International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.8, Issue.8, August 2020 E-ISSN: 2347-2693

Optimization of WEDM Development Para-Meter for HDS H13 BY Using Taguchi Orthogonal Array: Novel Approach

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Available online at: www.ijcseonline.org

Received: 11/Aug/2020, Accepted: 24/Aug/2020, Published: 31/Aug/2020

Abstract—Wire electrical discharge machining is extensively used in machining of conductive materials. The WEDM process has the ability to machine complex shapes and hard electrically conductive metal components precisely. The main goal of wire electrical discharge machine manufacturers and users are to achieve a better stability and high productivity of the process with desired accuracy and minimum surface damage. The main objectives of the present research are to experimentally study the effect of various process parameters like pulse on time, pulse off time, wire feed, and wire tension on the performance measures like material removal rate, surface roughness and wire wear ratio. WEDM is a widely recognized unconventional material cutting process used to manufacture components with complex shapes and profiles of hard materials. In this paper we are presenting the development of WEDEM process using various pre define parameters using Taguchi method.

Keywords—WEDM, doe, orthogonal array, parameters, Taguchi method, H13, HDS, mean of means, SF, MRR, Ra, etc.

I. INTRODUCTION

Wire electrical discharge machining (WEDM) technology has grown at exception rate since it was first applied more than 30 year ago. In 1974, D.H Dulebohn applied the optical-line follower system to automatically control the shape of the components to be machined by the WEDM process. By 1975, its popularity rapidly increased, as the process and its capabilities were better understood by the industry. It was only towards the end of the 1970s, when computer numerical (CNC) system was initiated into WEDM, which brought about

a major evolution of the machining process [1]. The demands for alloy material having high hardness, toughness and impact resistance are increasing. These material are difficult to be machined by traditional machining methods. Hence, non-traditional or un-conventional machining methods including electrochemical machining, ultrasonic machining, electrical discharging machine etc are applied in machining such difficult to machine materials.

1.1 Basic principle of WEDM process

WEDM is considered as a unique adoption for the conventional EDM process, which uses an electrode to initialize the sparking process. However, WEDM utilizes a continuously traveling wire electrode made of conductive materials like copper, brass or tungsten of diameter 0.05-0.30mm. The wire is kept in tension using mechanical guides. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire. An number from claiming which have been connected on different requisition domains that incorporate telecommunication. [3]

1.2 WEDM PROCESS

Analysis of variance was employed to estimate the significance of WEDM process parameters. The optimization of individual and multiple responses was performed using the desirability analysis to achieve the higher material removal rate, minimum kerf width, and minimum surface roughness.

1.3 H13 PARAMETRS

H13 Tool Steel is a versatile chromium-molybdenum hot work steel that is widely used in hot work and cold work tooling applications. The hot hardness (hot strength) of H13 resists thermal fatigue cracking which occurs as a result of cyclic heating and cooling cycles in hot work tooling applications.

For hot work applications, H13 is used in the hardness range of HRC 38 to 48. The usual hardness range for die casting dies is HRC 44 to 48 requiring a temper at approximately 1100°F. For improved shock resistance, the steel is often tempered at temperatures approaching 1150°F, resulting in harnesses of HRC 40 to 44.

II LITERATURE REVIEW

Devies et al.[2],reviewed several temperature measurement methods and used them in temperature monitoring during material removal in WEDM. There study outline the physics of each method, detailing the source and evaluation of uncertainty. Finally, using critical criteria in measuring.

Puri and Bhattacharya at. el [3],presented an analytical approach for the solution of the wire-tool vibrations in WEDM. They furter considered multiple spark discharge for investigate the effect of wire vibrations.

Kinoshita et al. [4],observed the problems in steep "taper-cutting".These problems were rectified by designing a new guide for electrode wire resulting in better stability of electrical discharge machining(EDM) process.

Scott et al. [5],showed that material removal rate and wire wear ratio were highly affected by pulse on time and pulse off time. They concluded that the surface finish increases with increases in discharge current, pulse duration and wire speed. However they did not provide a single combination of input levels of pulse on time, wire feed, wire tension.

