RESEARCH PAPER | Engineering | Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

A Review of Parametric Optimization of Wire Electric Discharge Machining

KEYWORDS: SS 316, Wire EDM, Machining variables, Surface roughness, Kerf width, Material removal rate.

Paras R. Bhavsar | Prof. S. M. Patel

Prof. N. K. Prajapati

Asst. Prof.

ABSTRACT This paper reports on optimization of different process parameters of the Wire EDM on the SS 316 material. The process parameters such as pulse on time, pulse off time, current, wire feed are the machining parameters. And the effects of these parameters were evaluated on surface roughness, kerf width and material removal rate.

I. INTRODUCTION

Wire electrical discharge machining (WEDM) technology has grown tremendously since it was first applied more than 30 years 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 control (CNC) system was initiated into WEDM, which brought about a major evolution of the machining process.

WEDM process with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process, alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, precise, corrosion and wear resistant surface.

WEDM is considered as a unique adoption of the conventional EDM process, which uses an electrode to initialize the sparking process. However, WEDM utilizes a continuously travelling wire electrode made of thin copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. The wire is kept in tension using a mechanical tensioning device reducing the tendency of producing inaccurate parts. 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, eliminating the mechanical stresses during machining.

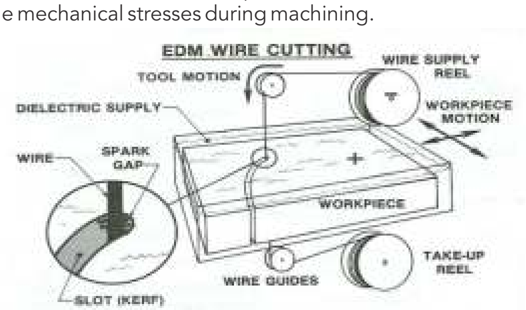

Fig. 1: Schematic diagram of Wire EDM Cutting

The present application of WEDM process includes automotive, aerospace, mould, tool and die making industries. WEDM applications can also be found in the medical, optical, dental, jewellery industries, and in the automotive and aerospace R & D areas.

Wire EDM Input Parameters:

1) Pulse on time and Pulse off time:

Electric discharge machining must occur (ON time) and stop (OFF time) alternately during machining. During the ON time, the voltage is applied to the gap between the workpiece and the electrode (wire), while no voltage is placed during the OFF time. Consequently, electric discharge occurs only for the duration of the ON time. To have a long duration of electric discharge, it may be possible to select the great value for the ON time; however, it may cause a short circuit to occur, resulting in wire breakage. [12]

2) Peak current:

The peak current is basically a most important machining parameter in WEDM. It is the amount of power used in WEDM and measures in unit of amperage. During each pulse on-time, the current increases until it reaches a preset level, which is expressed as the peak current. In both die sinking and wire-EDM processes, the maximum amount of amperage is governed by the surface area of the cut. Higher amperage is used in roughing operations and in cavities or details with large surface areas. [12]

3) Wire speed or wire feed:

Wire speed is another important parameter in WEDM that show the speed of wire in WEDM. As the wire speed increase the wire consumption and in result the cost of machining will increase while low wire speed can cause to wire breakage in high cutting speed. [12]

4)Wire tension:

Different Response Parameters:

1) Material removal rate and cutting speed:

Lots of research tried to maximize the material removal rate and cutting speed by different approaches. Because these factors can help to increase, economic benefits in WEDM considerably. Almost both of these factors (material removal rate and cutting speed) determine same phenomena which is the machining rate. MRR value normally obtained by the following equation: [12]

MRR = $(W_b - W_a)/(T_m \times p)$ (mm^3/sec)

2)Surface Roughness:
Lots of research tried to minimize the surface roughness by different approaches. Base on the theory surface roughness significantly affected by the pulse on time and peak current and the cutting speed and surface roughness have an inverse relationship. Base on investigation surface roughness decrease as the cutting speed increase. [12]

3) Kerf width and Sparking Gap:
Kerf width and sparking gap investigate the measure of the amount of the material that is wasted during machining. It can determine the dimensional accuracy of the finishing part and the internal corner radius of the product in WEDM operations are also limited by this factor. There are some conflict reports about pulse off time duration, peak current and dielectric flushing pressure for their influence on kerf width. WEDM parameters on kerf width while machining Stainless steel, it was found 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 on the kerf width. [12]

Material Selection:
The input parameters such as pulse on time, pulse off time, current and wire feed are used to take the response of surface roughness and kerf width. The SS 316 material have been selected for the experiment on Wire EDM with the dimensions of 15mm square bar of 1.5 feet long.

