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PARAMETRIC OPTIMIZATION TECHNIQUE IN WIRE CUT ELECTRICAL DISCHARGE MACHINING: AN OVERVIEW

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ABSTRACT
Electro Discharge Machining (EDM) is an emerging technology in the field of machining to fabricate very complex micro products. Wire EDM is a very complex process involving the different process parameters. The experiments are often time consuming and costly. It 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,but recent development in material have become a difficult task for WEDM process to be used for machining alternative in future,so there is need to make continuous improvement in current WEDM process to increase their productivity and efficiency in WEDM have directly contributed to increased cutting speed and dimensional accuracy. This paper reviews the various notable works in the field of WEDM and emphasis is made on optimization of machining parameters.

KEYWORDS: Wire Cut EDM, Principle, Surface finish , Dimentional accuracy ,Cutting Speed

INTRODUCTION
Electrical Discharge Wire Cutting is commonly known as Wire EDM which is generally use to produce complex two and three dimensional shapes through electrically conductive work pieces. Wire EDM comparatively new in manufacturing and there was first use of it in 1968.By 1975, its popularity was rapidly increasing because the process and its capabilities were becoming better understood by industry. This process is similar to counter cutting with a band saw, a slowly moving wire travels along a prescribed path, cutting the work piece, with the discharge sparks acting like cutting tooth. This is used to cut plates as thick as 300mm, and for marking punches, tools, and dies from hard metals. It can also cut intricate components for the electronics industry. The wire is usually made of brass, copper or tungsten; zinc or brass- coated and multi- coated wires are also used. The wire diameter a typically about 0.3mm for rough cutting and 0.2mm for finish cutting. The wire should have sufficient tensile strength and fracture toughness as well as high electrical conductivity [1]. In wire EDM, the conductive materials are machined with a series of electrical discharges that are produced between an accurately positioned moving wire (the electrode) and the work piece. High frequency pulses of alternating or direct current is discharged from the wire to the work piece 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 work piece. (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 work piece. 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 [1].

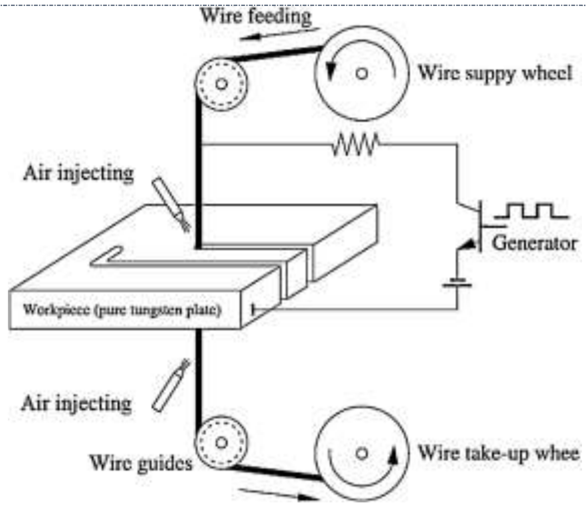

Figure 1: Principle of Wire cut EDM[1]

KEY BENEFITS OF WEDM

- Electrode wear is negligible.
- Forming electrode to produce shape is not required.
- Machined surface are very smooth.
- Dimensional and Geometrical Tolerances are very tight.
- Straight hole production is possible with higher precision.
- Relative tolerance between punch and die is much higher and die life is extended.
- The machine can be operated unattended for long time at high rate.
- No special skills are required to run the machine.
- Any electrically conductive material can be machined irrespective of its hardness.

LITRETURE WORKS

Kannachai kanlayasiri and prajak jattakul (2013) [8] have done simultaneous optimization of dimensional accuracy and surface roughness for finishing cut of wire-EDMed k460 tool steel. They have investigated parametric effect of cutting speed, peak current, and offset distance on dimensional accuracy and surface roughness. They have concluded that both peak current and offset distance have a significant effect on the dimension of the specimen while peak current alone affects the surface roughness. The optimal cutting condition determined at 2 A peaks current and 772 µm offset distance.

S. Sarkar et al (2005) [14] have done parametric analysis and optimization of wire electrical discharge machining of ¥-titanium aluminide alloy in order to get the desired surface finish and dimensional accuracy. They have concluded that both surface roughness as well as dimensional deviation is independent of the pulse off time. They have searched 20 pareto-optimal solutions out from set of all 243 outputs..

Neeraj sharma et al (2013) [10] have done work on multi quality characteristics of WEDM process parameters with RSM on high strength low alloy steel (HSLA) as a work piece material. They have investigated the effect of parameters such as Pulse on Time (TON), Pulse off Time (TOFF), Peak Current (IP), Spark Gap Set Voltage (SV) and Wire Tension (WT) on metal removal rate. They have observed that metal removal rate and surface roughness increases with increase in pulse on time and peak current. Metal removal rate and surface roughness decreases with increase in pulse off time and servo voltage. Wire mechanical tension has no significant effect on metal removal rate and surface roughness.

K. Kanlayasiri and s. Boonmung (2007) [7] have done an investigation on effects of wire-EDM machining parameters on surface roughness of newly developed DC53 die steel. They have investigated machining parameters like pulse-on time, pulse-off time, pulse-peak current, and wire tension using ANOVA technique to find out the parameters affecting the surface roughness. They have concluded that the pulse-on time and pulse-peak current are significant variables to surface roughness of wire-EDMed DC53 die steel. The surface roughness of the test specimen became larger when these two parameters are increased.

