

Review on MRR, Kerf Width and Surface Finish in WEDM Process

Dhruv Gajjar¹ Professor Jayesh Desai²

¹M.E Scholar ²Assistant Professor

^{1,2}Department of Mechanical Engineering

^{1,2}L.D.R.P., Gandhinagar

Abstract— Wire electric Discharge Machining (WEDM) is a thermo-electric non-traditional machining process in which material removal takes place through the process of controlled spark generation between a pair of electrodes which are submerged in a dielectric medium. Use of mineral oil based dielectric liquids is the major cause of environmental concerns associated with the WEDM process. In the current work, an independent machining unit has been designed and developed for implementing the wire EDM process. Effect of gap voltage, pulse-on time, peak current, and material removal rate, kerf width and surface finish will be determined. It was experimentally found that although the MRR is higher in wire EDM; surface finish is lower than in dry EDM.

Key words: Kerf Width, Material Removal Rate, Optimization, Surface finish, WEDM

I. INTRODUCTION

Nontraditional machining processes are most commonly used for machining of high strength material in industries & increase in the availability and use of difficult-to-machine materials. Wire EDM Machining (also known as Spark EDM) is an electro thermal production process in which a thin single-strand metal wire (usually brass) in conjunction with de-ionized water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material.

A thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically deionized water. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods. Due to the inherent properties of the process, wire EDM can easily machine complex parts and precision components out of hard conductive materials.

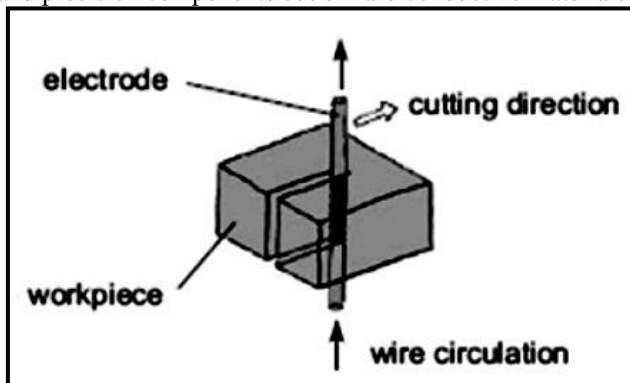


Fig. 1: Wire Electro Discharge Machining

WEDM machine tool consists of number of auxiliary components and drive mechanisms to control the complex machining process. WEDM machine tool comprises of a main worktable (X-Y) on which the work

piece is clamped; an auxiliary table (U -V) and wire drive mechanism. The main table moves along X and Y-axis and it is driven by the D.C servo motors. The travelling wire is continuously fed from wire feed spool and collected on take up spool which moves through the work piece and is supported under tension between a pair of wire guides located at the opposite sides of the work piece. The lower wire guide is stationary whereas the upper wire guide, supported by the U-V table, can be displaced transversely along U and V-axis with respect to lower wire guide. The upper wire guide can also be positioned vertically along Z-axis by moving the quill. As the process proceeds, the X-Y controller displaces the worktable carrying the work piece transversely along a predetermined path programmed in the controller. While the machining operation is continuous, the machining zone is continuously flushed with water passing through the nozzle on both sides of work piece. Since water is used as a dielectric medium, it is very important that water does while the machining operation is continuous; the machining zone is continuously flushed with water passing through the nozzle on both sides of work piece. Since water is used as a dielectric medium, it is very important that water does not ionize. Therefore, in order to prevent the ionization of water, an ion exchange resin is used in the dielectric distribution system to maintain the conductivity of water.

II. WORKING PRINCIPLE OF WIRE – EDM

In WEDM, the erosion mechanism has been described as melting and/or evaporation of the surface material by the heat generated in the plasma channel. A spark is produced between the wire electrode and work piece through deionized water, (used as dielectric medium surrounding the workpiece) and erodes the workpiece to produce complex two and three dimensional shapes.

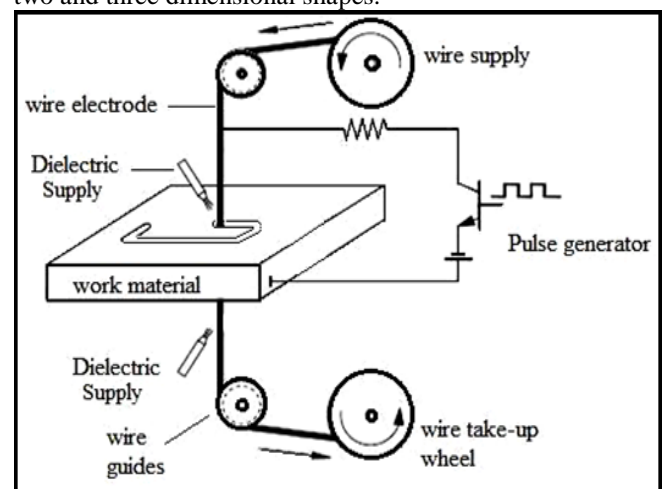


Fig. 2: Schematic diagram of working of WEDM

The important output parameter is MRR, Surface roughness and kerf width. they depend on machining parameters like pulse on time, pulse off time, servo voltage,

peak current, gap voltage, wire speed, wire tension, dielectric flow rate.

