© 2017 IJEDR | Volume 5, Issue 2 | ISSN: 2321-9939

A Comparison Study on Optimization of Process Parameters between Die sinking EDM and WEDM for Stainless Steel 304

[1] Nishant, [2] Dr. Soupayan Mitra

[1] Post Graduate Scholar, Department of Mechanical Engineering, Jalpaiguri Govt. Engineering College, India
[2] Associate Professor, Department of Mechanical Engineering, Jalpaiguri Govt. Engineering College, India

***Abstract*— Die sinking Electro Discharge Machining (EDM) and Wire Electro Discharge Machining (WEDM) are two important non-conventional machining processes. In this present study the process parameters which normally influence the metal removal rate (MRR) and surface roughness (SR) are optimized both for EDM and WEDM and compared for machining AISI 304 stainless steel. AISI 304 steel has good wear and abrasion resistance and the machining operations are conducted with the Tungsten carbide electrode as tool. Here the machining experiments are done following Taguchi L9 design to analyze the effect of three important machining parameters viz., discharge current, pulse on time, and applied voltage on material removal rate and surface roughness. The signal-to-noise ratios associated with the observed values in the experiments are determined and Analysis of variance (ANOVA) is done to ascertain the factors by which the response parameters viz., Material Removal Rate and Surface Roughness are most affected both for EDM and WEDM. The respective influence contribution of each of the machining parameters on response varies are also maintained**

***Keywords*— EDM, WEDM, Material removal rate, Surface roughness, Taguchi method**

I. Introduction

Non-conventional machining processes like Electro discharge machining (EDM) and wire electro discharge machining (WEDM) play important role in precision manufacturing industries like automobile, aerospace and sheet metal industries [1], especially for manufacturing of punch, dies, jigs and fixtures etc. Traditional machining processes are easy to implement and are used in much more occasions than non-conventional processes, however it is very difficult to machine complicated and complex shapes and hard materials like tool steels [1,2].Fig 1.1 and Fig 1.2 show the schematic diagrams of the working principle of EDM and WEDM processes.

The schematic of basis EDM process is shown in Fig 1.1. In die sinking EDM process [3,4,5] the work piece and tool are submerged into a non-conducting, dielectric fluid which is separated by a small gap for sparking. The dielectric fluid insulates the work piece from the tool and creates the resistance of electricity flow between the electrodes. The dielectric fluid may be typical hydrocarbon oil or de-ionized water. It also helps in cooling down the tool and work piece, clears the inter-electrode gap and concentrates the spark energy to a small cross sectional area under the electrode. Once adequate potential difference is applied by power supply across the small gap of work-piece and tool, high electrical discharge takes place in the form of spark at an interval of 10 of micro second and machining is accomplised.

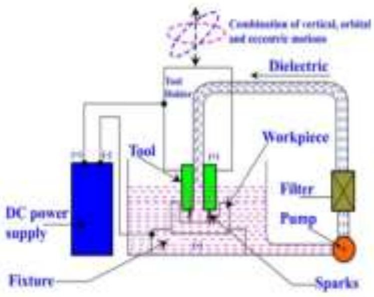

Fig. 1.1 Schematic Diagram of Electric Discharge Machining.

WEDM [6,7] uses electro thermal mechanisms to cut electrically conductive material. The mechanism of metal removal in WEDM is due to melting and vaporization caused by the electric spark discharge generated by a pulsating direct current supply between the electrodes i.e., the tungsten electrode and the wok piece, which acts as another electrode. In WEDM the positive electrode is the work piece and negative electrode is the moving wire. The spark will generate between two closely spaced electrodes under the influence of dielectric fluid. When the gap voltage is sufficiently large, high power spark is produced, which increase the temperature about 10,000 degree Celsius that leads to melting and removing of surface material. The removed particles are flushed away by the flowing Dielectric fluid. Thus machining is done.

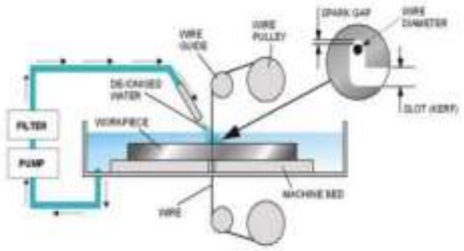

Fig 1.2 Schematic Diagram of the working principle of WEDM process.