Hascahk & Caydas at. el [6],investigated the surface roughness and tool life based on the parameter design by Taguchi method in the optimization of turning operation. They suggested that tool life is strongly affected by cutting speed and surface roughness by feed rate.

Qu.et al.[7],suggested a mathematical model for calculating material removal rate (MRR) of a cylindrical WEDM process. They applied this model to eliminate the irregularities obtained during machining of cylindrical shape objects. They further designed two experimental configurations to find the maximum material removal rate in cylindrical wire EDM.

Hsue et al.[8],performed the work on corner cutting. The concept of discharge angle was introduced by studying the geometric properties of WEDM. A mathematical expression was derived for the same by analytical geometry of WEDM.

Katz & Tibbles at. el [9],proposed a micro EDM model along with computer simulation for the channel expansion velocity as a function of spark duration. The establishment of a possible process model was aimed at relating input/output parameters. The simulation was linked to dimensionless groups, which was related to micro electro discharges and their effect on metal removal.

Banerjee et. al.[10],developed a simple computational model to estimate the temperatures for varying magnitudes of parameters. They used this distribution to predict the wire failures. Material removal rate, methods were compared and the results were presented in guide format for participants in this field of work.

1.5 Aim & objectives

The experimental study has been made to optimize the process parameters during machining of H-13 by wire electrical discharge machining (WEDM) using Taguchi L9 orthogonal array method. Following input process parameters of WEDM [Pulse-On time (TON), Pulse-Off time (TOFF) and Wire Speed rate (WS) and Wire Tension (WT)] were chosen as variables to study the process output in terms of Material Removal Rate (MRR), Wire wear ratio (WWR), Surface Flatness (SF).

The main objectives of present research work are:
1) To experimentally study the effect of input parameters (pulse on time, pulse off time, wire feed and wire tension) on the performance measures (material removal rate, surface roughness and wire wear ratio) of WEDM.
2) To optimize the performance measures with the help of a statistical method.

III. RESEARCH GAPS AND ISSUES

Many parameters in WEDM like polarity, servo control voltage, short pulse time, ignition pulse current, injection pressure, electric temperature, pulse width, pulse duration, wire tension and wire feed speed which can be changed during the machining process.

The optimization of WEDM a suitable range has to be selected for experiment. The selection of these parameters and experiment design is considered to be a very useful the optimization tasks. It establishes the methods for drawing inferences from observations when these are not exact but subject to variation.

The design of study is done by using Taguchi Method which is explained in this research work which is based on **parameters HDS H13.** In the this experimental work the performance of 3the WEDM by taguchi method model has been studied by considering the various performance measures (material removal rate, wire wear rate, surface flatness) by taking different input parameters (pulse on time, pulse off time, wire tension and Wire feed).

IV. PROPOSED WORK

The main proposed work is that examined for development of WEDM optimization using various pre-define parameters.

- The major input parameters involved in machine working are pulse on time (TON), pulse off time (TOFF), peak current, pulse peak voltage, flushing pressure of water dielectric, wire feed rate (WF), spark gap set voltage, servo feed and cutting speed.
- The performance of the machine can be judged in terms of work specific output parameters like wire wear ratio (WWR), material removal rate (MRR) and surface finish (SR) [4,5]. These parameters are uncontrollable parameters, but they can be optimized by selecting a suitable range of input parameters.
- Highlights the inter relationship of input parameters (pulse on time, pulse off time, wire feed and wire tension) to the performance parameters (material removal rate, wire wear ratio and surface roughness).
- Each experiment was conducted under different conditions of pulse on time, pulse off time, wire

speed, and wire tension. Result of response of material removal rate, wire wear ratio, surface flatness is considered for improving the machining efficiency. Optimal combinations of parameters were obtained by Taguchi's L9 orthogonal array and Mean of Mean approach method.

