Optimization of Process Parameters on EN 34 Steel for WEDM Operations

Mohammad Taha[1], S. Bose[2] T. Paul[1] and P. K. Bardhan[1*]
[1.] Department of Mechanical Engineering, JIS College of engineering
[2.] Department of Mechanical Engineering, Kingston Polytechnic College

***Abstract*:- Wire-cut Electrical Discharge Machine (WEDM) is a well-ordered manufacturing procedure that is adopted to making geometrically tricky profiles with exceptional exactness in which material removal rate (MRR) takes place by thermal erosion process, which shows that the developed model can be utilized to forecast the overcut values. A hybrid approach is employed to enhance the process parameters for MRR. The present research shows the consequence of process control factors on the MRR of EN-34 steel by WEDM. Taguchi Method is employed to optimize the output process factors with respect to the input factors. Based on the study, it is indicated that pulse on time (T_{on}) as well as pulse off time (T_{off}) are surplus key factors that affect the MRR.**

Keywords: WEDM, MRR, Taguchi Technique, ANOVA.

1. INTRODUCTION

In WEDM substance is confiscated from the job by a sequence of distinct electrical sparks between tool along with job spaced out through a layer of dielectric fluid which is simultaneously applied to the operation region to regress the worn elements [1]. To set off the machining operation tool and job are detached by a tiny breach identified as 'spark gap' which consequences in an electrical pulsed discharge reason for the abstraction of substance from the job [2]. The illustration of the WEDM is presented in Fig. 1.

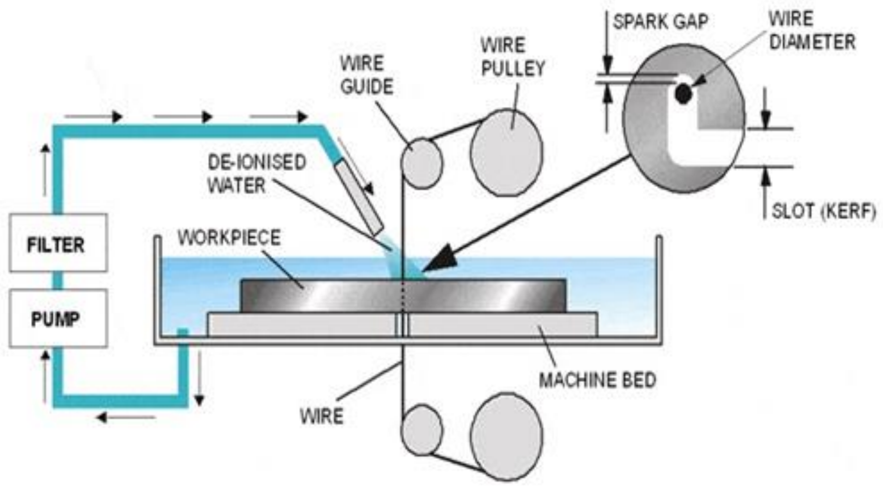

Fig. 1: Representation of the WEDM process [2]

The composition of alloy EN-34 steel is made up of nickel, chromium, and molybdenum that is comprehensively utilized in non-magnetic, evaporators, valves, cryogenic vessels, refrigeration equipment as a result of their unique corrosion-resistant and elevated ductility [3]. MRR is an important parameter in the machining procedure whereas allowing for machining performance. L27 orthogonal array is used to measure the MRR that greatly influences manufacturing cost and quality. An Appropriate array of control factor is crucial to get worthy MRR for a wide range of materials. S. Balasubramanian have observed that T_{on}, T_{off}, Current, wire feed rate (WFR), WT, SVG were important controlling parameter for measuring MRR [4]. C.D. Shah et al. have noticed that the role of T_{on}, $T_{off,}$ the current is the most important parameter on MRR of EN-34 steel by WEDM using response surface methodology and Taguchi's robust design [5]. G. Selvakumar et al. revealed experiments to review WEDM on EN-34 steel alloy material with the help of a brass wire. It is noticed that cutting speed was dominant on WT and MRR was free on T_{off} and WT [6]. Vipal B Patel et al. discovered the influence of process factors on the enactment of WEDM on HCHCR with the help of the Taguchi process and GRA. It has been resolved that optimizing the complex several operating factors applying GRA and achieve the MRR is enhanced together [7]. Rajyalakshmi.G has acknowledged discharge current, duration, and frequency of the pulse, WT, and dielectric flow as the key factors that modify the WEDM process, on Monel 400 material using Cu-Zn37 master brass wire. It is found that T_{off} and peak current has the most impact on MRR. [8]. Amitesh Goswami et al. have investigated the machining control parameter of Nimonic 80A in WEDM applying the Taguchi method and Analysis of Variance (ANOVA). The analysis of results indicates that T_{on} has been noticed to be the key parameter influencing the MRR (52.31%) and R_a (74.69%).