Experiment Design:

In the present analysis, Taguchi Design procedure has been followed for carrying out the experiments. Dr. Genichi Taguchi's approach or DOE (Design of Experiment) is highly effective where it is suspected that there are more than one contributing factors to determine the quality or performance of a product or, process. Taguchi method recognizes that not all factors that cause variability can be controlled. These uncontrollable factors are called noise factors [8]. Taguchi designs try to identify controllable factors (control factors) that minimize the effect of the noise factors. The Taguchi methodology of experimentation is designed in such a way so that the major contributing factors of the process or product concerned are set in an optimum way which makes the process or product robust, or resistant to variation from the noise factors [9].

For Die Sinking EDM: In this machining process the controlling parameters and their levels are given in Table 1.1 following Taguchi's L9 orthogonal array.

Table 1.1

Machining parameter	Symbol	Unit	Levels		
			Level 1	Level 2	Level 3
Discharge current	Ip	A	5	7	9
Pulse on time	Ton	µs	50	150	200
Voltage	V	V	45	55	65

For WEDM,

The controlling parameters and their levels are given [11] in Table 1.2 following Taguchi method.

Table 1.2

Machining control Parameter	Symbol	Unit	Level 1	Level 2	Level 3
Pulse On time	Ton	µs	105	115	125
Pulse Off time	Toff	µs	75	85	95
Spark gap Voltage	Sv	V	40	50	60
Peak current	IP	A	10	15	20

OBSERVATION DATA

For Die Sinking EDM, the experiments are done for nine numbers of different combinations considering the three control parameters and MRR is calculated by taking weight of work piece before machining and after machining for each run. Each experiment is conducted for 10 minute i.e., for each experiment machining time is 10 minute. After each experiment surface roughness (SR) is measured. The experimental data and corresponding results are presented in Table 1.3 and Table 1.4.

Table 1.3

Run	Ip	Ton	Voltage	Wt. of work piece (in gm)	
S. No.	(A)	(µs)	(V)	w_{bm}	w_{am}
1	5	50	45	150.592	150.356
2	5	150	55	150.356	150.030

3	5	200	65	150.030	149.758
4	7	50	55	149.758	149.371
5	7	150	65	149.371	148.886
6	7	200	45	148.886	148.358
7	9	50	65	148.358	147.883
8	9	150	45	147.883	147.145
9	9	200	55	147.145	146.464

Table 1.4

Run no.	Ip (A)	Ton (μs)	Voltage (V)	MRR (mm^3/min)	SR (μm)
1	5	50	45	2.9500	5.9333
2	5	150	55	4.0750	7.1333
3	5	200	65	3.4000	8.4000
4	7	50	55	4.8375	5.2667
5	7	150	65	6.0625	7.8000
6	7	200	45	6.6000	7.1333
7	9	50	65	5.9375	8.4000
8	9	150	45	9.2250	4.2000
9	9	200	55	8.5125	4.6667

For WEDM, similar to EDM, machining processes are carried out and the results obtained are shown in Table 1.5.

Table 1.5:

Ip	Ton	Toff	Sv	MRR	SR
10	105	75	40	5.68	5.34
10	115	85	50	6.38	6.65
10	125	95	60	6.54	7.14
15	105	85	60	7.80	6.78
15	115	95	40	8.27	8.09
15	125	75	50	6.94	7.61
20	105	95	50	7.82	7.06
20	115	75	60	7.34	7.14
20	125	85	40	8.66	8.76

RESULT AND DISCUSSION

Influence on MRR

Taguchi method is used to analysis the result of machining parameter for "larger is better" (since here the 'response' is MRR) criteria. The S/N ratios for MRR are calculated by using the equation (1)

$$\text{LB: } \eta = -10 \log [\frac{1}{n} \Sigma_{i=1}^{n} yi^{-2}] \qquad (1)$$

Where, η denotes the S/N ratios calculated from observed values

yi Represent the experimentally observed value of i^{th} experiment

n=1 is repeated number of each experiment in L-9 Orthogonal

Analysis of variance (ANOVA) is carried out for Die Sinking EDM, the results of which is shown in Table 1.6. This Table indicates that the discharge current is most significant factor while machining of AISI 304 Stainless steel with tungsten carbide tool after that pulse on time is also an important parameter and voltage is not significant factor during machining. Figure 1.3 represent that the main effect of S/N ratio on MRR by the factor.

