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Research Article

Optimizing the Parameters Influence the Performance of Wire cut EDM Machining

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Abstract

Wire electrical discharge machining process is a highly complex, time varying & stochastic process. The process output is affect by large no of input variables. Therefore a suitable selection of input variables for the wire electrical discharge machining (WEDM) process. WEDM is extensively use in machining of conductive materials when precision is of prime importance. Rough cutting operation in wire EDM is treated as challenging one because improvement of more than one performance measures viz. Metal removal rate(MRR), surface finish & cutting width (kerf) are sought to obtain precision work A proper selection of machining parameters is a must for the wire electrical discharge machining. The selection depends mainly on the operator's technology and experience because the range of parameters is quite diverse based on the Taguchi quality design method and ANOVA, an approach to determine parameter setting is propose. The important factors affecting the machining parameters like MRR, gap width, surface roughness, sparking frequency, average gap voltage and normal ratio are determine. The experimental work will show that the WEDM process parameters can be adjust so as to achieve better Metal Removal Rate.

Keywords: *Wire electrical discharge machining, MRR ANOVA etc.*

1. Introduction

The main goals of WEDM manufacturers and users are to achieve a better stability and higher productivity of the WEDM process, i.e., higher machining rate with desired accuracy and minimum surface damage. However, due to a large number of variables and the stochastic nature of the process, even a highly skilled operator working with a state-of-the-art WEDM is unable to achieve the optimal performance and avoid wire rupture and surface damage as the machining progresses. Although most of the WEDM machines available today have some kind of process control, still selecting and maintaining optimal settings is an extremely difficult job. The lack of machinability data on conventional as well as advanced process.

Electrical discharge wire cutting, more commonly known as wire electrical discharge machining (WEDM), is a spark erosion process used to produce complex two- and three-dimensional shapes through electrically conductive workpieces by using wire electrode. The sparks will be generated between the workpiece and a wire electrode flushed with or immersed in a dielectric fluid. The degree of accuracy of workpiece dimensions obtainable and the fine surface finishes make WEDM particularly valuable for applications involving manufacture of stamping dies, extrusion dies and prototype parts. Without WEDM the fabrication of precision workpieces requires many hours of manual grinding and polishing. wire electrical discharge machining (WEDM) has been improved significantly to meet the requirements in various manufacturing fields, especially in the precision die industry. WEDM is a thermoelectrical process in which material is eroded from the workpiece by a series of discrete sparks between the workpiece and the wire electrode (tool) separated by a thin film of dielectric fluid (deionized water) that is continuously fed to the machining zone to flush away the eroded particles.

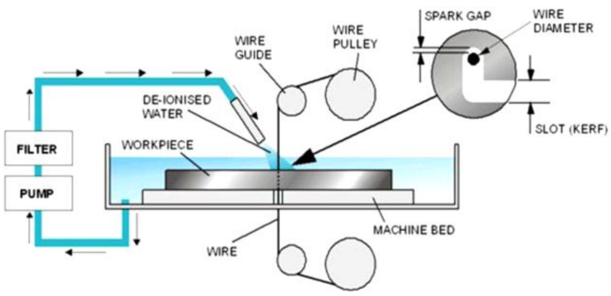

Figure1- Principle of Wire EDM

The movement of wire is controlled numerically to achieve the desired three-dimensional shape and accuracy of the workpiece. Electrical Discharge Machining, EDM is one of the most accurate manufacturing processes available for creating complex or simple shapes and geometries within parts and assemblies.

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EDM works by eroding material in the path of electrical discharges that form an arc between an electrode tool and the work piece. EDM manufacturing is quite affordable and a very desirable manufacturing process when low counts or high accuracy is required. Turnaround time can be fast and depends on manufacturer back log. The EDM system consists of a shaped tool or wire electrode, and the part. The part is connected to a power supply. Sometimes to create a potential difference between the work piece and tool, the work piece is immersed in a dielectric (electrically nonconducting) fluid which is circulated to flush away debris.

The WEDM process consists of three operations, a roughing operation, a finishing operation, and a surface finishing operation. The performance of various types of cutting operations is judged by different measures. In rough cutting operation both metal removal rate and surface finish are of primary importance. In finish cutting operation, the surface finish is of primary importance. Dimensional accuracy is highly dependent on cutting width. This means that the rough cutting operation is more challenging because three goals must be satisfied simultaneously. Hence, the rough cutting phase is investigated in the present approach considering three performance goals like MRR, SF.

