WIRE CUT EDM PROCESS - A REVIEW

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ABSTRACT

Wire cut electrical discharge machining (WEDM) is one of the most emerging non conventional manufacturing process for machining materials which are hard to machine and intricate shapes which are not possible with conventional machining methods. The wire cut EDM is also known as wire electrical discharge machining and wire cutting. In this, a thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically de-ionized water. The optimum utilization of the capacity of WEDM process requires proper selection of machining parameters. WEDM is complex in nature and is controlled by large number of parameter. It has been observed that process parameters such as voltage, current and pulse related parameters (viz. pulse on time, pulse off time) are the most important parameters in EDM/WEDM. They along with interaction time (pulse width x frequency) dominate the output parameters viz., MRR, surface roughness, etc. The depth of crater, temperature generated and the resultant surfaces obtained (along with its constituents) are result of pulse energy applied. Various researchers have focused on these aspects and prescribe for supply of optimum energy which in turn avoids post process failures. This paper reviews the effects of various WEDM process parameters such as pulse on time, pulse off time, servo voltage, peak current, dielectric flow rate, wire speed, wire tension on different process response parameters such as material removal rate (MRR), surface roughness (Ra), Kerf (width of Cut), wire wear ratio (WWR) and surface integrity factors. This paper also reviews various optimization methods applied by the researchers and finally outlines the recommendations and future trends in WEDM research.

Keywords: *EDM, ionize, MRR, process parameters, WEDM, work piece.*

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1. INTRODUCTION

In WEDM, an electrical spark is created between an electrode and a work piece. The spark is visible evidence of the flow of electricity. This electric spark produces intense heat with temperatures reaching 8000 to 12000 degrees Celsius, melting almost anything. The spark is very carefully controlled and localized so that it only affects the surface of the material. The EDM process usually does not affect the heat treat below the surface. With wire EDM the spark always takes place in the dielectric of de-ionized water. The conductivity of the water is carefully controlled making an excellent environment for the EDM process. The water acts as a coolant and flushes away the eroded metal particles.

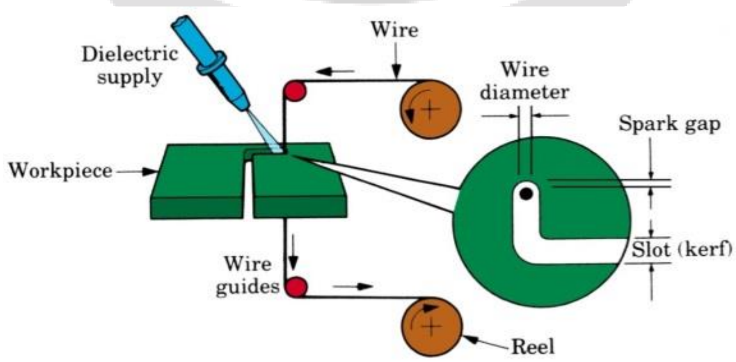

Fig-1: Working principle of WEDM

EDM wire cutting uses a metallic wire to cut a programmed contour in a work piece. Extrusion dies and blanking punches are very often machined by wire cutting. Cutting is always through the entire work piece. To start machining it is first necessary to drill a hole in the work piece or start from the edge. On the machining area, each discharge creates a crater in the work piece and an impact on the tool. The wire can be inclined, thus making it possible to make parts with taper or with different profiles at the top and bottom. There is never any mechanical contact between the electrode and work piece. The wire is usually made of brass or stratified copper, and is between 0.1 and 0.3 mm diameter.

2. INFLUENCE OF PROCESS PARAMETERS ON THE WIRE CUT EDM PROCESS

The main goal of WEDM manufacturers and users is to achieve a better stability of the process and higher productivity. As newer, more exotic materials are developed and more complex shapes are presented, conventional machining operations reach their limitations; hence the increased use of WEDM in manufacturing continues to grow at an accelerated rate. Wire electrical discharge machining manufacturers and user emphasize on achievement of higher machining productivity with a desired accuracy and surface finish. However, due to a large number of variables even a highly skilled operator with a state-of the art WEDM is rarely able to achieve the optimal performance. The optimum utilization of the capacity of WEDM process requires proper selection of machining parameters. This part of literature review aims to investigate the effect of various process parameters on desirable output. WEDM is complex in nature and is controlled by large number of parameter.

