile strength, elongation etc. A EDM wire will break when a discharge introduces a flaw in the wire. Each spark creates a crater in both, the wire and work piece. This crater is termed as flaw in WEDM. As flushing conditions deteriorates, the tendency of wire breakage increases [3].

Zinc in the electrode enhances the performance but more than 40% zinc will result in wire drawing problems. These changes makes wire too brittle, to escape this difficulty, zinc is added to the surface of wire which helps in sliding the wire through the wire guide. These coated wires offer highest cutting speeds. Authors found that the zinc coatings enhance the speed and performance of the wire electrode. It has been discovered that the addition of zinc to copper wire improves the performance of the wire in many ways. The wire gives more energy to work zone as the zinc present in the wire evaporates while cutting and cools off the wire, also some particles of zinc help in ionization of the gap and cutting process [3].

A. Wire EDM with Coated Electrodes

In 1979 researchers discovered that wire electrodes coated with low vaporization temperature metal or alloy gives more protection to the core of the wire from thermal shock [4]. U.S. Patent No.4968867-90, discussed the use of a wire electrode which includes a core wire having high thermal conductivity, then a layer of low boiling point metal or alloy and outermost layer of a metal/alloy having high mechanical strength, which ultimately results in increasing the machining speed [5].

In recent years, high performance coated wires, having high conductivity and better flushability have been developed and used for machining, resulting in better surface finish and improved cutting speeds [6]. But these wire are costly as well as cause many impurities in dielectric fluid and also some environmental hazards [7].

B. Wire EDM With Multi- Layered Electrodes

Korean Patent No.10-1985-0009194 reported a wire electrode, which includes a steel core coated with copper or some other materials. Large amount of work has been reported in various patents for multi layered steel core wire electrodes and majority of these multi layered wire electrodes results in accuracy and precision problems with increased tool life. It may be therefore concluded that coating is done on the steel wires to achieve high strength and rigidity [8].

Kruth, et. al. of Katholieke University, Belgium studied and experimentally tested several compositions of wires, with high tensile core and several coatings. They have found that, while cutting with prototype wires, a significant rise in accuracy is obtained, especially in corner cutting, while the cutting rate is at a comparable level as commercial reference wire [9].

C. Wire EDM with Advance Power Supply

Mu-Tian Yan and Yi-Peng Lai of Huaan University, Taiwan, have developed a new fine finish power supply in WEDM. The supply is transistor controlled and composed of a full bridge circuit, two snubber circuits and a pulse control circuit, to provide the functions of anti electrolysis, high frequency and very low energy pulse control. Test results indicated that, with the adjustment of capacitance in parallel with the sparking gap, will results in shortening the pulse duration of discharge current. Experimental results shows that, the developed fine power supply is very useful in eliminating titanium's bluing and rusting effects and also in reducing micro cracking in tungsten carbide caused by electrolysis and oxidation. It is also useful in achieving fine surface finish of the order of 0.22 μm Ra [10].

D. Model for Powder Mixed WEDM using FEM

Kansala et. al. (2008) proposed a simple and easily reasonable model for an axisymmetric two-dimensional model for Powder Mixed Electric Discharge Machining (PMEDM) using the FEM. The model uses many important features such as temperature sensitive material properties, shape and size of heat source (Gaussian heat flux distribution), % distribution of heat among tool, work piece and dielectric fluid, pulse on/off time, material discharge efficiency and phase change etc. to predict the thermal behavior and material removal mechanism in PMEDM process. The developed model first calculates the temperature scattering in the work piece material using ANSYS software and then material removal rate (MRR) was predictable from the temperature profiles. The effect of various process parameters on temperature circulations along the radius and depth of the work piece has been studied. Finally, the validation was done by relating the theoretical MRR with the experimental MRR obtained from a newly designed experimental setup [11-12].

E. New Control System to Improve Machining Accuracy

Mu-Tian Yan and Pin-Hsum Huang have presented a closed loop wire tension control system for WEDM to improve the machining accuracy. Dynamic performance of the closed loop wire tension system was examined by Proportional Integrate (P.I.) controller and one step ahead controller. Further in order to reduce the vibration of the wire electrode, dynamic dampers were employed. From a series of experiments they have concluded that, this system can achieve fast transient response and a small steady state error than an open loop control system. They have also concluded that error of geometrical contour can be reduced approximately up to 50 % while corner cutting [13].

F. New Guide to Eliminate Wire Bending Defects

Research Scholars in university of Tokyo/Japan have developed a new guide of wire electrode. The guide does not cause locally sharp bending of the wire, and wire runs through the guide smoothly. Hence helps in reducing the defects that arises due to sharp bending of the wire [14].

G. New Materials for WEDM Electrodes

Prohaszka et al (1996) proposed the requirements of the materials that can be used as WEDM electrodes and will lead to the improvement of WEDM performance. He discussed the material requirements for fabricating WEDM electrodes for improving WEDM performance. Experiments were carried out regarding the choice of suitable wire electrode materials, the effects of the material properties on the machinability of WEDM. He evaluated the influence of the various materials used for the fabrication of wire electrodes on the machinability of WEDM. A series of experiments have been conducted on a standard EDM unit. Negative polarity rods of pure magnesium, tin and zinc, of a diameter of 5.0 mm were used as the tool electrodes. The work piece (anode) was annealed non alloyed steel with low carbon content. The operational parameters were kept constant during all the experiments performed [15].

H. Wire Electrodes with Cryogenic Treatment

In electronics industries, Aluminum, Brass, Copper, Tin, Lead shows better wear resistance after cryogenic treatment [16]. EN 31 steel, when machined with cryogenic treated brass wire, with three process parameters namely type of wire electrode, pulse width, and wire tension, shows a significant improvement

in Surface Roughness than the untreated wire electrode. Strong interaction is observed between type of wire and wire tension; pulse width and wire tension [17].

V. Conclusion

From the literature review, it may therefore be concluded that wires with greater tensile strength can be made but they face adverse effects in terms of increase in resistance to breakage. Coated wires can perform better in the present scenario where surface finish and tool life is most preferred. The zinc coated brass wires performs better when compared to simple brass wire because of its low wear rate and low breakage at increased currents. Due to high precision and good quality of surface finish, WEDM is potentially an important process. The research is on for the development of the WEDM as Micro WEDM, where it can be used for the fabrication of micro components, more efficiently and more effectively on industrial scale. Some work has been done with Cryogenic treatment on the different types of work pieces; this area can play a vital role in the development of WEDM. More compositions may be developed and used for the new multilayered electrodes; fine finish power supply can explore more zones to achieve good quality of surface finish as well as enhanced tool life. To sum up we can say enormous research has been done in the past and large amount of work can still be done in the future on the topic, so that WEDM can serve the purpose of high speed machining with good quality products in short time period and at reduced costs.

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