Table 1.6

Effect	Analysis of Variance (MRR) Mean = 14.5931 Sigma = 3.40187				
	SS	df	MS	F	P
1 Ip	76.42654	2	38.21327	1857.607	0.000538
2 Ton	14.00673	2	7.00337	340.445	0.002929
3 V	2.10735	2	1.05367	51.221	0.019149
Residual error	0.04114	2	0.02057		

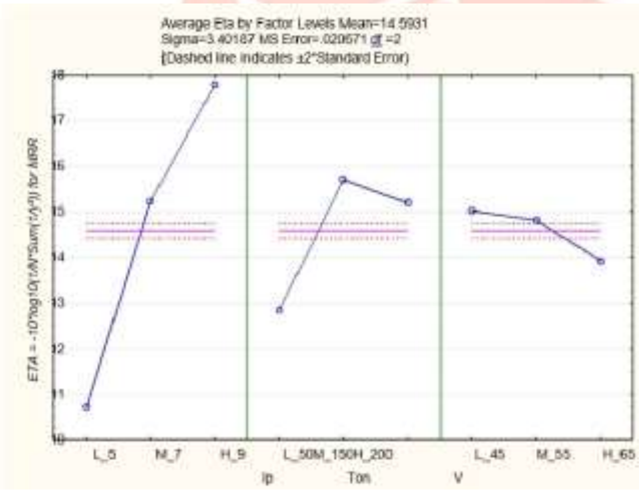

Fig 1.3 – S/N ratio plot for MRR.

For WEDM, Table 1.7 shows the ANOVA values of MRR for each parameter level and are graphically represented in Figure 1.4

Table 1.7

Effect	S/N ratio (dB)			D	SS	V	% Contribution
	Level1	Level2	Level3				
Ip	15.83	17.67	17.98	2	5.2614	2.630	75.92
Ton	16.93	17.25	17.30	2	1.7186	0.859	12.41
Toff	16.41	17.56	17.51	2	0.3686	0.184	08.62
Sv	17.40	16.93	17.16	2	0.1338	0.066	03.05
Total				8	7.4824		100

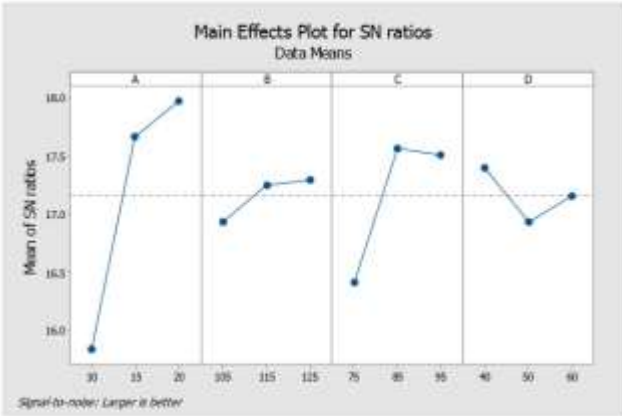

Fig 1.4 S/N graph for MRR of WEDM

Generally the S/N ration are selected based on their characteristics; and a higher value of S/N represents the better performance. Therefore, out of all the three levels, the optimal level parameters are selected corresponding to the higher values of S/N ratio.

Influence on SR

Taguchi method is used to analysis the result of response (since here the 'response' is surface roughness) of machining parameter for "smaller is better". The S/N ratio for Surface roughness are calculated by using the equation (2)

$$\text{SB: } \eta = -10\log\left[\frac{1}{n}\Sigma_{i=1}^{n} yi^{2}\right] \qquad (2)$$

Where, η denotes the S/N ratios calculated from observed values

yi Represent the experimentally observed value of i[th] experiment

n= 1 is repeated number of each experiment in L-9 Orthogonal

For Die Sinking EDM, ANOVA analysis (Table 1.8) is performed for EDM to know the % contribution of controlling parameters on 'response' i.e., surface roughness. It is observed that percentage contribution of voltage is about 65.64% and thus voltage has the maximum contribution or influence on the quality of surface roughness. The parameters such as discharge current (Ip) and pulse on time (Ton) has very less impact on surface quality of the work-piece.

n the Table 1.8, D.F. is the degree of freedom, SS is the sum of square, F is the Fisher value and % is the percentage of contribution of controlling parameter.

