Review on Experimental Investigation of Process Parameters on the Performance of WEDM Process Using Nicrofer 3718

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Abstract— Parametric optimization of electric discharge machining (EDM) is a challenging task. Many researchers have employed different multi-objective optimization techniques for the same. This work employs multi-response signal-to-noise (MRSN) technique to find the optimum factor/level combination of input parameters. Experiments have been conducted on die-sinking EDM by taking heat treated D2 steel as work piece and copper as tool electrode. Experiments have been designed as per Taguchi's L36 orthogonal array. Two cases v.i.z. high cutting efficiency and high surface finish have been taken. Analysis of variance (ANOVA) is employed to indicate the level of significance of machining parameters in both the cases. Finally, results have been verified experimentally and a significant improvement in material removal rate and surface roughness is observed.

Keywords: WEDM (Wire Electric Discharge Machining), MRR, Ra (Surface Roughness), Nicrofer, Taguchi, molybdenum, pulse on time, current, pulse off time

I. INTRODUCTION

In this process the metal is rapidly removed from the work piece due to erosion by recurring spark discharge. Taking place between equipment and work pieces. Display Mechanical set up and electrical set up and electrical circuits for electrical discharge machining. A thin gap of 0.025 mm is placed between the tool and the work piece by a servo system. Both the tool and the work piece are immersed in a dielectric fluid. Kerosene / EDM oil / deionized water is a very common type of liquid dielectric

A. *Gaseous dielectric is also used.*

Wire-electrical discharge machining (EDM) is a non-traditional machining process in which a pulsed voltage difference between a wire electrode and a conductive work piece initiates sparks which erode work piece material. Removing material in such a way is often advantageous when the work piece material would be difficult to machine with traditional machine tools due to high strength, hardness, toughness, etc. This process has been used in commercial machine tools for nearly half a century. It is well known that the EDM process has a detrimental impact on the surface integrity of machined surfaces. Each spark melts a small portion of the work-piece. A portion of this molten material is ejected and flushed away. The remaining material re-solidifies to form a surface layer known as the recast layer. This layer can contain an altered microstructure, tensile stresses, micro cracks, impurities, and other undesirable features which can lead to premature part failure when put to service. Consequently, wire-EDM cut parts must often be post-processed to remove the negatively affected material. Furthermore, the surface integrity effects are dependent upon both the wire-EDM process parameters and the chemical composition of the work piece. Electrical Discharge Machining (EDM) is a non-traditional manufacturing process in which electric sparks are used to remove work piece material. There are two main types of EDM: ram or die-sinking EDM, and travelling-wire, wire-cut, or simply wire-EDM. In either kind, the underlying principle is the same. A power supply initiates a voltage potential between the electrode and the electrically conductive and grounded work piece. This scenario is analogous to the two plates of a parallel plate capacitor. As the tool approaches the work piece, the electric field strength grows in the gap until the dielectric medium separating the tool and the work piece breaks down. At this point, electrical discharge is initiated and the voltage drops as the current rises.

The dielectric ionizes and a plasma channel is created, compressing the surrounding dielectric. The plasma may reach a temperature of as high as 40,000 K and a pressure of 3kbar. As both electrons and ions bombard the work piece surface, the work piece is heated such that a portion of the surface is melted. However, the plasma pressure prevents vaporization. At the conclusion of the discharge, the plasma channel collapses and a vapour bubble occurs causing the superheated molten material on the surface of the work piece to explode into the dielectric. The ejected material is flushed away, while a portion of the molten material resolidifies onto the work piece surface forming a crater [10]. This resolidified material is known as the remelted, or recast layer.

In die-sinking EDM, the electrode is a specific shape and machines the negative of this shape into the work piece. Typically the tool is the anode and the work piece is the cathode with discharges occurring over tens to hundreds of microseconds. The dielectric medium is often a hydrocarbon such as kerosene. In wire-EDM, the tool is a wire which can cut an extruded geometry similar to a conventional band saw. Generally, the wire is the cathode, and the duration of each discharge is usually less than 10 µs, and often less than 1 µs. De-ionized water is the usual dielectric.