V. RESEARCH METHODOLOGY

The basic principle involved in WEDM is the conversion of electrical energy in to spark energy. This spark energy is utilized in cutting process of WEDM. The spark generation around the work piece can be controlled by two electrical parameters namely pulse on time and pulse off time. The output characteristics of WEDM are also affected by electrode parameters like wire feed and wire tension [11]. These parameters are explained below:

- Pulse on time(TON)
- Pulse off time (TOFF)
- Wire feed.
- Wire tension.

VI. SIMULATION WORK AND RESULT DETAILS

- Taguchi method based result graph and tables generated for optimization AWEDM process for various parameters HDS H13.
- By using the various parameters development the process of WEDM has determined by various test performance.
- Optimization of WEDM process by using various test determination has been done.
- It is basically novel approach for using Taguchi method for determine the WEDM development process.

Mean response of surface roughness at different level of pulse on time.

Levels	**1**	**2**	**3**
TON	**0.6**	**1.2**	**1.8**
Mean SR	**2.21**	**2.73**	**2.37**

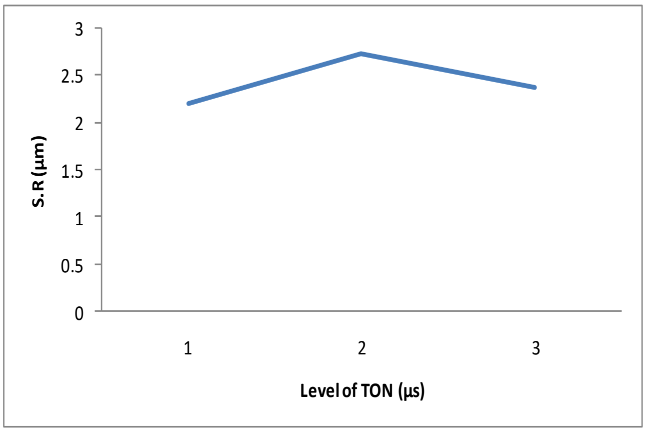

Fig 1.1 Graph represent Mean response of SR vs TON.

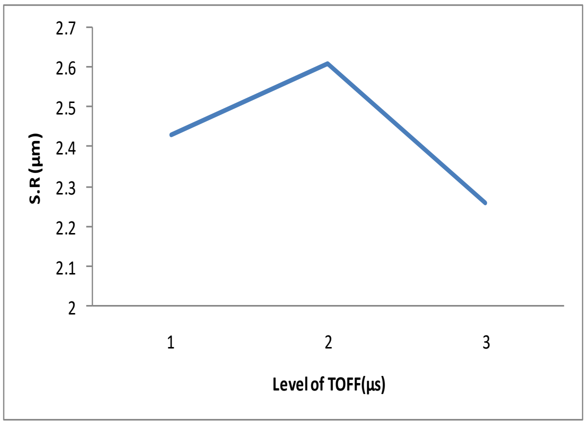

Fig 1.2: Mean response of S.R vs TOFF

VII. CONCLUSION AND FUTURE SCOPE:

This study described the multi objective optimization of the WEDM process parametric design of Taguchi methodology. The effect of various machining parameter such as pulse on time, wire tension, delay time, wire feed speed has been studied through machining of heat treated tool steel. It was identified that the pulse on time have influenced more than the other parameters considered in this study. Moreover the multiple performance characteristics such as material removal rate, surface roughness and wire wear ratio for the WEDM process can be improved concurrently. From the present analysis it is evident that the optimal parametric combination will be very beneficial to the manufacturing communities who are working in the WEDM process.

FUTURE WORK

Basically there are three main categories of machining variables. These are tool variables, work piece variables and set-up variables. Tool variables includes tool material, nose radius, tool wear, tool geometry, tool vibration, machine tool rigidity and tool overhang etc. Work piece variables include work piece material, hardness, length and diameter etc. Set-up variables include cutting speed, feed rate, depth of cut etc. In the present work only few tool variables, work piece variables and few set- up variables of different variety are considered.

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