3. LITERATURE BASED ON PROCESS PARAMETERS

3.1 Influence of pulse parameters

In most of the commonly used wire-cut EDM, the pulse on time is the switch-on period of electrical charge to the capacitor bank and the peak current actually the charging current. Before, the capacitor has been charged to the peak voltage, a driving pulse with the preset on and off- time, switches on and off the transistors rapidly. Therefore, the gap voltage proceeds towards the full value step by step. The pulse on time, peak current and the capacitance determine the number of steps to reach the peak value. If the on time and peak current are sufficient and the capacitance is small enough, the gap voltage can take only one step to jump to the peak value.

3.2 Influence of wire positioning

It was concluded that the fundamental limit on machining accuracy is due to the dimensional consistency of the wire, and the positional accuracy of worktable. However, other factors conspire to prevent this theoretical precision from being achieved. Most of the uncertainties arise because the working region is an unsupported section of the wire, remote from the guides. It is necessary to hold the wire in a designated position against the object because the wire repeats complex oscillations due to electrical discharge between wire and the work piece. It may also be noted that the unsupported length of wire changes with thickness of the job endanger the wire vibration frequency. The computer controlled positioning system constantly maintains the gap between the wire and the work piece. Disturbances from the external and internal sources generate vibrations in the wire, which ultimately influence the repetitive sparking process in spite of the controlled positioning system. This deviation of the electrode from its mean position therefore has considerable influence on the occurrence of the next discharge. It also influences the breakdown voltage of the discharge and the discharge energy since the gap is changing continuously during the vibration.
It was reported that the amplitude of the vibrations can easily reach 10μm or more, and cannot be neglected. Most commercial machines are specially designed for rigidity to minimize the tool deflection, even though it is not possible to completely eliminate the influences, which tend to displace the wire from its mean position.

3.3 Influence of wire tension

Within considerable range, an increase in wire tension significantly increases the cutting speed and accuracy. The higher tension decreases the wire vibration amplitude and hence decreases the cut width so that the speed is higher for the same discharge energy. However, if the applied tension exceeds the tensile strength of the wire, it leads to wire breakage (Fig-2). Moreover excessive amplitude of equivalent to the spark gap length might cause short-circuit.

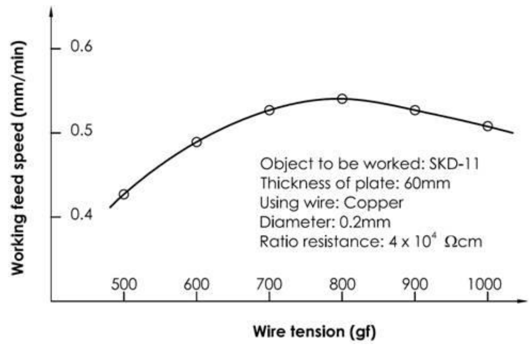

Fig-2: Change in cutting speed with wire tension

3.4 Influence of wire material composition

A desirable wire material for WEDM electrode should possess the properties such as adequate tensile strength with high fracture toughness, high electrical conductivity [% IACS - International Annealed Copper Standard, a unit of electrical conductivity for metals and alloys relative to a standard annealed copper conductor; an IACS value of 100% refers to a conductivity of 5.80×10^7 siemens per meter (58.0 MS/m)], good flushing ability, low melting point and low energy requirement to melt and vaporize.

It was reported that the machining rates increase with increase in Zn content in the wire. Higher the Zn content allows lower servo voltage (mean machining voltage), thereby making short circuiting difficult. The machining is known to increase with the increase in Zinc content. This is because of cooling due to zinc evaporation and also because the Zinc oxide coating on the surface helps to prevent short circuits.

3.5 Influence of work piece material

Researchers have also communicated that specific physical, metallurgical, and electrical properties of the work piece material also influence the process. These properties include how well the metal is polished, its magnetic condition, and how the metal was removed from the heat treatment process when it was produced. One must also consider the phenomenon of expansion and contraction according to the temperature of the material. For material processed by EDM or WEDM, the initial surface condition affects the results. A low melting point in the material increases the material removal rate and improper heat treatment of the metal results in distortion, breakage of the die and punches while machined by WEDM.

3.6 Influence of thickness work piece

In the WEDM process, cutting speed decreases as the thickness of the work piece increases. Normally, WEDM uses a transistor controlled capacitor circuit in which the cutting speed is controlled by a capacitor value. When using a fixed capacitor to machine a thicker work piece, the cutting speed is decreased.