2. Literature review

Y.S Liao *et al.* devised an approach to determine machining parameter settings for WEDM process .Based on the Taguchi quality design and the analysis of variance (ANOVA), the significant factors affecting the machining performance such as MRR, gap width ,surface roughness , sparking frequency ,average gap voltage, normal ratio(ratio of normal sparks to total sparks) are determined. By means of regression analysis, mathematical models relating the machining performance and various machining parameters are established. Based on the mathematical models developed, an objective function under the multi-constraint conditions is formulated. The optimization problem is solved by the feasible direction method, and the optimal machining parameters are obtained. Experimental results demonstrate that the machining models are appropriate and the derived machining parameters satisfy the real requirements in practice.

Tian *et al.* towards process monitoring and control of micro wire EDM process by developing a new pulse discrimination & control system . This system functions by identifying 4 major gap states classified as open ckt, normal spark, arc discharge, and observing the characteristics of gap voltage waveforms. The influence of pulse interval, machining feed rate, and workpiece thickness on the normal ratio, arc ratio & short ratio. It could be concluded from the experiment that a longer pulse interval would result in increase of short ratio at constant machining feed rate. A high machining federate as well as increase of work piece height results in increase of short ratio. **Lee *et al.*** was to study the effect of machining parameters in EDM of tungsten carbide on the machining characteristics. The characteristics of EDM refer essentially to the output machining parameters such as material removal rate (MRR), relative wear ratio (RWR) and surface roughness (Ra). The machining parameters are the input parameters of the EDM process namely electrode material ,polarity , open circuit voltage , peak current, pulse duration, pulse interval & flushing pressure.

Pattnaik *et al.* Rough cutting operation objectives are three fold High MRR, high surface finish & low cutting width (kerf). Using Taguchi's parameter design significant machining parameters affecting the performance are identified as discharge current, pulse duration, pulse frequency, wire speed, wire tension & dielectric flow. In this study the relationship between control factors & responses like MRR, SF and kerf are established by means of non linear regression analysis resulting in a valid mathematical model. The cutting of Tungsten Carbide ceramic using electro-discharge machining (EDM) with a graphite electrode by using Taguchi methodology has been reported by **Radzi *et al*** The Taguchi method is used to formulate the experimental layout, to analyze the effect of each parameter on the machining characteristics, and to predict the optimal choice for each EDM parameter such as peak current, voltage, pulse duration and interval time. It is found that these parameters have a significant influence on machining characteristic such as metal removal rate

(MRR), electrode wear rate (EWR) and surface roughness (SR). The analysis of the Taguchi method reveals that, in general the peak current significantly affects the EWR and SR, while, the pulse duration mainly affects the MRR.

Jatinder Kapoor *et.al.* was studied the results of the effect of Cryogenic treated brass wire electrode on the surface of an EN-31 steel machined by WEDM. Full factorial experimental design strategy is used in the experimentation. Three process parameters, namely type of wire electrode (untreated and cryogenic treated brass wire electrodes), Pulse width, and wire tension have been considered. The process performance is measured in terms of surface roughness (SR). Type of wire, pulse width and wire tension significantly affect the SR in WEDM ANOVA results indicated that all the process parameters have significant effect on SR.

3. Experimental Setup

Figure2- Wire EDM Machine

Table 3.1 shows the chemical composition of En31 Material.

Table 3.1: Chemical Composition of EN31

C%	Mn%	Si%	P%	S%	Cr%	Cu%
1.0	0.47	0.17	0.022	0.013	0.14	0.16

Table 3.2: Shows the experimental setup followed by the experiment

Work piece	En 31
Length of work piece	25mm
Dia of work piece	20mm
Machine used	Wirecut EDM
Wire material	Brass
Environment	Wet
Dielectric fluid	Water

Table 3.3: Machining settings used in the experiments

Controlled parameters	Levels		
	L_1	L_2	L_3
Voltage	130	150	170
Discharge Current	15	25	35
Wire Tension	1150	1250	1350

The experimental layout for the machining parameters using the L9 orthogonal array was used in this study. This array consists of three control parameters and three levels, as shown in Table 3.3

Table 3.4: Taguchi's L9 orthogonal array with values of levels

Experiment No.	Voltage	Discharge Current	Wire tension
1	130	15	1150
2	130	25	1250
3	130	35	1350
4	150	15	1250
5	150	25	1350
6	150	35	1150
7	170	15	1350
8	170	25	1150
9	170	35	1250

Experiments were conducted using L9 OA shown in Table 3.4 to find the effect of process parameters on the MRR. The experiments were done on EN31 Steel. High speed brass wire was used as tools. The rate of cutting speed for each work piece and tool materials were collected in same experimental conditions.

