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A Review on Recent Developments in Wire EDM

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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 affect the machining performance of WEDM are also discussed.***

Keywords: WEDM, Coated Electrodes, Multilayered Electrodes, Surface Finish

1. Introduction

Wire electrical discharge machining (WEDM) is a process of causing intermittent discharge between wire electrode and work piece, through a working fluid. There is relative movement of work piece and wire electrode for cutting the work piece into a desired configuration such as various types of metal moulds, dies, punches, machine components, etc. WEDM is an indispensable machining technique used to produce complex two- and three- dimensional shapes through difficult to machine electrical conductive metals (Pandey and Shan, 1980). The performance measures in WEDM are cutting speed, surface finish and form accuracy. The main machining parameters, which affect the performance of WEDM are; pulse-on time, pulse-off time, wire speed, wire tension, servo reference mean voltage, type of wire and dielectric fluid pressure etc.. Several studies have been undertaken in the past in order to improve the performance characteristics, namely the cutting speed, surface roughness and wire wear ratio etc. Since the invention of WEDM machine, many efforts have been made to augment the machining performance and process stability. Process stability is the key factor for converting a material removal process into a controllable machining process. The demand for high surface accuracy at relatively high machining rate is constantly rising in manufacturing industries. The wire electrode is one of the factors amongst the various factors contributing the overall performance of WEDM. Many researchers have put their efforts towards the improvement of wire electrodes for enhancement of WEDM capabilities.

2. Principle of Wire EDM

The Spark Theory on a wire EDM is basically the same as that of the vertical EDM process. In wire EDM, the conductive materials are machined with a series of electrical discharges (sparks) that are produced between an accurately positioned moving wire (the electrode) and the workpiece. High frequency pulses of alternating or direct current is discharged from the wire to the workpiece with a very small spark gap through an insulated dielectric fluid (water). Many sparks can be observed at one time. This is because actual discharges can occur more than one hundred thousand times per second, with discharge sparks lasting in the range of 1/1,000,000 of a second or less. The volume of metal removed during this short period of spark discharge depends on the desired cutting speed and the surface finish required.

The heat of each electrical spark, estimated at around 15,000° to 21,000° Fahrenheit, erodes away a tiny bit of material that is vaporized and melted from the workpiece. (Some of the wire material is also eroded away) These particles (chips) are flushed away from the cut with a stream of de-ionized water through the top and bottom flushing nozzles.

The water also prevents heat build-up in the workpiece. Without this cooling, thermal expansion of the part would affect size and positional accuracy. Keep in mind that it is the ON and OFF time of the spark that is repeated over and over that removes material, not just the flow of electric current.

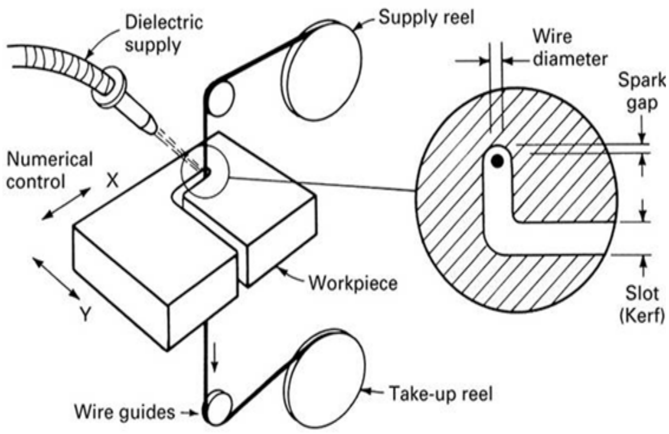

Figure 1: Schematic Diagram of Wire EDM

3. Types of EDM

3.1 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.

3.2 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].

