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A REVIEW OF EXPERIMENTAL INVESTIGATION OF WIRE EDM FOR ALUMINUM 7075-T6

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ABSTRACT

Wire electrical discharge machining (WEDM) is a specialized thermal machining process which is capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the conventional machines. This practical technology of the WEDM process is based on the conventional EDM sparking factor utilizing the widely accepted non-contact technique of material removal. This paper reviews the various works in field of WEDM and magnifies on effect to machining parameters on MRR, kerf width and surface roughness.

KEYWORDS Zinc coated wire, Tungsten wires, MRR, DOE, Surface Roughness.

I. INTRODUCTION

Wire electrical discharge machining (WEDM) is an indispensable machining technique for producing complicated cut-outs through difficult to machine metals without using high cost grinding or expensive formed tools. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material.

It can machine anything that is electrically conductive regardless of the hardness, from relatively common material such as tool steel, aluminum, copper, and graphite, to exotic space-age alloys including has alloy, was alloy, Inconel, titanium, carbide, polycrystalline diamond compacts and conductive ceramics .Parts that have complex geometry and tolerances don't require you to rely on different skill level so multiple equipments. Most work pieces come off the machine as a finished part, without the need for secondary operations.

II. WORKING PRINCIPLE OF WIRE-EDM

A model of Wire EDM is shown in figure 1.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 work piece. High frequency pulse so 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).Wire EDM uses a travelling wire electrode that passes through the work piece. The wire is monitored precisely by a computer-numerically controlled (CNC) system.

Many sparks can be observed tone 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.

Fig.1: Wire EDM model

The most important performance measures in WEDM are metal removal rate, surface finish, and cutting width. They depend on machining parameters like discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate. Among other performance measures, the kerf, which determines the dimensional accuracy of the finishing part, is of extreme importance. The internal corner radius to be produced in WEDM operations is also limited by the kerf. The gap between the wire and work piece usually ranges from 0.025 to 0.075 mm and is constantly maintained by a computer controlled positioning system.

III. LITERATUREREVIEW

Vikrant Aggarwal, Rajeev Kumar, Atul Goyal [1] studied effect of WEDM processes on material AN31 in WEDM machining. In which, The experiment shows the effect of various parameters like TON, TOFF, IP, Wire Tension and Servo Voltage on the cutting speed, surface roughness, wire wear, cutting time. The EN31 material was used as work piece of dimensions 100 mm X 100mm X 20mm. Twenty Five Square slots of 8mm*8mm*20mm were cut using Brass wire of diameter 0.25mm. And concluded that Input parameters has no significant effect on wire wear.

Pujari shrenivas rao, koona ramaji beela satyanarayana [2] studied the influence of Wire EDM parameter for Surface Roughness, MRR, and White layer machining of Aluminum Alloy. All the machining operation are conducted on ULTRA Cut 843/ ULTRA Cut f2 CNC wire EDM. Process Characterization is made by using ANOVA to identify the key input variables that affects SR and MRR. In which surface roughness measurements are done using a stylus-type profilometer. The cutting speed values which are displayed on the monitor of machine tool are taken for calculation of MRR using the equation MRR = $\mathbf{V_c * {}_B * H}$ **MM³/MIN.** In which they concluded that parameters pulse on time, peak current and spark gap voltage have shown significant effect on booth SR and MRR but different in optimum levels wire tension in SR and pulse off time and servo feed rate in MRR with a high regression coefficient value.

Rao and Sarcar [3] studied the influence of optimal parameters on cutting speed, surface roughness, spark gap, and material removal rate (MRR). He evaluated the optimal parameters such as discharge current, voltage at rated wire speed and tension for brass electrode of size 5-80mm. Mathematical relation was developed for cutting speed, spark gap and MRR. Effect of wire material on cutting Criteria was also evaluated for brass work piece with four wires of different copper percentages. This study is useful for evaluating cutting time for any size of job and to set parameters for required surface finish for high accuracy of cutting. Mathematical relations are helpful for estimating cutting time, custom machining, process planning and accuracy of cutting for any size of job within machine range. Results obtained are helpful for quantification of parameters for quality cuts. Also, results are useful in manufacturing wire EDM system for die and tool steel electrodes.

Nihat, Can, Gul [4] investigated on the effect and optimization of machining parameters on kerf and material removal rate (MRR) in WEDM operations. Experimental studies were conducted using different pulse duration, open circuit voltage, wire speed, and di electric flushing pressure. Importance levels of parameters were analyzed using analysis of variance (ANNOVA). The optimum machining parameter combination was obtained by using the analysis of signal-to-noise(S/N) ratio. The variation of kerf and MRR with machining parameters is mathematically modelled by using regression analysis is method. Objective of minimum kerf together with maximum MRR was performed. The experimental studies were performed on a sodick A320D/EX21WEDM machine tool. CuZn37 Master Brass wire with 0.25 mm diameter was used in the experiments. As work piece material, AISI4140 steel (DIN 42CrMo4) with 200 mm× 40 mm × 10 mm size was used.

S.B. Prajapati, N.S.Patel, V D Asal [5] studied the effect to process parameter like Pulse ON time, Pulse OFF time, Voltage, Wire Feed and Wire Tension on MRR, SR, Kerf and Gap current. Output parameters of Wire EDM of AISIA2 Tool Steel are predicted by using Artificial Neural Network (ANN). ANN was founded a powerful tool for data prediction and it gives agreeable result when Experimental and Predicted Data were compared. Taguchi method is used for Design of Experiment. The control factors considered for the study are Pulse-on, Pulse-off, Bed speed and Current. Three levels for each control factor were used. Based on number of control factors and their levels, L27 orthogonal array (OA) was selected for data collection. From Comparison of Experimental result and ANN Predicted result it was found that they were very close and error was very less. The maximum error is 0.14.ANN is powerful technique for prediction of process parameters giving very accurate result.