It was reported that the thicker the work piece, the faster is the cut, all other factors being equal. In any EDM operation, every pulse does not produce a spark. However, the longer length of wire electrode in a thicker work piece provides more opportunities for the spark to occur. This makes the process more efficient for a thicker work piece.

3.7 Influence of flushing and dielectric fluid

The commonly used flushing methods are immersion, spray or jet flushing. Figure 3, shows the curve of influence of flushing pressure on machining speed and surface roughness. The cutting performances during roughing cuts have been improved since the removed particles in the machining gap are evacuated more efficiently (the pressure must be reduced during finishing in order to avoid geometrical part errors). It can be seen that when flushing pressure is less than certain pressure value, it is impossible to do any machining. Along with increased flushing pressure the machining speed also increases, but when it is over 1 kg/cm^2 (98066.5Pa), the increased trend slows down while the surface roughness improves gradually with increased flushing pressure due to effective removal of debris. When flushing pressure is less than 0.3kg/cm^2 (29420Pa), high temperature is easily registered along electric discharge area.

The dielectric fluid and the flushing thereof perform following functions:

- To insulate the gap before a large amount of energy is accumulated
- To concentrate the discharge energy to a small area (insulator)
- To recover a desired gap condition after the discharge by cooling the gap and de-ionizing (cooling)
- To flush away the debris of the work piece removed by spark (flushing medium)

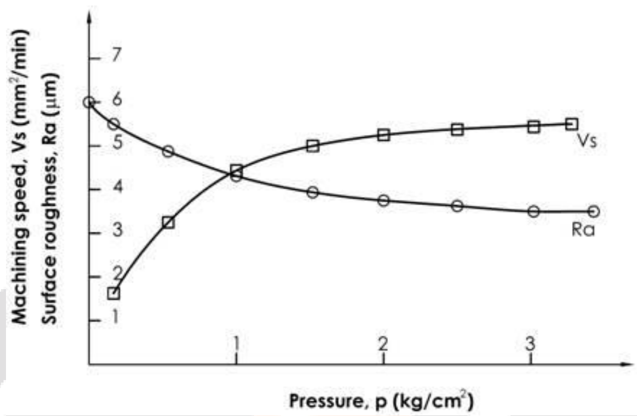

Fig- 3: Influence of flushing pressure on surface roughness, machining speed

4. CONCLUSIONS

Wire-cut electrical discharge machining is one of the most emerging non conventional manufacturing processes for machining hard to machine materials and intricate shapes which are not possible with conventional machining methods. This is more efficient and economical for machining hard to machine materials. The effect of various parameters and setting of various parameters at their optimal levels is very much required for manufacturers. From the literature, the parameters and their effects observed are given as under.

A. Higher the pulse-on time, higher will be the energy applied there by generating more amount of heat energy during this period. Material removal rate and wire wear rate increase with increase in pulse on time where as surface finish will decrease.

B. Reducing pulse off time can increase cutting speed, by allowing more productive discharges per unit time. However, reducing off time, can overload the wire, causing wire breaks and instability of the cut by not allowing enough time to evacuate the debris before the next discharge.

C. Servo voltage acts as the reference voltage to control the wire advances and retracts. At higher value of SV the gap between work piece and wire becomes wider and it decreases the no of sparks, stabilizes electric discharge and the rate of machining slows down. Whereas at smaller value of SV, the mean gap becomes narrow which leads to an increase in number of electric sparks, speed up the machining rate and unstable discharge results in wire breakage.

D. Peak current is the amount of power used in discharge machining and is measured in unit of amperage. The current increases until it reaches a preset value during each pulse on time, which is known as peak current. Peak current is governed by surface area of cut. Higher peak current is applied during roughing operation and details with large surface area. MRR directly increases with increased peak current.

E. Gap voltage is also called open circuit voltage and specifies the supply voltage to be placed on the gap, greater this value, the electric discharge becomes greater. If the gap voltage increases, the peak current will also increase which leads to higher MRR.

F. Dielectric flow rate is the rate at which the dielectric fluid is circulated. Flushing is important for efficient machining.

G. As the wire feed rate increases, the consumption of wire and cost of machining will increase. Low wire speed will cause wire breakage in high cutting speed.

H. If the wire tension is high enough the wire stays straight otherwise wire drags behind. Within considerable range, an increase in wire tension significantly increases the cutting speed and accuracy. The higher tension decreases the wire.

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