A REVIEW ON PARAMETRIC OPTIMIZATION OF WIRE CUT ELECTRO DISCHARGE MACHINE USING TAGUCHI METHOD ON D2 TOOL STEEL

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Abstract

The main objective of this project is to develop and establish of Cutting procedure by WEDM and investigation of Cutting characteristics of most commonly used D2 Tool Steel Plate. To perform the experiment, an experimental design matrix was constituted using the design of the experiments.

For this purpose, in the Taguchi method, L27 Orthogonal Array was chosen as a statistical tool to build an experimental layout and for the Optimization Taguchi Method. Half Hard Zinc Coated wire will be used for Performing the Experiment on WEDM. Three Process parameters Wire Speed, Pulse ON and Pulse OFF and Wire Feed has been Selected for the Experiment and Other Factors Will be considered as Constant. Cutting Characteristic will be evaluated by Two Responses, Cutting Speed and Kerf Width. ANOVA and Regression Analysis will be performed for Analysis and model Verification and Optimization will be performed by Design Expert Software.

Keywords – *WEDM, Wire-cut, Parametric Optimization, Taguchi*

I. INTRODUCTION

Manufacturing industry is becoming even more conscious about time and quality with Respect to the demand, efficiency, global acceptance and competence, also the need to use complicated and precise components having some special shape with high tolerances. The demand for hard, temperature resistive, tough, abrasive, wear and corrosive resistant material are growing day by day. These market trends have enforced on the use of new and advanced technologies for higher conversion rate of raw materials turning into finished goods; with less or possibly no time being required for tooling and other unnecessary operations. The conventional machining processes, in spite of recent technical advancement, are inadequate to machine complex shapes in hard, high strength temperature resistant alloys and die steels. Keeping these requirements into mind, a number of Non-traditional machining (NTM)/unconventional processes have been developed. The unconventional methods of machining have several specific advantages over conventional methods of machining and these promise formidable tasks to be undertaken and set a new record in the manufacturing technology. These methods are not limited by hardness, toughness and brittleness of materials and can produce any intricate shape on any work piece material by suitable control over the various physical parameters of the processes.

A. WORKING PRINCIPLE OF WEDM

The Spark Theory on a wire EDM is basically the same as that of the vertical EDM process. 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).

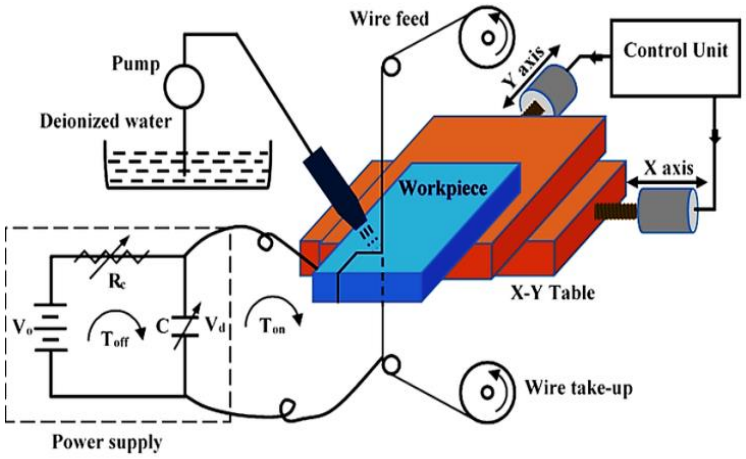

Figure 1: WEDM Process Setup

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.

B. WEDM EFFECTING PARAMETERS:

The process parameters that can affect the quality of machining or cutting or drilling in Wire EDM process are shown through Ishikawa cause – effect diagram as shown in figure.

The major parameters are as follows:

•Electrical parameters: Peak current, pulse on time, pulse off time, supply voltage and polarity.
•Non – electrical parameters: wire speed; work feed rate, machining time, gain and rate of flushing.
•Electrode based parameters: Material and size of wire.
•Dielectric system: Type, viscosity and other flow characteristics.