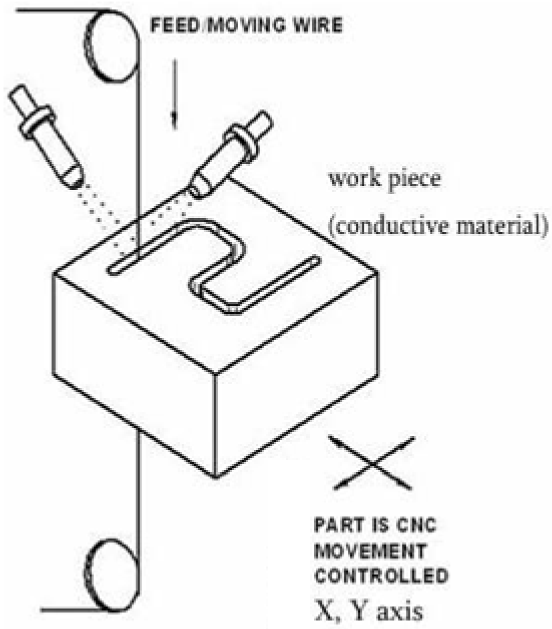

Figure 2: Wire Cut EDM Process

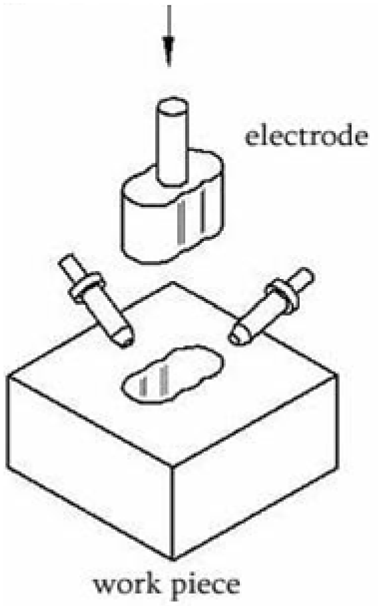

Figure 3: Die Sinking EDM

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.

4. 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].

4.1 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 flushibility 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].

4.2 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 [7].

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].

4.3 Wire EDM with Advanced Power Supply

Mu-Tian Yan and Yi-Peng Lai of Huafan 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 [8].

4.4 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 validatization was done by relating the theoretical MRR with the experimental MRR obtained from a newly designed experimental setup [9-10].

4.5 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 [10-11].

4.5 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 [10-11].

4.6 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 [11-12].

4.7 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 [11-12].

5. 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.

References

[1] Poddar A.,"Experimental Investigation of MRR, Surface Roughness & Overcut of AISI 304 Stainless Steel in EDM", NIT, Rourkela, Vol.2, pp.165-171, 2010
[2] Kalpakjian S., Steven R., Schmid,"Manufacturing Process for Engineering Materials", Fourth Edition, Pearson Publishers, 2010.
[3] Kapoor J., Singh S., Khamba J.S.,"Recent developments in Wire electrodes for high performance WEDM", Proceedings of world congress on engineering, Vol. 2, pp. 1065-1068, 2010.
[4] U.S patent No. 14, 927-1979.
[5] U.S. Patent No. 4968867-90.
[6] Patric B, Michel L, Gerald S,"Composite wire for Electrical Discharge Machining", U.S Patent No. 20080061038.
[7] [Online] Available: http://www.kernedm.com/technicalArticles/TechTipsM-A-7.pdf.
[8] Korean Patent No.10-1985-0009194.
[9] Kruth J.P., Lauwers B., Schacht B., Humbeek J.,"Composite wires with high tensile core for WEDM", CIRP Annals – Manufacturing Technology, Vol. 53, Issue 1, pp. 171-174, 2004.
[10] Mu-Tian Yan, Yi-Peng Lai,"Surface Quality improvement of wire EDM using a fine finish power supply", International journal of machine tools and manufacture, Vol. 47, Issue 11, pp. 1686-1694,2007
[11] Kansala H.K., Singh S., Kumar P.,"Numerical simulation of Powder Mixed Electric Discharge Machining (PMEDM) using finite element method", Mathematical and Computer Modelling, Vol. 47, pp 1217–1237,2008.
[12] Kumar A, "Modelling Of Micro Wire Electro Discharge Machining (WEDM) In Aerospace Material", NIT Rourkela 2011 P.hD Thesis.