A Review on Machining Parameters and optimization of Wire EDM Process

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Abstract:

Wire cut Electrical Discharge Machining (WEDM) is a non-traditional machining process which is based on thermoelectric energy between the workpiece and an electrode. The increase in the demand of higher surface finish and increased material removal rate requires newer and better techniques which are more efficient. Wire Electrical Discharge Machining is one such type of process which can 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. It works on the principle of spark erosion and is capable of machining the materials irrespective of their hardness and toughness. WEDM is used in tool and die making industries, automobiles, aerospace, nuclear, computer and electronics industries. Brass wire is used extensively as a wire electrode in WEDM. Various high performance electrodes like zinc coated, diffusion annealed, coated steel core wires etc. have been developed to satisfy the machining needs. 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), wire wear ratio (WWR) and work related development in wire electrode's materials.

Keywords: Wire cut EDM, Process Parameters, Ra and WWR

Introduction:

Wire electrical discharge machining (EDM) is a non-traditional machining process that uses electricity to cut any conductive material precisely and accurately with a thin, electrically charged copper or brass wire as an electrode. During the wire EDM process, the wire carries one side of an electrical charge and the workpiece carries the other side of the charge. When the wire gets close to the part, the attraction of electrical charges creates a controlled spark, melting and vaporizing microscopic particles of material. The spark also removes a miniscule chunk of the wire, so after the wire travels through the workpiece one time, the machine discards the used wire and automatically advances new wire. The process takes place quickly—hundreds of thousands of sparks per second—but the wire never touches the workpiece. The spark erosion occurs along the entire length of the wire adjacent to the workpiece, so the result is a part with an excellent surface finish and no burrs regardless of how large or small the cut. Wire EDM machines use a dielectric solution of deionized water to continuously cool and flush the machining area while EDM is taking place. In many cases the entire part is submerged in the dielectric fluid, while high-pressure upper and lower flushing nozzles clear out microscopic debris from the surrounding area of the wire during the cutting process. The fluid also acts as a non-conductive barrier, preventing the formation of electrically conductive channels in the machining area. When the wire gets close to the part, the intensity of the electric field overcomes the barrier and dielectric breakdown occurs, allowing current to flow between the wire and the workpiece, resulting in an electrical spark.(fig.1)

On most wire EDM machines, the path of the wire is controlled by computer numerically-controlled (CNC) diamond guides, which can move independently of each other on multiple axes for tapered cuts and complex shapes such as small-radius inside corners and narrow slots. Additionally, wire sizes vary from 0.012" diameter down to 0.004" for high-precision work. Wire EDM is capable of holding tolerances as tight as +/-0.0001".Wire EDM provides a solution to the problems encountered when trying to machine materials that are normally difficult to work with, such as hardened steel, aerospace-grade titanium, high-alloy steel, tungsten carbide, Inconel, and even certain conductive ceramics.

One requirement of the wire EDM process is a start hole for threading the wire if the part's features do not allow you to cut an edge. Wire EDM can only machine through features; however, we can quickly drill a hole in any conductive material using another type of EDM, small hole drilling or "hole pop" EDM.

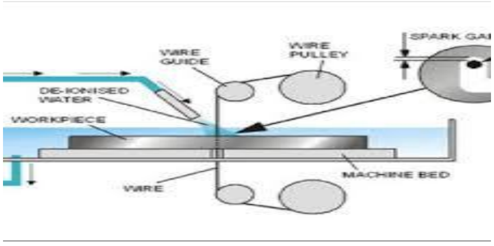

Fig 1.Wire EDM operating system

Parameters of Wire Edm

1)*Pulse on Time* - It is the duration of time for which the current is allowed to flow in each cycle. It is denoted as Ton and expressed in micro seconds (μs).

2) *Pulse off Time* – It is the duration of time between two simultaneous sparks. It is also called pulse interval. It is denoted as Toff and expressed in micro seconds (μs).

3) *Spark Gap* - It is the distance between the electrode and the work-piece during the EDM process. 4) Peak Current - It is the maximum value of the current passing through the electrodes for the given pulse. It is denoted by IP and expressed in amperes (A).

5) *Spark Gap Voltage* - It gives the specific voltage for the actual gap between the work piece material and the wire. The spark gap voltage is also known as open circuit voltage. It is denoted by SV and expressed in volts (V).

6) *Wire Feed* - The rate at which the wire travels along the wire guide path and is fed for generating the sparks is called wire feed rate.

7) *Wire Tension* - How much the wire is to be stretched between upper and lower wire guides is determined by the wire tension.

8) *Pulse Peak Voltage* - Pulse peak voltage setting is for selection of open gap voltage.

9*) Dielectric Pressure* - Dielectric Pressure is the pressure of the dielectric fluid which surrounds the work piece and the wire. It is the rate at which this fluid is circulated in the tank.

Literature review:

Harish H J1, Ravikiran B S2, Bhaskar HB3 1 Material removal rate of both the Al7003 alloy and Al7003+ 6 wt. % TiO2 composite material decreases as the servo voltage increases. Material removal rate of the Al7003 alloy and Al7003+ 6 wt. % TiO2 composite material increases with increases in Pulse on time (TON), the Pulse on time parameter has direct effect on the material removal rate. When the Pulse off time (TOFF) is increased the material removal rate is decreased.