Table 3.5: The L9 Orthogonal array with Performance

Experiment No.	Voltage	Discharge Current	Wire Tension	MRR
1	130	15	1150	7.89
2	130	25	1250	7.22
3	130	35	1350	6.24
4	150	15	1250	7.69
5	150	25	1350	8.09
6	150	35	1150	7.77
7	170	15	1350	6.79
8	170	25	1150	7.80
9	170	35	1250	6.24

Table-3.6 Analysis of variance (ANOVA) for SN Ratio

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%Contribution
Voltage	2	1.38987	1.38987	0.69493	28.68	0.034	33.83
Discharge current	2	1.46907	1.46907	0.73453	30.31	0.032	35.75
Wire Tension	2	1.20140	1.20140	0.60070	24.79	0.039	29.24
Error	2	0.04847	0.04847	0.02423			1.18
Total	8	4.10880					100

The tables 3.7 include ranks based on delta statistics, which compares the relative magnitude of effects. The delta statistic is the highest average minus the lowest average for each factor. Minitab assigns ranks based on delta values in descending order; the highest delta value has rank1 and rank 2 is assigned to the second highest, and so on. The ranks indicate the relative importance of each factor to the response. Pulse width has the maximum effect on cutting speed followed by time between two pulses and peak current.

Table 3.7: Response Table for Signal to Noise Ratio Larger is better

Level	Voltage	Discharge current	Wire tension
1	17.01	17.43	17.86
2	17.90	17.72	16.93
3	16.79	16.54	16.90
Delta	1.10	1.19	0.96
Rank	2	1	3

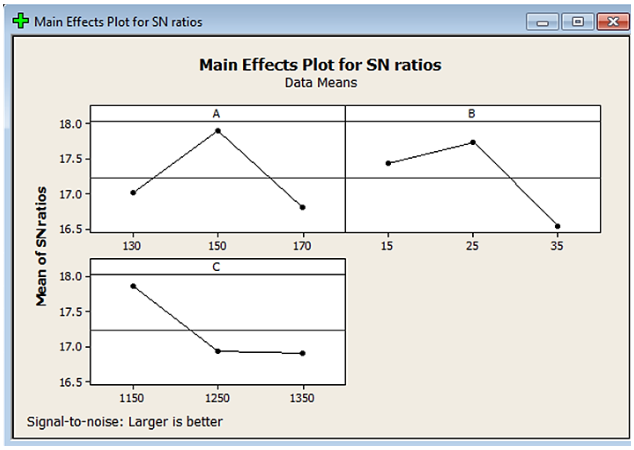
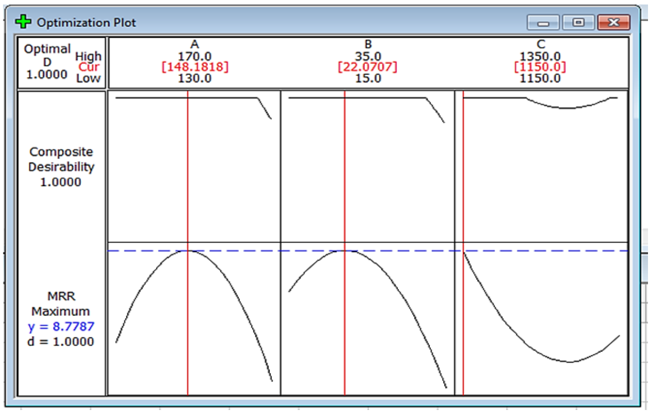


Figure 3.3 S/N Ratio for MRR

Analysis of variance (ANOVA) is performed and signal-to-noise (S/N) ratio will be determined to know the level of importance of the machining parameters. To obtain the optimal machining performance the lower the better quality characteristics for MRR.As can be seen from Table (above), the MRR is most significantly influenced by the Discharge current followed by the Voltage. The respective values of these parameters are 1.19 and 1.10. After finding all the observation as given in Table 3.7 & 3.8 , S/N ratio are calculated and graph for analysis is drawn by using Minitab 15 software. The S/N ratio for MRR is calculated on Minitab 15 Software using Taguchi Method.

Confirmation Result by Minitab Software

The confirmation result is verified in Optimization plot by Minitab tab in which the values getting are Voltage 148.1818, Discharge Current 22.0707 and Wire tension is 1150 which are approximately same as the values in experiment.



Conclusion

From the experimental results, S/N ratio and ANOVA analysis and predicted optimum machining parameters, the following conclusions are drawn:

1. From ANOVA Table 3.7 and Response table for Signal to Noise, based on the ranking it shows that Discharge has a greater influence on the MRR followed by Voltage and . Wire Tension had the least influence on MRR.
2. The optional setting of process parameters for optimal Roughness is Voltage (150), Discharge current (25), and Wire tension (1150).
3. The validation experiment confirmed that the error was less than .04847 % between equation and actual value.
4. The optimum value of MRR is when took the parameters Voltage (150), Discharge current (25), and Wire tension (1150) is 8.154.

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