B. *Description of the Problem*

The present work "Effect of process parameters on performance measurement of wire electrical discharge machining" has been done keeping in mind the following problems:

- It has long been believed that cutting conditions such as timed pulse, pulse off time, servo voltage, peak current and other machining parameters should be selected for good surface finish.
- Part The higher cost of numerically controlled machine tools than their traditional counterparts has forced us to operate these machines as efficiently as possible to get the necessary paybacks.
- Predicted a pre-determined optimal solution using the best possible setting of the machining parameters suggested by any technique cannot be practically obtained. Therefore, all predictive parameters must be

verified experimentally using a combination of machining parameters.

C. Objective of the Study

After a thorough study of the existing literature, several graphs have been observed in the machining of WEDM. Most researchers have investigated the effects of a limited number of process variables on the processes responses of WEDM processes.

A review of the literature suggests that researchers have done most of the work on the development, monitoring, and control of WEDM, but very limited work has been reported on the optimization of parameters for processes.

From now on, current methods for developing mathematical models of machining reactions and performing a comprehensive analysis of input process parameters. The reaction surface methodology (RSM) used for this purpose with optimization techniques has been effective. It is very necessary to establish the optimal parametric combination with the intention of obtaining a better machined surface. The results of the investigation confirm the feasibility of the approach and the extent of machining conditions will be useful for manufacturing communities.

The aim of the present work is an attempt to find the feasibility of machining (NICROFER 3718) equipment using molybdenum wire electrodes and internal flushing. The machining parameters are spark gap, pulse on time, and pulse off for time using the Taguchi design approach that analyzes reactions MRR, and SR.

Study of working limits and levels of WEDM process parameters using a factor on a time approach

Viz. is Experimental determination of the effects of various process parameters such as pulse on time, pulse of time, and peak current, performance measures such as on surface roughness in the WEDM process

The process parameters of the WEDM process are changed according to the main parameters according to the surface roughness

II. LITERATURE REVIEW

Mustafa Ilhan Gokler and Alp Mithat Ozanozu [1] present the experimental study to select the most suitable cutting and offset parameter combination for the wire electrical discharge machining process in order to get the desired surface roughness value for the machined workpieces. A series of experiments have been performed on 1040 steel material of thicknesses 30, 60 and 80 mm, and on 2379 and 2738 steel materials of thicknesses 30 and 60 mm.

M.T. Antar, S.L. Soo, D.K. Aspinwall, D. Jones and R. Perez [2] made a brief review of recent minimum damage EDM pulse generator developments, experimental data is presented for work piece productivity & integrity when WEDM Udimet 720 nickel based super alloy and Ti-6Al-2Sn-4Zr-6Mo titanium alloy, using Cu core coated wires (ZnCu50 and Zn rich brass). Up to a 70% increase in productivity was possible compared to when using uncoated brass wires with the same operating parameters. Surfaces measuring ~ 0.6 Ïm Ra, with near neutral residual stresses and almost zero recast were produced following two trim passes. Cross-sectional micrographs of specimens following rough machining (~180mm 2 /min) showed the recast to be < 7 Ïm thick (up to 11 Ïm for uncoated wire), with comparable results for both alloys. Surface cracking, when evident, was restricted to within the recast layer.

Fuzhu Han, Jun Jiang and Dingwen Yu [3] gives the journal on Influence of machining parameters on surface roughness in finish cut of WEDM, according to them Surface roughness is significant to the finish cut of wire electrical discharge machining (WEDM). This paper describes the influence of the machining parameters (including pulse duration, discharge current, sustained pulse time, pulse interval time, polarity effect, material and dielectric) on surface roughness in the finish cut of WEDM. Experiments proved that the surface roughness can be improved by decreasing both pulse duration and discharge current. When the pulse energy per discharge is constant, short pulses and long pulses will result in the same surface roughness but dissimilar surface morphology and different material removal rates. The removal rate when a short pulse duration is used is much higher than when the pulse duration is long.

