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Review Paper

Effect of Control Parameters in Electrical Discharge Machining- A Review

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ABSTRACT

The machining of hard composite materials causes serious tool wear due to the abrasive nature of reinforcement by conventional machining techniques. Therefore non- conventional machining techniques are used to machine such advanced materials. Wire cut electric discharge machining process is a non- conventional machining technique that fulfills the requirements of tooling and machining industries. Wire Electrical discharge machining (WEDM) has higher capability for cutting complex shapes with high precision for these materials without using high cost of cutting tools. The risk of wire bending and breakage is a serious problem, which reduce the efficiency and accuracy of the WEDM operation. The main causes of wire bending and breakage are energy between wire tool and work piece, dielectric fluid and wire material. This research paper highlights the review of the published work on WEDM which are related to energy, dielectric fluid and material of wire tool. The main purpose of this research paper is to investigate the effect of produced energy during operation, dielectric fluid and material of wire tool on the response parameters material removal rate, surface roughness and kerf width in wire electrical discharge machining (WEDM).

Keywords – Wire Electrical Discharge Machining (WEDM), Dielectric fluid, Wire wear rate

1. INTRODUCTION

Many manufacturing industries are facing challenges from advanced materials such as nano material, ceramics, super alloys and metal matrix composites. These advanced material are hard and difficult to machine. The machining cost increases as they require high accuracy and surface quality excellence [1]. Hard machining is the machining process of a material having hardness greater than 45Rc. The conventional machining operation is expensive, environmentally unfriendly and inflexible [2]. There are two types of input variable of WEDMwhich are shown in figure 1.The electrical input variables include: peak voltage, peak current, pulse duration, polarity, pulse interval, and pulse wave. The non-electrical input variables include: dielectric fluid, electrode material and work piece material. The response output parameters of Wire EDM

Process are material removal rate (MRR), surface roughness (Ra), tool wear rate (TWR), current rate (CR), overcut (OC) and kerf width (KW) [3].

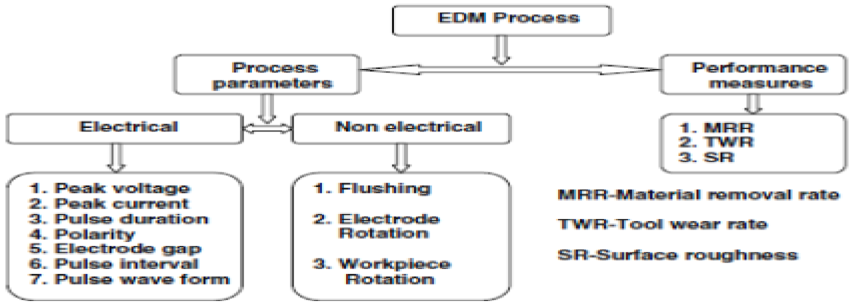

Figure 1: Process parameters and Performance measure of WEDM

Schematic Diagram of the Basic Principle WEDM Process is shown use in Figure 2. Due to applying voltage pulses between the work–piece and the wire electrode, a temperature range of 8000°C–12,000°C carry on between cathode and anode in the form of thermal energy. When the pulsating DC power supply going on between 20,000 and 30,000 Hz is switched off, the plasma channels breaks down. During discharge, the plasma channel collapses and a vapour bubble occurs. Due to vapour bubble, the superheated molten material of work piece surface to burst into the dielectric [4].

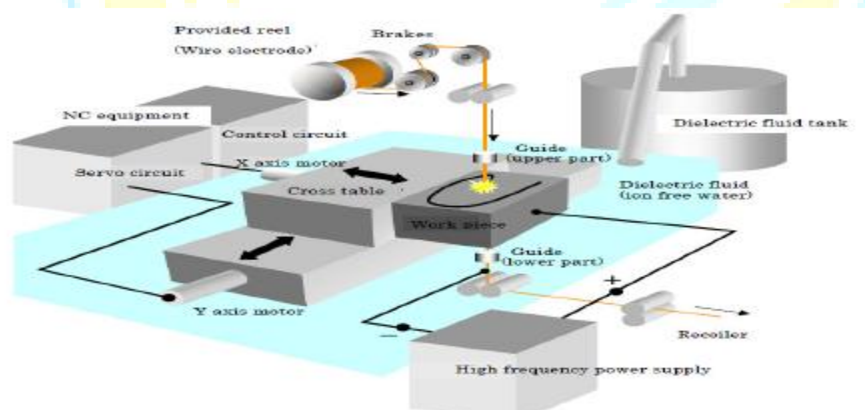

Figure 2: Schematic Diagram of the Basic Principle WEDM Process

1. EFFECT OF AN ENERGY-DISTRIBUTION BETWEEN WIRE AND WORKPIECE

There are many power supply circuits used in EDM process: Resistance –Capacitance (R-C) Circuit, Rotary Impulse Generator Circuit and Controlled Pulse Circuit [5]. The relaxation circuit provides larger over-cut and deeper penetration on the surface of the work-piece as a result the surface finish is poor. The pulse circuit produces better work-piece surface finish with more accuracy for equivalent rates of metal removal. The energy consumption of pulse circuits is also 2-3 times less and the tool wear is reduced by 5 to 20 times [6]. Two controlled pulse generator power supply units are used to control amount of energy. The first power supply is called ignition unit (100V-300V). It feeds pulses until a spark appears. Once ignition has occurred, the other power supply unit called duty cycle starts operating, at output voltage of 40V- 60V. Gap current is a sum of ignition current and duty current during the duty cycle [7].

