A Literature Review on Effect of Machining Parameters in Wire – EDM

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Abstract—The recent upgradation of newer and harder materials has made the machining task in WEDM quite challenging. Thus for the optimum use of all the resources it is essential to make the optimum use of parameters to get the best output to increase the productivity. Advances in technology have impacted with an increased cutting speed and tight tolerances in WEDM. This paper reviews the various notable works in field of WEDM and magnifies on effect of machining parameters on MRR, kerf width and surface roughness.

Key words: Brass wires, coated wires, MRR, DOE, Surface roughness, ANOVA

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 [9]. 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 materials such as tool steel, aluminium, copper, and graphite, to exotic space-age alloys including hast alloy, wasp 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 levels or 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 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). 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 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.

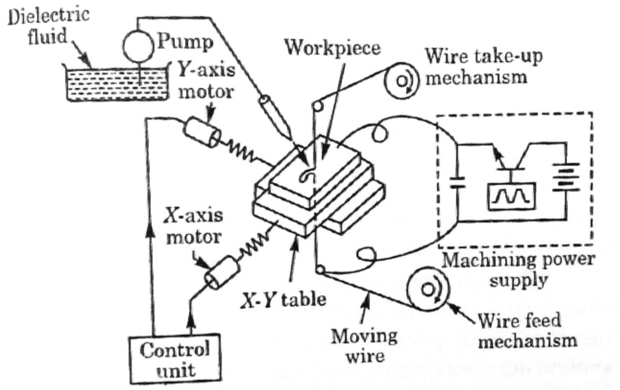

Fig. 1: Wire EDM model

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. LITERATURE REVIEW

S. B. Prajapati, N. S. Patel [1] evaluates the effect of pulse On-Off time, voltage, wire feed and wire tension on MRR, SR, kerf and gap current in Wire EDM. A series of experiments have been performed on AISI A2 tool steel in form of a square bar. Analysis of data optimization and performance is done by Response Surface Methodology (RSM).

Atul J. Patel, Prof. Satyam Patel [2] used Taguchi L9 orthogonal array to find out effects on AISI 304 Stainless Steel of thickness 10 mm in Wire EDM. Input parameters such as pulse On-Off time, wire tension and input power have been used to evaluate their influence on Surface Roughness and Material Removal Rate. Mathematical relations between input parameters and performance characteristics were established by the linear regression analysis method by using MINITAB software.

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 5-80 mm. 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, cost of 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 dielectric flushing pressure. Importance levels of parameters were analysed 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 method. Objective of minimum kerf together with maximum MRR was performed. The experimental studies were performed on a Sodick A320D/EX21 WEDM machine tool. CuZn37 Master Brass wire with 0.25mm diameter was used in the experiments. As work piece material, AISI 4140 steel (DIN 42CrMo4) with 200mm × 40mm × 10mm size was used.

S. B. Prajapati, N. S. Patel, V D Asal [5] studied the effect of 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 AISI A2 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. Josephkunju 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 0.040407mm. 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 with increase in dielectric pressure corresponding to maximum value of pulse off time.

Aniza Alias, Bulan Abdullah, Norliana Mohd Abbas [7] aims to investigate the influence of feed rate on the performance of WEDM on Titanium Ti-Al-4V. Brass wire was employed as the electrode for the investigation. The best combination of machining parameter viz. machine feed rate (4 mm/min), wire speed (8 m/min), wire tension (1.4kg) and voltage (60V) were identified. The selection of parameters depends on the requirements based on a better surface roughness or a maximum material removal rate. Hence an appropriate combination of variables can be selected accordingly. Furthermore, this combination can contributes to increase production rates perceptibly by reducing machining time. The outcome of this study will help in improving the quality of Titanium Ti-6Al-4V products as well as minimizing the machining cost to realize the economic potential to the fullest.

Pujari Srinivasa Rao, Koona Ramji, Beela Satyanarayana [8] studied Wire-cut electric discharge machining of Aluminum-24345. Experimentation has been done by using Taguchi’s L18 (21x37) orthogonal array under different conditions of parameters. The response of surface roughness is considered for improving the machining efficiency. Optimal combinations of parameters were obtained by this method. The confirmation experiment shows, the significant improvement in surface finish (1.03µm) was obtained with this method. Multiple linear regression model have been developed relating the process parameters and machining performance and a high correlation coefficient (r2 = 0.97) indicates the suitability of the proposed model in predicting surface roughness. The study shows that with the minimum number of experiments the stated problem can be solved when compared to full factorial design. All the experiments were conducted on Ultra Cut 843/ ULTRA CUT f2 CNC Wire-cut EDM machine. The size of the work piece considered for experimentation on the wire-cut EDM is 25 mm x 20 mm x 10 mm. Increasing the discharge energy generally increases surface irregularities due to much more melting and re-solidification of materials. Hence, it is found that SR tends to decrease significantly with decrease in IP and TON.

Saurav Datta, Siba Sankar Mahapatra [9] 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 process: maximum MRR, good surface finish and 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. 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) Increase in Input power, value of surface roughness is increase. Increase in Pulse on time, value of material removal rate is increase.
3) 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.
4) Corresponding to minimum value of pulse off time the spark gap decreases with 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 increases simultaneously. Smoother surface can be obtained with low setting of machine feed rate.
6) It is found that SR tends to decrease significantly with decrease in IP and TON.

V. FUTURE SCOPE

For researchers there is wide scope for analysing 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, Aluminium alloys etc.

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