WWR has been mainly influenced by wire offset with a % provision of 45.34 [9]. Ashish Goyal revealed experimentation to study micro WEDM on Inconel 625 material using zinc coated wire and cryogenic treated zinc lined twine as an electrode material. It has been observed that current and T_{on} are the most substantial constraints that influence the MRR [10].
For settings of the optimal process parameter, a huge of study has been done in the engineering design. The optimal parametric combinations regarding a variety of performance control factors are not the same.

2. DESIGN OF EXPERIMENTS

2.1 Taguchi Method

The Taguchi method is an easy, logical, and further capable process to find out optimal or proximate optimal settings of process control factors. Taguchi method used to reveal the consequences of output process factors of WEDM process like MRR. Taguchi propositioned to obtain the process parameters data by employing orthogonal arrays, and to analyse the performance measure from the data to determine the best possible input process factors, for the scope of planning as well as enhancing the feature of the final product [11, 12]

2.2 Selection of Orthogonal Array

"Orthogonal Arrays" gives a set of well-balanced test combinations [13]. The contribution factors are T_{on} (μs), T_{off} (μs), and WF (mm/min). Based on several parameters and their levels, L27 OA was carefully chosen. Table 1 shows numerous levels of variables and table 2 displays an investigational proposal with allocated data.

Table 1: Input parameter with three level

Response Parameters		Material Removal Rate (mm3 /min.)		
		Levels		
Factor	Parameter	L1	L2	L3
A	T_{on}	6	8	10
B	T_{off}	8	10	13
C	WFR	4	6	8

Table 2: Experimental design

Sl. No.	T_{on}	T_{off}	W_f
1	8	13	6
2	6	10	4
3	6	10	6
4	8	10	8
5	6	13	6
6	8	13	8
7	8	13	6
8	6	10	8
9	8	10	6
10	8	8	4
11	10	8	6
12	8	10	4
13	8	8	8
14	8	10	4
15	8	10	6
16	6	10	6
17	8	8	6
18	6	8	6
19	8	8	6
20	10	10	6
21	10	10	4
22	8	10	8
23	8	13	4
24	8	10	6
25	10	10	8
26	10	10	6
27	10	13	6

2.3 Selection of Material

The material of the job piece utilized here for investigation is EN-34 steel. Dimension of sample is 8 × 5 × 5 mm. It has strong core strength and impact qualities with moderate temper brittleness, making it ideal for applications requiring wear and shock resistance.

Table 3 displays the chemical amalgamation of the work piece.

Table 3: Chemical Composition of the test specimen i.e., EN34 steel

Element	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**
Weight %	0.20	0.40	0.75	.035	.04	0.30	0.3	2

2.4 Experimental Work

Experiments were conducted on EDM machine (JOEMARS WT355) which was manufactured by JOEMARS MACHINERY & ELECTRIC INDUSTRIAL CO., LTD., Taiwan. CNC WEDM" as displayed in Fig. 2 and 3.

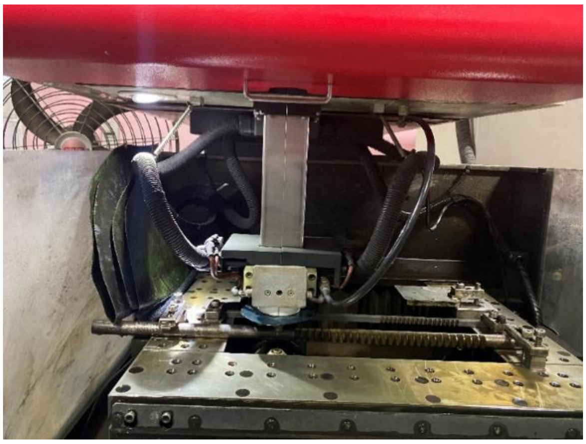

Fig. 2 WEDM Setup

Fig. 3 WEDM Controller

Table 4: MRR of experimental value

Sl. No	T_{on}	Toff	WF	MRR
1	8	13	6	4.19
2	6	10	4	3.14
3	6	10	6	3.32
4	8	10	8	3.03
5	6	13	6	1.91
6	8	13	8	2.26
7	8	13	6	2.21
8	6	10	8	1.44
9	8	10	6	2.90
10	8	8	4	2.96
11	10	8	6	3.87
12	8	10	4	2.74
13	8	8	8	3.40
14	8	10	4	3.37
15	8	10	6	2.72
16	6	10	6	2.37
17	8	8	6	3.43
18	6	8	6	2.01
19	8	8	6	3.09
20	10	10	6	4.74
21	10	10	4	4.77
22	8	10	8	3.44
23	8	13	4	3.15
24	8	10	6	3.41
25	10	10	8	4.98
26	10	10	6	5.27
27	10	13	6	2.88