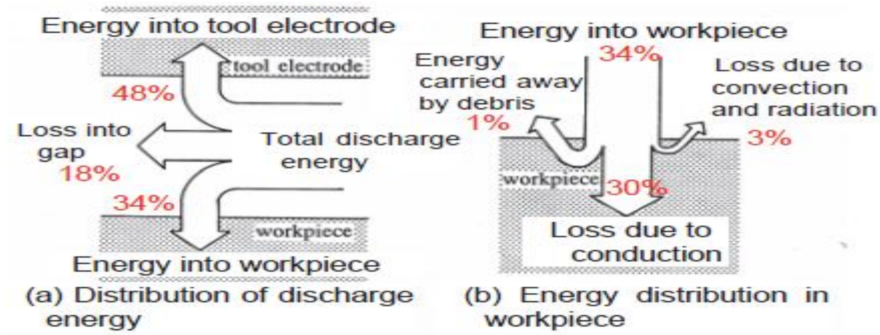

Figure 3: Energy distribution in EDM process

The higher cutting speed is a result of more powerful generator, good dielectrics and new wire materials. They are directly proportional to the effective pulse power. A large joule heat generation is produced because of high power pulse density. This is harmful for wire breakage [8]. To obtain a high machining speed during roughing, a high accuracy and a very good surface finish during finishing, a transistor-controlled power supply is developed using Complex Programmable Logic Device (CPLD) based pulse-control circuit for micro-wire EDM [9]. Under the same machining circumstances, the relative relationship of Specific discharge energy (SDE) between different materials is fixed. The values of all response parameters are almost the same. This indicates that materials with similar SDE values would really result in very similar all response [10]. In EDM process, the electrode wear amount reduces because of the shielding effects of carbon layer with high boiling temperature and high thermal resistance. It was found that 48%, 38% and 18% of the energy goes to the tool electrode, workpiece and discharge gap respectively, shown in figure 3 [11]. Due to non-symmetrical current density and different melting temperatures of the electrode materials, removal rate of the workpiece and tool electrode is 99% and 1% respectively [12]

2. EFFECT OF DIELECTRIC FLUID

The Wire EDM is capable of machining any material with electrical conductivity more than 0.01µS/cm. The water applies pressure to nozzle up to 300 psi to surround the cutting wire and flush away the eroded material. The length of plasma channel is about 10µm. The higher electrical conductivity of dielectric gives a higher removal rate [13]. When oil with long pulse-on time is used in macro-EDM, positive electrode polarity is used. When deionized water is used in wire-EDM and micro-EDM, the negative electrode polarity is used. The reason is that carbon layer does not appear. MRR of deionized water is more higher as compared to MRR of EDM oil. The reason is that , the resistivity of deionized water is less than EDM oil, the voltage is mostly stable at high level with less discharge comparatively deionized water and Chemical reaction between the oxygen workpiece material made the discharge crater larger[14]. Machining with distilled water is shown higher MRR and lower wear ratio than in kerosene. The machining accuracy is not good however the surface finish was better with distilled water. In case of using copper tools with negative polarity, the electrode wear is negligible [15].The polarity depends on matter of tool material, work material, current density and pulse length combinations. Deionized water is used for wire-EDM and high precision die-sinking due to its low viscosity and carbon-free nature. The dielectric fluid is flushed through the spark gap to eliminate gaseous and solid debris through machining. It also maintains the dielectric temperature by acting as coolant [16].

3. EFFECT OF WIRE TOOL

The material removal rate of plain brass wire is 21.25 % higher than molybdenum wire and 2.77 % additional than zinc coated brass wire. The surface roughness of molybdenum wire is 7.95 % lower than plain brass wire and 4.02 % lesser than zinc coated brass wire. Whereas, the material removal rate of zinc coated brass wire is 17.98% higher than molybdenum wire and 2.77% lower than the plain brass wire. The surface roughness is 4.02% greater than the molybdenum wire and 3.77% lower than plain brass wire. Due to this, for Inconel 600 material the zinc coated brass wire gives the optimum results out of these three wires [17]. For chromium steel with brass wire, temperature levels increase in the zone of the discharge channel with increase of power input .The pulse on time have same influence in increasing the maximum temperature. The effect of the wire velocity on the temperature distribution is negligible. The lower diameter of the wire gives greater thermal load, higher maximum temperature and increased probability of rupture [18]. When the velocity of brass wire increases, vibrations generate this reduces the accuracy of operation. The thermal load on the wire electrode earlier to rupture exceeded the average power dissipation through normal sparking conditions [19]. The experiment is conducted under different settings of pulse duration, open circuit voltage, wire speed and dielectric fluid pressure with brass wire of 0.25 mm diameter and AISI 4140 steel. The WWR decreases with an increase in wire speed due to the reducing number of craters on the unit length. The WWR (wire wear rate) increases due to increasing open circuit voltage. The WWR decreases as dielectric flushing pressure increases [20]. Due to large conductivity and small permeability of copper workpiece, the resultant electromagnetic force is repulsive since the dynamic force is responsible. With steel workpiece, which has large permeability and small conductivity, the resultant electromagnetic force is attractive because the static force is responsible [21]. The MRR achieved by the magnesium electrode is greater than that of the zinc electrode; however its evaporation temperature is larger than zinc. The greater the melting temperature of the tool electrode the smaller the penetration of the melting in material, as a result, the bigger the amount of energy is available for the erosion of the workpiece [22].There is an increase in machining area and in machining time in wire bunch electrode method with an increase in number of wires in electrodes. As the discharge current and pulse time increase, the EWR and MRR values increase and machining time decreases [23].

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