Jayant Vikram Singh1, Mohd Faizan Hasan 2, Syed Asghar Husain Rizvi3 2 optimization of input machining parameters in Wire-Electrical Discharge Machining of EN24 using L9 orthogonal array of Taguchi method. As we increase the current, the MRR tends to increase but with further increase in Ip the MRR tends to reduce. The reason for drop of MRR at 6A current is due to the breakdown of spark in the dielectric due to the presence of debris of removed material between the spark gap. A small time is available to clear the gap between two consecutive sparks. Peak current is the second most influencing parameter for MRR and has a contribution of 21.65%. MRR reduces with increase in pulse on time. Pulse on time is the most dominating parameter for MRR and has a contribution of 56.05%. In the case of wire tension, a similar trend is followed as that focase of pulse on time. In the case of wire tension, a similar trend is followed as that for the case of pulse on time. The MRR reduces with increase in wire tension. Wire tension contributes 18.71% towards MRR. Peak current is the most dominating parameters for wire offset and has a contribution of 52.78% . With Ip, the wire offset initially decreases but with further increase of Ip from 4 A to 6 A, the wire offset increases. This is due to the force exerted by sparks at higher current increases and hence the dimensional shift experienced is more. With pulse on time and wire tension, wire offset show an increasing trend. Pulse on time is the second most influencing parameter for wire offset with 36.11% contribution. As the intensity of spark increases, the force on wire increases and hence the wire offset increases. Wire tension is the least influencing parameter and contributes only 2.78% towards wire offset. The graph obtained is almost flat and has negligible influence on wire offset.

V.Sai Surendra3 The process is done for 8011 aluminum alloy when the machining is done with coolant using Brass coated wire. Actually the surface roughness increases with the increase in Voltage and decreases with increase in Pulse on time, whereas the effect of depth of cut is not regular. It is also found that, the Voltage and depth of cut are both dominant parameters with respect to the MRR. The MRR increases with increase in Voltage and also depth of cut, but the effect of pulse on time is not regular.

K Venkatarao1 and T Anup Kumar 4 effect of wire tension along with current, pulse on time, and pulse off time on the performance characteristics like spark gap, surface roughness, amplitude wire vibration, and cutting rate were studied in WEDM process of Inconel 718 metal. frequency and amplitude of the wire displacement at the top of the plate was found to be more when compared to the bottom of the plate and it results in a tapered groove.

S. Banerjee1, S. Mitra2, B. Panja5 Taguchi orthogonal array is employed to optimize the WEDM process parameters with respect to surface roughness of EN47 spring steel. It is seen that pulse on time and wire feed rate have the most significant influence in controlling roughness characteristics of the material. The interaction of pulse on time and pulse off time and pulse on time and wire feed have adequate contribution to control the roughness behaviour. The optimal parameter combination for minimum surface roughness is obtained as Ton3Toff3WF1V1 i.e., highest levels of pulse on time and pulse off time along with lower level of wire feed and gap voltage. The surface roughness is reduced by about 26 % from initial to optimal.

Ajay Sharma2, Amit Sethi6 for W EDM process the effect of current, pulse-on time, pulse off time and voltage has been investigated. The effect of input parameter on output response like Surface roughness were analyzed for work material EN36. L9 orthogonal array based on Taguchi design and ANOVA was performed for analyzing the result. And the optimal parameters values are the current (6),voltage(70),pulse on time(5),pulse off time(3).The most predominant factor for the SR is current, rest three factors (pulse on time, pulse off time, voltage) has less impact as compared to the current.

Veeresh Murthy, B. M. Rajaprakash7 The optimum process parameters in WEDM for higher MRR and lower Ra is determined for Al 7075-T651 alloy using Taguchi"s technique. WEDM parameters for higher MRR determined is TON=106, TOFF=40 and SV=15 and for lower Ra, TON=100, TOFF=40 and SV=15. TON is the most significant WEDM parameter for higher MRR and lower Ra.

Abhinay Kumar Rajak, Subodh 8Kumar In this work, it is intended to study the maximizations of MRR and minimization of surface roughness of Hot Die Steel 13 with WEDM process. Based on Taguchi optimization method the optimum input parameter setting obtain for maximum MRR are TON = 60, POFF =8 and feed = 50 and similarly optimized condition to get minimum surface roughness TON =40, TOFF = 7 and feed = 70. ANOVA analysis show that in case of MRR, TON and TOFF have significant factor as (p=0.50) and (p=0.048) on Hot Die Steel – 13 and in case of surface roughness, TOFF has significant factor as (0.027).

DWAIPAYAN De 1, TITAS Nandi 2, ASISH Bandyopadhyay3 9 The 3-D response surface and contour plots show that Pulse on Time (TON) plays a vital role as input parameters and influences the output responses. With the increase in TON both MRR and Ra value increases simultaneously. Pulse on Time (TON) shows this behaviour irrespective of other parameters position in center line value. P. Hema1* and U. Sainadh2 It is observed that based on % contribution values, pulse peak current has great influence on kerf width It is observed that based on %contribution values, pulse on time has great influence on material removal rate.

Conclusion:

From the present study, it is found that all of the input parameters significantly affect the Wire EDM process. Among the significant factors pulse on time, pulse off time and peak current has the maximum influence on the entire process. Wire feed, wire tension and water pressure has the minimum effect on the process. Therefore it is essential to optimize the process parameters to achieve the desire results. So here are some points which always kept in mind during research work on WEDM process parameters - Higher the value of current, intensity of spark is increased and results in high Material Removal Rate. - The Surface Roughness can be improved by decreasing both pulse duration and discharge current. - The increasing pulse duration and open circuit voltage increase the wire wear ratio whereas the increasing wire speed decreases it. - The new developed high cutting speed wires can increase the production rate by a significant amount as compared to generally used brass wire and zinc coated wire.

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