From the response table 4 of MRR

We consider T_{on}, T_{off}, WFR, as our input parameters for material removal rate as our responses. Here L27 experiments are carried out by changing the values of T_{on}, T_{off}, WFR, where temperature, current, etc, are kept constant. It has been assumed that changing the values of T_{on}, T_{off}, WFR tends to change the values of MRR. The MRR values are maximum and minimum for different parameters. The MRR values changes due to discharge energy increase when pulse duration and servo voltage increased which leads to a higher removal rate. An ideal parameter combination is used for obtaining maximum and minimum MRR by using the analysis Material removal rate is one of the observed experimental results for performance measures = 5.27 mm^3/min maximum and 1.91 mm^3/min minimum.

3. RESULTS AND DISCUSSION

Taguchi Technique is used for the evaluation of optimal factors for MRR. S/N ratio η values for MRR and most important influences.

Table 5: S/N ratio η datas for MRR

Level 1	T_{on}	T_{off}	WFR
1	7.890	10.840	9.648
2	9.115	9.145	9.588
3	11.392	8.411	9.161
Delta	3.503	2.428	0.487
Rank	1	2	3

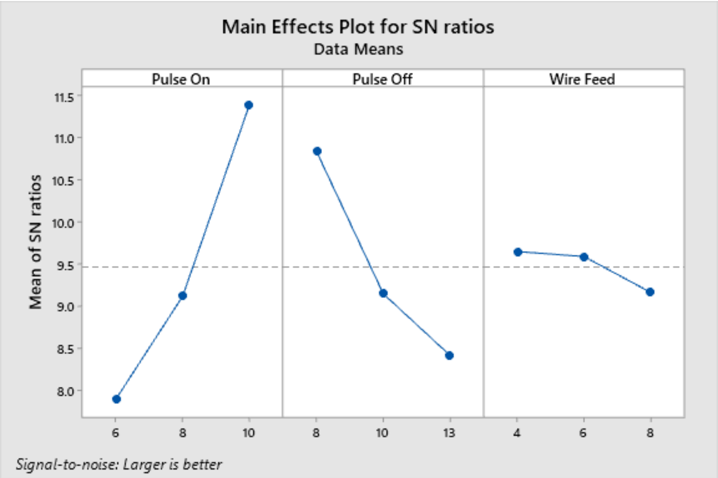

Fig. 4: Main effects plot for MRR

We consider T_{on}, T_{off}, WFR, as our input parameters for material removal rate as our responses. The results of the experiment are analyzed by using the Taguchi method with aim to know MRR which will be maximum or minimum. With the change in T_{on}, T_{off}, W_f, MRR tends to change accordingly, T_{on} 10 µs, T_{off} 10 µs, and WFR 6 mm/min it will have a larger value for MRR and when T_{on} 6 µs, T_{off} 10 µs and WFR 8 mm/min is taken it will give a lower value of MRR and according to this S/N ratio also changes. MRR values are directionally proportional to S/N ratio values i.e., the greater the MRR, the higher the S/N ratio value. As a result, constant improvements to the current WEDM qualities are required to expand machining capability while also increasing machining productivity and efficiency.

Table 6: ANOVA table for MRR of WEDM process

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution %
T_{on}	1	7.1264	7.12639	10.91	0.003	30.39
T_{off}	1	1.2977	1.29774	1.99	0.172	5.53
WFR	1	0.0017	0.00168	0.00	0.960	0.01
Regression	3	8.4258	2.80860	4.30	0.015	35.93
Error	23	15.0260	0.65330			
Total	26					

Table 6 of the ANOVA discloses that the input process factors have a significant impact on MRR. The maximum MRR is obtained T_{on} and T_{off} of 10 µs and 10 µs respectively as a result of their leading control over the input process factor. The parameter T_{off} has less impact on MRR, and an increase in MRR is noticed when T_{off} decreases.

4. CONCLUSION

In machining, the effects of T_{on}, T_{off}, and WFR are examined experimentally on Wire-cut EDM of EN 34 steel. ANOVA is used to investigate the relevance of machining factors of MRR, and it is shown that T_{on} is most noteworthy whereas T_{off} and WFR is less significant. A best possible parametric sequence designed for the extreme MRR was acquired by employing Signal-to-Noise (S/N) ratio. It has also been observed that the MRR can be maximum when the parameters are taken as T_{on} 10 μs, T_{off} 10, μs and WFR 6 mm/min. It is witnessed that the T_{on} has the most important effect upon the MRR which is 30.39 % of the total contribution and the use of low energy resulted in wire breakage.

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