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Amitesh goswami and jatinder kumar (2014) [3] have done investigation of surface integrity, material removal rate and wire wear ratio for WEDM of nimonic 80A alloy using GRA and taguchi method. The employed SEM (scanning electron microscope) on the machined samples to investigate the effect and microstructure of the samples after machining. They have concluded that a higher pulse-on time setting leads to thicker recast layer and at lower value of pulse-on time and higher value of pulse-off time, the wire deposition on the machined surface is low. They also have concluded that a pulse-on time (TON) and pulse-off time (TOFF) are the most significant factors for MRR at 95% significance level, with percent contributions of 46% and 33% respectively, the two factor interactions (TON*TOFF and TON*IP) have been found to contribute most to the variation in WWR.

Aniza alias et al (2012) [4] have done work on influence of machine feed rate in machining Titanium Ti-6AL-4V using brass wire and constant Current (4A).they have investigated influence of feed rate on kerf width, material removal rate And surface roughness. they optimized machine feed rate at (4 mm/min), wire Speed at (8 m/min), wire tension at (1.4kg) and voltage at (60v).they have concluded that feed rate plays an important role.

Brajesh kumar lodhi and sanjay agarwal (2014) [5] have done an optimization of machining parameters in WEDM of AISI D3 steel using taguchi technique. They have carried out experiment under varying pulse-on-time, pulse-off-time, peak current, and wire feed and also have employed an orthogonal array, the signal-to-noise (s/n) ratio, and the analysis of variance (ANOVA) to the study the surface roughness. They have concluded that the discharge current is the most influential factors on the surface roughness, also the pulse on time and current have influenced more than the other parameters.

P. Sivaprakasam et al (2014) [11] have done modelling and analysis of micro-WEDM process of titanium alloy (Ti-6AL-4V) using response surface approach. They have investigated the influence of three different input parameters such as voltage, capacitance and feed rate of Micro-wire electrical discharge machining (micro-WEDM) performances of material removal rate (MRR), kerf width (KW) and surface roughness (SR) using response surface methodology with central composite design (CCD).they have concluded that the optimal machining performance of material removal rate, kerf width and surface roughness are 0.01802 mm3/min, 101.5 mm and 0.789 mm, respectively, using this optimal machining conditions viz. Voltage 100 v, capacitance 10 nf and feed rate 15 µm/s.

M.S. Hewidy et al (2015) [9] have done work on Modelling the machining parameters of wire electrical discharge machining of Inconel 601 using RSM.they have investigated the effect of parameter such as: peak current, duty factor, wire tension and water pressure on the metal removal rate, wear ratio and surface roughness. they have concluded that the volumetric metal removal rate generally increases with the increase of the peak current value and water pressure, Wear ratio increases with the increase of the peak current, Surface roughness increases with the increase of peak current and decreases with the increase of duty factor and wire tension. The best surface finish (Ra) that has been reached is 0.8 µm.

R. Ramakrishnan and L. Karunamoorthy (2008) [13]- Authors have done Modeling and multi-response optimization of Inconel 718 on machining of CNC WEDM process. they have performed Experiment on Inconel 718 under different cutting conditions of pulse on time, delay time, wire feed speed, and ignition current in order To predict the performance characteristics namely material removal rate and surface roughness using artificial neural network models. they have concluded that that the pulse on time, delay time and ignition current is influenced more than wire feed speed, But wire feed speed plays a very significant role for allotting equal importance to both responses and by an increase of pulse on time and ignition current, the effect of MRR is improved. But at higher rates of pulse on time and ignition current the surface quality of the work specimen is affected.

Probir Saha et al (2013) [12] have done Multi-objective optimization in wire-electro-discharge machining of TiC reinforced composite through Neuro-Genetic technique on 5 vol% titanium carbide (TiC) reinforced austenitic manganese steel metal matrix composite (MMC).they have found that The process parameters namely pulse on-time and average gap voltage have great influence on the cutting speed and the kerf width and concluded that an increase in the average gap voltage leads to the decrease of the cutting speed but increase in the kerf width, within the parametric range under consideration. It is also observed that an increase in pulse on-time increases both the cutting speed and kerf width.

A.B. Puri and B. Bhattacharyya (2003) [1] have done an analysis and optimisation of the geometrical inaccuracy due to wire lag phenomenon in WEDM. They have determined most influencing factor such as such as: average cutting speed, surface finish characteristic and geometrical inaccuracy caused due to wire lag. They have concluded that The average cutting speed (Vc) is mostly effected by pulse on time, pulse off time and pulse peak current during rough cutting; The surface roughness values (Ra) are influenced mostly by pulse peak current during rough cutting; and pulse on time, pulse peak voltage, servo spark gap set voltage, dielectric flow rate, wire tool offset and constant cutting speed during trim cutting, and The significant factors for geometrical inaccuracy due to wire lag (g) are pulse on time, pulse off time and pulse peak current during rough cutting; and pulse peak voltage, wire tension, servo spark gap set voltage, wire tool offset and constant cutting speed during trim cutting.

J.T. Huang et al (1999) [6] have done Investigation of finish-cutting operation number and machining-parameters setting in wire electrical discharge machining. They have done study on parametric effect of pulse-on time, pulse-off time, table feed-rate, flushing pressure, distance between wire periphery and work piece surface to measure the gap width, the surface roughness and the white layer depth of the machined work piece surface. they have found that the pulse-on time and the distance between the wire periphery and the work piece surface are two significant factors affecting the machining performance, they also have found that a medium Dww (about 30 µm)can achieve a better surface roughness, but the whole surface will not be machined.

CONCLUSION

From the papers referred above many conclusions can be drawn. These are summarized below:

1. Good surface roughness can be generated with a short pulse duration and with a high peak value, which cannot be achieved with long pulses.
2. Decrement in both pulse duration and discharge current can improve surface roughness.
3. Increment in wire speed decreses wire wear ratio and same phenomenon in pulse duration and open circuit voltage increase it.
4. Hardness and strength of material are least significant factor that affect tool wear.

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