II. LITERATURE REVIEW

D. Sudhakara et al. **[1]** Wire electrical discharge machining process is an electro thermal modern machining process, is mainly used to cut complicate profiles of dies and mould of engineering materials. In the modern machine tool industry machining time is very important. The machining time is mainly depends upon the gap current. So that optimum conditions are very much required to cut the components in optimum time. The present research work mainly shows the optimization of process parameters of WEDM by Taguchi Design. ANOVA is used to study the effect of process parameters on machining process. The machining parameters investigated are pulse on time(ON) , pulse off time (OFF), Peak current (IP), Spark gap set Voltage(SV), Wire tension (WT) and Water pressure (WP). An L27 orthogonal array has been used to plan and conduct the series of experiments and raw data and S/N ratio are employed to analyze the influence of these parameters on gap current. The main intention is to find out the crucial factors and combination of factors influencing the machining process to achieve the best gap current. In this study MINITAB is used to find out the effect of each parameter on response characteristic and to predict the optimum setting of control parameters. In this study Powder metallurgical cold worked tool Steel is used for the experimental work and ELECTRONICA ULTIMA 1F

Liew Hui Ling et al. **[2]** showed This study presents an experimental investigation of wire electric discharge machining (WEDM) for improving the process performance. The effects of the machining parameters were investigated WEDM) for improving the process performance. The effects of the machining parameters were investigated on the machining performance. Adaptive neuro-fuzzy inference system (ANFIS) was applied to determine the effect of significant parameters on WEDM performance. In addition, ANFIS was used to predict the cutting speed, surface roughness and heat affected zone in WEDM. The predicted cutting speed, surface roughness, and heat affected zone were compared with measured data, and the average predict.

Neeraj Sharma et al. **[3]** Wire electric discharge machine (WEDM) is a spark erosion non conventional machining method to cut hard and conductive material with the help of a wire electrode. High strength low alloy steel (HSLA) is a hard alloy with high hardness and wear resisting property. The purpose of this study is to investigate the effect of parameters on metal removal rate for WEDM using HSLA as work-piece and brass wire as electrode. HSLA used in cars, trucks, cranes,

bridges, roller coasters and other structures that are designed to handle large amounts of stress. It is 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. Response Surface methodology (RSM) is used to optimize the process parameter for metal removal rate and surface roughness. Response Surface Methodology is formulating a mathematical model which correlates the independent process parameters with the desired metal removal rate and surface roughness. The central composite rotatable design (CCRD) has been used to conduct the experiments

Rupesh Chalisgaonkar et al. **[4]** In this research, input parameters such as pulse on time (TON), pulse off time (TOFF), peak current (IP), wire feed (WF), wire tension (WT), and servo voltage (SV) has been selected for process capability investigation in WEDM process. The process capability index was evaluated for machining characteristics such as machined work-piece dimension (MWD) and surface roughness (SR). Taguchi's approach to experiment design and analysis was utilized to study the influence of machining parameters on the process capability index. Single response optimization was performed for both machining characteristics to find out the parametric setting which could optimize WEDM process capability. Surface integrity aspects such as microstructure analysis (including, debris, cracks, and crater size etc.) of the selected machined titanium samples have also been investigated.

Vikram Singh et al. **[5]** The objective of the present work is to investigate the effects of various WEDM process parameters such as pulse on time, pulse off time, servo voltage and wire feed rate on the Material Removal Rate (MRR), Surface Roughness (SR) and cutting rate. Secondly, to obtain the optimal settings of machining parameters at which the Material Removal Rate (MRR) and cutting rate are maximum and the Surface Roughness (SR) is minimum in a range. The experiments were carried out as per design of experiment approach using L27 (34) orthogonal array. In the present investigation, AISI D2 steel specimen is machined by using brass wire as electrode and the response surface methodology (RSM) is used for modelling a second-order response surface to estimate the optimum machining condition to produce the best possible response within the experimental constraints. The results from this study will be useful for manufacturing engineers to select appropriate set of process parameters to machine AISI D2 steel.

Pujari Srinivasa Rao et al. **[6]** The quality of a wire EDM surface is strongly influenced by its parameter settings and material to be machined. The one characterization among the metals for studying its effect is light and heavy metals. Much of the work is concentrated on heavy metals and partly on titanium and magnesium alloys in the light metals. Here, an attempt has been made to study the effect of wire EDM parameters on aluminum alloy because of its growing applications in various industries. In the present research, parametric analysis of wire EDM parameters was performed by Taguchi method on surface roughness (SR) and material removal rate (MRR). The above performance measures are simultaneously optimized by hybrid genetic algorithm with the use of developed linear regression models. The obtained results show a good agreement with experimental values. Finally, for a suggested combination of parameters white layer measurements were also made as it adversely affects many other properties.