Kuriachen Basil, Dr. Joseph kunju Paul, Dr. Jeoju M. Issac [6] Investigates the effect of voltage, dielectric pressure, pulse on-time and pulse off-time on spark gap of Ti6AL4V alloy. It has been found that pulse on time and pulse off time have the more impact on the spark gap. The minimum spark gap was obtained as 0.040407 mm. The WEDM experiments were conducted in Electronic ultra-cut S1 machine using 0.25 mm brass wire as the tool electrode. 'Pulse on time',' pulse off time' ,'voltage' and' dielectric pressure 'are the four WEDM parameters that were selected for investigations. In this experimental study two level full factorial experiment is adopted because this gives all possible combinations of machine parameters. It can be noticed that corresponding to minimum value of pulse off time the spark gap decreases with increase in dielectric pressure, whereas the spark gap increases within crease in Dielectric pressure corresponding to maximum value of pulse off time.

Saurav Datta, Siba Sankar Mahapatra [7] experimented with six process parameters: discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate; to be varied in three different levels. Data related to the process responses viz. material removal rate (MRR), roughness value of the worked surface and kerf have been measured for each of the experimental runs; which correspond to randomly chosen different combinations of factor setting. These data have been utilized to fit a quadratic mathematical model (Response Surface Model) for each of the responses, which can be represented as a function of the aforesaid six process parameters. Predicted data have been utilized for identification of the parametric influence in the form of graphical representation for showing influence of the parameters on selected responses. Predicted data given by the models (as per Taguchi's L27 (3*6) Orthogonal Array (OA) design) have been used in search of an optimal parametric combination to achieve desired yield of the Dimensional accuracy of the product. Grey relational analysis has been adopted to convert this multi-objective Criterion into an equivalent single objective function. The work piece, a block of D2 tool steel with 200 mm × 25 mm×10 mm size, has been cut 100 mm length with 10 mm Depth along the longer length.

IV. OBJECTIVE

Encouraging for the use of Aluminum 7075-T6 Tool Steel instead of Aluminum 6068 Tool Steel due to its less wear resistant property. Finding out the best suitable wire material for machining Aluminum 7075-T6 Tool Steel depending upon requirements such as SR, MRR which directly affects quality of machining and machining time. Also finding out optimum value and effect of input variable parameters such as wire tension, wire speed and injection pressure on Surface Roughness, Material Removal Rate and Kerf Width.

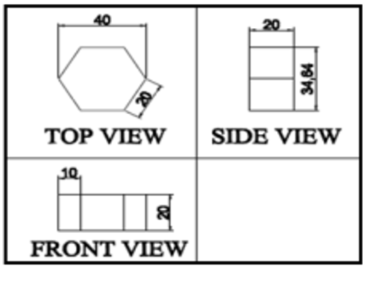
V. EXPERIMENTAL SET UP

Material to be used as work piece: - D2 Tool Steel. Electrode to be used :- Soft brass wire, ½ hard brass wire, ½hard zinc coated wire all of 0.25 mm diameter./Variable input parameters: - Wire speed, wire tension, injection pressure .Hexagonal work piece has to be machined with each side of 20 mm where each side will be one run of DOE table. Experiment has to be done on Ratnaparkhi CNC Wire– EDM.

The Aluminum alloy 7075 T6 is used as work piece for Hexagonal shaped work piece to be cut on W-EDM process to find out the optimum result for machining as shown in figure below.

Full factorial method is used for DOE.A design in which every setting of every factor appears with every setting of every other factor is a full factorial design. Three-level full factorial design is used. The three-level design is written as a 3^k factorial design. It means that k factors are considered, each at 3 levels. This is a design that consists of three factors, each at three levels. It can be expressed as a 3 x 3 x 3 = 27 designs for each wire.

Factors	Level 1	Level 2	Level 3
Wire Speed (m/min)	6	9	12
Wire Tension (Kg)	0.8	1.1	1.4
Pulse Width	1	1	1
Wire material	0	-1	1



VI. FUTURE SCOPE

For researchers there is wide scope for analyzing and developing new technology. Many different types of wire material can be used for machining on a particular material and optimum parameters can be obtained. Also many different work piece materials that can be used for research are Tool Steels, Titanium alloys, EN series, Inconel, Nickel alloys, Aluminum alloys etc.

VII. EXPECTED OUTCOME

The wire materials to be used include plain brass and coated wires. Thus it is likely that the coated wire will be more effective in terms of MRR and Surface roughness but with increased cost and high wear rate. Thus we may use ½ hard plain brass wire which performs reasonably well for the required application with optimized input parameters.

VIII. CONCLUSION

1) For cutting rate and surface roughness, the pulse ON and pulse OFF time is most significant. The spark gape set voltage is

significant for kerf.

2) Open circuit voltage was three times more important than pulse duration for controlling kerf, while for MRR, open circuit voltage was about six times more important than pulse duration.

3) Increase in Input power, value of surface roughness is increase. Increase in Pulse on time, value of material removal rate is increase.

4) Corresponding to minimum value of pulse off time the spark gap decreases within increase in dielectric pressure, whereas the spark gap increases with increase in dielectric pressure corresponding to maximum value of pulse off time.

5) As the machine feed rate increases, the kerf width decreases. Increasing machine feed rate, the MRR will increase simultaneously. Smoother surface can be obtained with low setting of machine feed rate.

6) The parameter pulse on time, peak current and spark gap voltage have shown significant effect on both SR and MRR but differs in optimum levels. Wire tension in SR and pulse off time and servo feed rate in MRR has also shown a significant effect.

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