III. LITERATURE REVIEW

Many investigators have suggested various methods to find out MRR, Kerf width and surface finish in WEDM.

Rajmohan T. et al. have studied on optimization of machining parameters in electrical discharge machining of 304 stainless steel. Author experimented that the effect of electrical discharge machining parameter such as pulse on time, pulse off time, voltage and current on material removal rate in 304 stainless steel was studied. The experiment was carried out as per design of experiments approach using L9 orthogonal array. The results were analyzed using analysis of variance and response graphs. From this study, it is found that different combination of EDM process parameters is required to achieve higher MRR for 304 stainless steel. Signal to noise ratio and analysis of variance is used to analyze the effect of parameters towards the MRR is also identified. Author concluded that, the current and pulse OFF time are most significant machining parameter for MRR in EDM of 304 stainless steel. For EDM of 304 stainless steel. Based on minimum number of trails conducted to arrive at the optimum cutting parameters, Taguchi method seems to be an efficient methodology to find the optimum cutting parameters. [1]

Vishal parashar et al. have studied Investigation and Optimization of Surface Roughness for Wire Cut Electro Discharge Machining of SS 304L using Taguchi Dynamic Experiments. Optimization of surface roughness using Taguchi's dynamic design of experiments is proposed for WEDM operations. Experimentation was planned as per Taguchi's L'32 mixed orthogonal array. Each experiment has been performed under different cutting conditions of gap voltage, pulse ON time, pulse OFF time, wire feed and dielectric flushing pressure. Stainless Steel grade 304L was selected as a work material to conduct the experiments. From experimental results, the surface roughness was determined for each machining performance criteria. Signal to noise ratio was applied to measure the performance characteristics deviating from the actual value. Finally, experimental confirmation was carried out to identify the effectiveness of this proposed method. The authors conclude that, the S/N ratio with Taguchi's parameter design is a simple, systematic, reliable and efficient tool for optimizing the performance characteristics of WEDM process parameters. The effect of various machining parameters such as gap voltage, pulse on time, pulse off time, wire feed speed and flushing pressure were studied while machining of SS 304L. Pulse On time is the most influencing machining parameter for surface roughness. The gap voltage, pulse off time and flushing pressure as the little effect on surface roughness. The wire feed has the lowest effect on the surface roughness. The confirmation test indicates that it is possible to decrease the surface roughness by using the proposed Taguchi methodology. The surface roughness is decreased by 2.15 times. [2]

A.Rehman et al. have studied Kerfs width analysis for wire cut electro discharge machining of SS 304L using design of experiments. Statistical and regression analysis of kerf width using design of experiments is proposed for WEDM operations. Experimentation was planned as per Taguchi's

L'32 mixed orthogonal array. Each experiment has been performed under different cutting conditions of gap voltage, pulse on time, pulse off time, wire feed and dielectric flushing pressure. Stainless steel grade 304L was selected as a work material conduct the experiments. From experimental results, the kerf width was determined for each machining performance criteria. Analysis of variance (ANOVA) technique was used to find out the variables affecting the kerf width. Assumptions of ANOVA were discussed and carefully examined using analysis of residuals. Variation of the kerf width with machining parameters was mathematically modeled by using the regression analysis method. The authors concluded that, the application of statistical analysis coupled with Taguchi design of experiments is simple, effective, and efficient in developing a robust and versatile EDM process. Results from this study were in agreement with findings in literature in which kerf width of EDMed work piece depended on gap voltage, pulse on time, pulse off time, wire feed and flushing pressure (3, 6, 8 & 9). The parameters affecting the kerf width were identified using ANOVA technique. Assumptions of ANOVA were tested using residual analysis. After careful testing, none of the assumptions was violated. Results showed that, pulse on time and dielectric flushing pressure are the most significant factors, while gap voltage, pulse off time and wire feed are the less significant factor to the kerf width of wire EDMed SS304L. Finally a mathematical model was developed using multiple regression method to formulate the gap voltage, pulse on time, pulse off time, wire feed and dielectric flushing pressure to the kerf width. [3]

S. sivakiran et al. studied of Effect of Process Parameters on MRR in Wire Electrical Discharge Machining of En31 Steel. To study the influence of various machining parameters Pulse on, Pulse off, Bed speed and Current on metal removal Rate (MRR).The relationship between control parameters and Output parameter (MRR) is developed by means of linear regression. Taguchi's L16 (4*4) Orthogonal Array (OA) designs have been used on EN-31 tool steel to achieve maximum metal removal rate. Author concluded that, the better Parameter setting is Pulse on 24 μ s, pulse off 6 μ s, Bed speed 35 μ m/s and Current to obtain maximum metal removal rate. The order strength of parameters are found from response table is current, pulse on, Bed speed and pulse off. Regression analysis is used to predict the MRR with 6.77% error. [4]