Uts N/mm^2 Min.	0.2% Proof Street N/mm^2 Min.	%Elongation on 50 mm Min	Hardness RB Max.
515	205	40	95

Table 1. Chemical composition of SS 316

C	Si	Mn	Cr	Ni	P	S	Mo
0.08	0.75	2.0	16.0-18.0	10.0-14.0	0 - 0.045	0.03	2.00-3.00

Table 2. Mechanical Properties of SS 316

Density (g/cm^3)	Melting point (°C)
8.0	1370-1400

Table 3. Physical Properties of SS 316

II. LITERATURE REVIEW

Brajesh Kumar Lodhi et al [1] investigated effect of parameter on machining of AISI D3 steel through wire cut EDM. The machining parameters selected are 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 the 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. It was identified that the pulse on time and current have influenced more than the other parameters considered in this study. The confirmation experiment has been conducted. Result shows that the error associated with SR is only 3.042 %.

G. Selvakumar et al [2] investigated effect of parameter on machining of 5083 aluminum alloy through wire cut EDM. Based on the Taguchi experimental design (L9 orthogonal array) method, a series of experiments were performed by considering pulse-on time, pulse-off time, peak current and wire tension as input parameters. The surface roughness and cutting speed were considered responses. ANOVA test was performed to determine the level of significance of the parameters on the cutting speed and surface roughness. ANOVA revealed that the CS was independent on wire tension and Ra was independent on pulse-off time and wire tension. An optimum parameter combination for the minimum Ra and the maximum CS was obtained by the analysis of signal-to- noise (S/N) ratio.

Pratik A. Patil et al [3] investigated effect of parameter on machining of AISI D2 cold work steel through wire cut EDM. This research deals with Response Surface Methodology approach for maximizing the material removal rate in wire electrical discharge machining. The investigated machining parameters were wire tension, pulse on time and peak current. After the experimentation, the effect of the parameters on MRR was determined by analysis of variance (ANOVA). From the investigation work it is clear that MRR increases as the peak current increases. Also the wire tension and pulse on time influences the MRR, but to a smaller extent.

Amitesh Goswami et al [4] investigated effect of parameter on machining of Nimonic 80A using wire-cut electrical discharge machining (WEDM) process. Two important process responses MRR and CS have been studied as a function of four different control parameters namely Pulse-on time, Pulse-off time, Input current and servo gap set voltage. By using the one factor at a time approach they have concluded that Pulse-on time and peak current has significant influence on material removal rate and cutting speed. There is an increase in response value with increase in these process parameters. With increase in process parameters namely pulse-off time and spark gap set voltage, the response values material removal rate and cutting speed decreases.

M. Durairaj et al [5] investigated effect of parameter on machining of SS304 through wire cut EDM. Two important process responses surface roughness and kerf width have been studied as a function of four different control parameters namely gap voltage, wire feed, pulse on time, and pulse off time. By using multi objective optimization technique grey relational theory, the optimal value is obtained for surface roughness and kerf width and by using Taguchi optimization technique, optimized value is obtained separately. The Analysis of Variance resulted that the pulse on time has major influence on the surface roughness (μm) and kerf width (mm) in both the Taguchi optimization method and Grey relational analysis.

Taha A. El-Taweel et al [6] investigated effect of parameter on machining of CK45 steel through wire cut EDM. The investigated machining parameters were Feeding speed, duty factor, water pressure, wire tension and wire speed have been considered and the process performances such as material removal rate (MRR), tool wear rate (TWR), and surface roughness (SR) were evaluated. By using Response surface methodology is obtain that the metal removal rate generally increases with the increase of feeding speed value, duty factor and water pressure. Further, the effect of wire tension and wire speed on metal removal rate is limited. Lower tool wear rate has been obtained at the parametric combination of lower feeding speed and lower duty factor. It has also been found that the increase of water pressure, wire tension and wire speed decreases tool wear. Fine surface quality has been obtained at lower feeding speed, lower duty factor and higher water pressure.

Rajmohan T. et al [7] investigated effect of parameter on machining of 304 stainless steel using wire electric discharge machining. The investigated machining parameters were pulse on time, pulse off time, Voltage and current considered and the process parameter on material removal rate were evaluated. By using Taguchi methodology it was found that different combination of process parameters are required to achieve higher material removal rate. On the basis of the experiment by calculating S/N ratio and ANOVA the current and pulse off time are the most significant machining parameter for material removal rate.