S. S. Mahapatra and Amar Patnaik [4]- studied optimization of wire electrical discharge machining (WEDM) process parameters using Taguchi method, Wire electrical discharge machining (WEDM) is extensively used in machining of conductive materials when precision is of prime importance. Rough cutting operation in WEDM is treated as a challenging one because improvement of more than one machining performance measures viz. metal removal rate (MRR), surface finish (SF) and cutting width (kerf) are sought to obtain a precision work. Using Taguchiís parameter design, significant machining parameters affecting the performance measures are identified as discharge current, pulse duration, pulse frequency, wire speed, wire tension, and dielectric flow. It has been observed that a combination of factors for optimization of each performance measure is different. In this study, the relationship between control factors and responses like MRR, SF and kerf was established by means of nonlinear regression analysis, resulting in a valid mathematical model. Finally, genetic algorithm, a popular evolutionary approach, was employed to optimize the wire electrical discharge machining process with multiple objectives. The study demonstrated that the WEDM process parameters can be adjusted to achieve better metal removal rate, surface finish and cutting width simultaneously.

A. Identified Gaps in the Literature

After a comprehensive study of the existing literature, a number of gaps have been observed in machining of WEDM.

- Most of the researchers have investigated influence of a limited number of process parameters on the performance measures of WEDM parts.
- Literature review reveals that the researchers have carried out most of the work on WEDM developments, monitoring and control but very limited work has been reported on optimization of process variables.
- The effect of machining parameters on Die steel has not been fully explored using WEDM with brass wire as electrode.
- Surface Roughness of WEDM parts is another thrust area which has been given less attention in past studies.

III. PROPOSED METHODOLOGY

A. *Input Parameters*

Electrical Parameters

- Machining peak current

Pulse/ Time domain

- Pulse On period
- Pulse Off period

B. *Output Parameters*

Performance Measure

- Surface Quality:
  Surface roughness
- Process Inaccuracies:
  Material removal rate

C. *Technical Specifications*

Table Size	: -	860X580mm
Maximum work-piece height	: -	300mm
Maximum work-piece weight	: -	1000 kg
Main Table Traverse (X, Y)	:-	600, 400 mm
Positioning Accuracy	: -	0.005 mm
Positioning Repeatability	: -	± 0.002 mm
Aux. table traverse (u, v)	:-	80, 80 mm
Maximum taper angle	: -	± 30^0 / 50 mm
Maximum JOG speed	: -	900 mm / min
Resolution	: -	0.0005 mm
Maximum wire spool capacity	: -	6 Kg.
Wire electrode diameter	: -	Dia. 0.25 mm (Standard) 0.1, 0.15, 0.20, 0.30 mm (optional)

D. *Experimental Procedure*

1) *Experimental Design and Planning*

In this research, the main machining performance measured is the machined surface roughness (Ra) and material removal rate. A fine surface was expected by adjusting the machining parameters in the finishing phase. Keeping in mind the actual machining situation, the factors that control the factors including spark on time, pulse off time and peak current are chosen to conduct the experiments. Similarly the wire is also fitted in the holder passing through various rollers to maintain the desired roll, after that the doors of this setup are closed, the dielectric fluid (D. M. Water) is poured into a tank 40 mm above the sample and then sparked at a pre-determined setting. The sample surface roughness is measured with the Taylor –Hobson machine after each experiment. These results are organized in tabular form and then graphs are plotted based on the results.

IV. PROPOSED OUTCOMES

Taguchi optimization technique will be employed to find the effect of machining parameters on Electro-Discharge Machining process responses. Besides, analysis of variance statistical method has been employed to predict the importance of individual machining parameters in the responses. The result of this research reveals that the proper selection of the input variables plays an important role in die-sinking EDM process. Applications: Ni base alloys are widely used in aviation, ship building and defence industries because of their better properties such as good impact strength, high ultimate tensile strength, high yield strength, high resistance to corrosion, retaining the strength even at high temperatures and fatigue resistance.

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