Singaram Lakshmanan et al. have studied, Optimization of Surface Roughness using Response Surface Methodology for EN31 Tool Steel EDM Machining. The work piece material was EN31 tool steel. The pulse on time, pulse off time, pulse current and voltage were the control parameters of EDM. RSM method was used to design. Author concluded that, The various 2nd order response equation have been modeled and validated with ANOVA The optimum level of process parameter for five surface roughness measurement has been arrived at followed by conformation experiment for validation. [5]

Brajesh kumar lodhi and sanjay agarwal studied Optimization of machining parameters in WEDM of AISI D3 Steel using Taguchi Technique. In this work, an attempt has been made to optimize the machining conditions for surface roughness based on (L9 Orthogonal Array) Taguchi

methodology. Experiments were carried out under varying pulse-on-time, pulse-off time, peak current, and wire feed. An orthogonal array, the signal-to-noise (S/N) ratio, and the analysis of variance (ANOVA) were employed to study the surface roughness in the WEDM of AISI D3 Steel. It was observed that the discharge current was the most influential factors on the surface roughness. Authors concluded that, the Taguchi's parameter design is a simple, systematic, reliable, and more efficient tool for optimization of the machining parameters. The effect of various machining parameter such as pulse-on time, pulse off time, peak current and wire feed has been studied through machining of AISI D3 steel. It was identified that the pulse on time and current have influenced more than the other parameters considered in this study. Result shows that the errors associated with SR are only 3.042 %. Thus the optimized condition, not only makes the WEDM a more commercially viable process for industrial applications, but also turns a spotlight on WEDM process as a promising field for further advancements. [6]

Gaurav Raghav et al. studied Optimization of Material Removal Rate in Electric Discharge Machining Using Mild Steel. There aims at achieving the integrated approach to solve the optimization problem of EDM process. At any stage, the dominance factor of the input variables and output variables contained in the constraints and objective functions can be computed. In the present work, relationships have been developed between the input decision variables and the desired goals by applying the statistical regression analysis of investigations obtained by Electro Discharge machining process for a considerable variation in the crisp sets of variables. The objective functions were maximized or minimized by using the generalized Genetic Algorithms and the data are stored for a given set of objectives. The results are interpreted with respect to those obtained by using the bi-criterion approach. It is concluded that the results obtained by bi-criterion approach are approximately of the same order of accuracy as calculated experimentally but the computational simplicity of this method makes this methodology favorable to use to solve such mechanical engineering complex problems. Author concluded that, the present method adopted to solve the optimization problem of EDM process is simple enough and is flexible in selection of objective functions and the constraints for such machining processes. At any stage, the dominance factor of the input variables and output variables contained in the constraints and objective functions can be computed. This technique helps in getting the reliable multi-objective decisions under constrained penalties for the constrained optimization of such processes. During the solution of the problem, it has been found that the results obtained by the bi-criterion approach show their convergence towards the exact solutions obtained by optimization of objective functions under min-max condition. However, the absolute values of the objective function differ significantly for their absolute values under max-max or min-min condition. [7]

Amit Kohli et al. studied Optimization of Material Removal Rate in Electrical Discharge Machining Using Fuzzy Logic. The objective of present work is to stimulate the machining of material by electrical discharge machining (EDM) to give effect of input parameters like discharge current (Ip), pulse

on time (Ton), pulse off time (Toff) which can bring about changes in the output parameter, i.e. material removal rate. Experimental data was gathered from die sinking EDM process using copper electrode and Medium Carbon Steel (AISI 1040) as work-piece. The rules of membership function (MF) and the degree of closeness to the optimum value of the MRR are within the upper and lower range of the process parameters. It was found that proposed fuzzy model is in close agreement with the experimental results. By Intelligent, model based design and control of EDM process parameters in this study will help to enable dramatically decreased product and process development cycle times. Author concluded that, the operation of fuzzy logic to evaluate the response of the output parameter. After comparison between the experimental values and the values generated by fuzzy operation were found to be interrelated with accuracy of 97.36%. During the research the fuzzy logic system was found to be more simple to evaluate and responsive than experimental models. Present study favors that the fuzzy logic technique can be introduced as a practicable technique to carry out analysis without conducting actual experiments. [8]

IV. CONCLUSION

This paper represents the effect on MRR, Surface Roughness and Kerf width.

- (1) Pulse on time and pulse off time are more useful for MRR and Surface roughness. Increase in pulse on time increase in the MRR and decreasing the surface roughness.
- (2) Decreasing in the pulse off time decrease the MRR and increase the surface roughness. However more decreasing in the pulse off time leads to wire breakage.
- (3) Servo voltage is affecting the kerf width of the work piece. Higher the servo voltage kerf width increase and lower the servo voltage kerf width decrease.

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