Pragya Shandilya et al [8] investigated effect of parameter on machining of SiCp/6061 Al metal matrix composite by wire electrical discharge machining using response surface methodology (RSM). The machining parameters were selected as servo voltage, pulse-on time, pulse-off time and wire feed rate to study the process performance in terms of kerf width. ANOVA results show that voltage and wire feed rate are highly significant parameters and pulse-off time is less significant. Pulse-on time has insignificant effect on kerf.

Aniza Alias et al [9] investigated effect of parameter on machining of Titanium Ti-Al-4V using wire electrical discharge machining with Taguchi methodology. The machining parameters were selected as machine feed rate, current, wire speed, wire tension, voltage and the results on kerf width, material removal rate and surface roughness. Wire speed, wire tension and open voltage at constant while the machine feed rate varies. The lowest value of machine feed rate give smallest kerf width. Material erosion is influenced by the spark energy. As feed rate increase MRR also increases. By increasing wire tension, it reduces the vibration and improves the machined surface quality.

Sivakiran et al [10] revealed effect of machining parameters of EN-31 tool steel material on CONCORD DK7720C four axis CNC WEDM machine. The machining parameters selected were Pulse-on, Pulse-off, Bed speed and Current to optimize volumetric material removal rate[VMRR]. In this study, the settings of machining parameters were determined by using Taguchi experimental design method. The order strength of parameters are found from response table is current, pulse on, Bed speed and pulse off. For maximum VMRR current, voltage, bed speed should be high and bed speed in medium range.

III.CONCLUSION

From the review of different literatures it concludes that the surface roughness increase with the increase of peak current and it decreases with the increase of wire tension. By increasing wire tension, it reduces the vibration and improves the machined surface quality.

For the kerf width the voltage and wire feed rate are highly significant parameters and pulse-off time is less significant. The lowest value of machine feed rate give smallest kerf width.

The MRR is increases as the peak current increases. The pulse on time and peak current has significant influence on MRR and cutting speed. The pulse off time and sparking gap increases then MRR and cutting speed decreases.

REFERENCE

[1] Brajesh Kumar Lodhi, Sanjay Agarwal, "Optimization of machining parameters in WEDM of AISI D3 Steel using Taguchi Technique." Procedia CIRP 14 (2014), pp. 194-199. | [2] G. Selvakumar, G. Sornalatha, S. Sarkar, S. Mitra, "Experimental investigation and multi-objective optimization of wire electrical discharge machining (WEDM) of 5083 aluminum alloy." Trans. Nonferrous Met. Soc. China 24(2014), pp. 373-379. | [3] Pratik A. Patil, C.A. Waghmare, "Optimization of process parameters in wire-edm using response surface methodology." Proceedings of 10th IRF International Conference, 01st June-2014, pp. 110-115. | [4] Amitesh Goswami, Jatinder Kumar, "Study of machining characteristics of Nimonic 80A using wire-cut EDM." International Journal of Advanced Engineering Applications, Vol.7, Iss.1, (2014), pp. 73-81. | [5] M. Durairaj, D. Sudharsun, N. Swamynathan, "Analysis of Process Parameters in Wire EDM with Stainless Steel using Single Objective Taguchi Method and Multi Objective Grey Relational Grade." Procedia Engineering 64 (2013), pp. 868-877. | [6] Taha A. El-Taweel, Ahmed M. Hewidy, "Parametric Study and Optimization of WEDM Parameters for CK45 Steel." International Journal of Engineering Practical Research (IJEPR) Volume 2 Issue 4, November 2013, pp. 156-169. | [7] Rajmohan T., Prabhu R., Subba Rao G., Palanikumar K., "Optimization of machining parameters in electric discharge machining(EDM) of 304 stainless steel." Procedia Engineering 38 (2012), pp. 1030 – 1036. | [8] Pragya Shandilya, P.K.Jain, N.K. Jain, "Parametric optimization during wire electrical discharge machining using response surface methodology." Procedia Engineering 38 (2012), pp. 2371 – 2377. | [9] Aniza Aliasa, Bulan Abdullaha, Norliana Mohd Abbas, "WEDM: Influence of machine feed rate in machining titanium ti-6al-4v using brass wire and constant current (4a)" Procedia Engineering 41 (2012), pp. 1812-1817. | [10] Sivakiran S., Reddy B., Reddy C.E., "Effect of process parameters on MRR in wire electrical discharge machining of en31 steel." International Journal of Engineering Research and Applications, Vol. 2, Issue 6, November- 2012, pp. 1221-1226.