Farnaz Nourbakhsha et al. **[7]** This paper presents an experimental investigation of wire electro-discharge machining (WEDM) of titanium alloy. The objective is to investigate the effect of seven process parameters including pulse width, servo reference voltage, pulse current, and wire tension on process performance parameters (such as cutting speed, wire rupture and surface integrity). A Taguchi L18 design of experiment (DOE) has been applied. All experiments have been conducted using Charmilles WEDM. It was also found that the cutting speed increases with peak current and pulse interval. Surface roughness was found to increase with pulse width and decrease with pulse interval. The Analysis of Variance (ANOVA) also indicated that voltage, injection pressure, wire feed rate and wire tension have non-significant effect on the cutting speed. Scanning Electron Microscopic (SEM) examination of machined surfaces was performed to understand the effect of different wires on work piece material surface characteristics. A brief review of WEDM of titanium alloy is also included in the paper.

Ravindranadh Bobbili et al. **[8]** In the current investigation, a multi response optimization technique based on Taguchi method coupled with Grey relational analysis is planned for wire-EDM operations on ballistic grade aluminium alloy for armour applications. Experiments have been performed with four machining variables: pulse-on time, pulse-off time, peak current and spark voltage. Experimentation has been planned as per Taguchi technique. Three performance characteristics namely material removal rate (MRR), surface roughness (SR) and gap current (GC) have been chosen for this study. Results showed that pulse-on time, peak current and spark voltage were significant variables to Grey relational grade. Variation of performance measures with process variables was modelled by using response surface method. The confirmation tests have also been performed to validate the results obtained by Grey relational analysis and found that great improvement with 6% error is achieved

Lokeswara Rao et al. **[9]** This paper describes an optimum cutting parameters for Titanium Grade5 (Ti-6Al-4V) using Wire-cut Electrical Machining Process (WEDM). The response of Volume Material Removal Rate (MRR) and Surface Roughness (Ra) are considered for improving the machining efficiency. A brass wire of 0.25mm diameter was applied as

tool electrode to cut the specimen. The Experimentation has been done by using Taguchi's L25 orthogonal array (OA) under different conditions like pulse on, pulse off, peak current, wire tension, servo voltage and servo feed settings. Regression equation is developed for the VMRR and Ra. The optimum parameters are obtained by using Taguchi method. This study shows that the stated problem is solved by minimum number of experiments when compared to full factorial design.

Bijendra Singh Diwaker et al. **[10]** This paper presents an investigation on the effect and optimization of machining process parameters on the Material removal rate (MRR) and surface roughness (SR) in CNC wire electrical discharge machining (WEDM) operations. The cutting of High Chromium High Carbon (HCHC) die steel work piece using CNC WEDM by using Taguchi methodology has been reported. Many experiments were conducted to consider the effect of Current, Voltage, Wire speed and Wire tension on the MRR and SR response. An L9 (3*4) Taguchi standard orthogonal array (OA) is chosen for design of experiments and the main influencing factor are determined for each given machining criteria by using Analysis of variance (ANOVA). We found out the optimal parameter setting for MRR and SR. The analysis of the Taguchi methodology reveals that. In general the Current significantly affect the MRR and SR. Experimental observed values are provided to verify this methodology.

III. CONCLUSION

In the presented work, experiments are carried out for Cutting Speeds and KERF width with variables as pulse on time, pulse off time and Wire Feed. There are 27 experimental readings taken for all variables to conduct the parametric study.
Finally it can be concluded that:
Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it is found that pulse on time at level 3 (60), pulse off time at level 2 (200), Wire Feed at level 2 (4) are the best process parameter for the KERF width and Cutting Speed. Process parameters do not have some little effect for every response. Significant parameters and its percentage contribution changes as per the behaviour of the parameter with objective response. Increase of Pulse on time generates more spark energy as the length of time that electricity supply increases. KERF width response increasing with pulse on time. Pulse on time found most significant parameter in all response. Cutting speed also increases with increase of pulse on time because the increases of pulse on time produce crater with broader and deeper characteristic. Pulse off time has opposite effect to pulse on time. Kerf Width increase with increase of pulse off time, while cutting speed reduces. During off time removed material flushed away. More the off time better the flushing..

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