Table 1.8

Effect	Analysis of Variance (MRR) Mean = 14.5931 Sigma = 3.40187				
	SS	df	MS	F	P
Ip	76.42654	2	38.21327	1857.607	0.000538
Ton	14.00673	2	7.00337	340.445	0.002929
V	2.10735	2	1.05367	51.221	0.019149
Residual error	0.04114	2	0.02057		

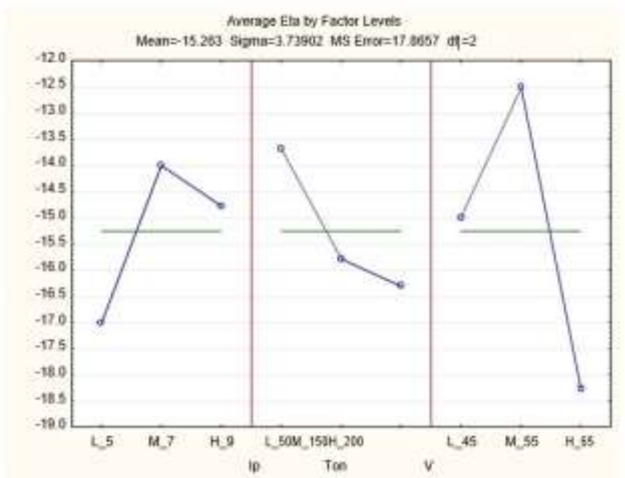

Fig 1.5- S/N ratio plot of Surface Roughness for EDM

For WEDM, The ANOVA Table1.9 shows the effect of individual controlling parameters for WEDM. It is observed that, percentage contribution of the parameter Ton (24.59 % contribution) is most significant, Ip (64.83 % contribution) and Sv (06.02% contribution) are significant and Toff (04.56% contribution) is less significant on performance measures and are graphically represented in fig 1.6.

Table 1.9

Effect	S/N ratio (dB)			D	SS	V	% Contribution
	Level 1	Level 2	Level 3				
Ip	-9.309	-8.252	-6.156	2	1.400	0.570	64.83
Ton	-9.148	-7.671	-6.919	2	0.490	0.245	24.59
Toff	-7.221	-7.228	-9.289	2	0.653	0.326	04.56
Sv	-7.407	-7.708	-8.623	2	0.211	0.105	06.02
Total				8	2.7559		

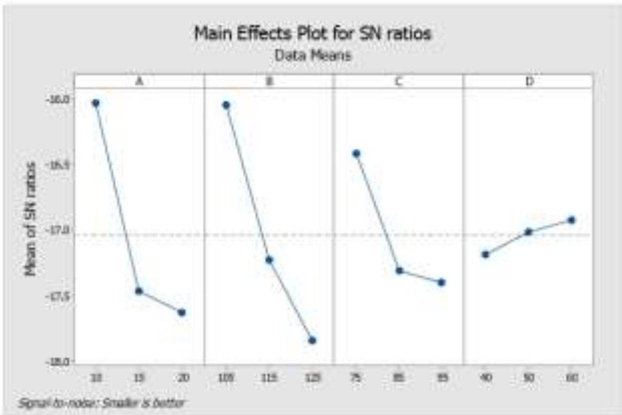

Fig 1.6- S/N graph for SR of WEDM.

CONCLUSION

From the above analysis, it is evident that contribution of voltage on SR for EDM is 65.64 which is overwhelming but for WEDM it is 24.59 for pulse on time Ton and64.83 is for Ip. By comparing results for die sinking EDM and WEDM it can be further concluded that for MRR in Die sinking EDM increases linearly with some extent of current and decrease slightly with pulse on time where as in WEDM the discharge current is influencing factor then pulse on time and at last is voltage on the given input. In WEDM the S/N ratio shows that the surface quality of steel can be improved by reducing surface roughness using present statistical analysis. In Die sinking EDM the voltage is the effective parameter in case of surface roughness after that current and voltage are less effective on machined work piece.

REFERENCE

[1]ecoursesonline.iasri.res.in/mod/page/view.php?id=12848
[2] docsity.com/en/edm-lecture-notes/650915/
[3]www.scribd.com/document/29413913...-ANOVA-Die-Steel-H13
[4]www.ijera.com/papers/Vol5_issue11/Part- 1/A511010105.pdf
[5]scribd.com/document/209591239/Electrical-Discharge nptel.ac.in/courses/112107077/module3/lecture9/lecture9.pdf
www.academia.edu/1204859/Experimental_In..._AISI_P20_Tool_Steel

[6] Marafona J, Chousal J A G (2005). A finite element model of EDM based on the Joule effect. International Journal of Machine Tools & Manufacture, 46:1–8.
[7] Luis C J, Puertas I, Villa G (2005) Material removal rate and electrode wear study on the EDM of silicon carbide. Journal of Materials Processing Technology, 164–165:889–896.
[8]G. Taguchi, E.A. Elsayed , T.C Hsiang `Quality Engineering in Production System`; McGraw-Hill 1989 & P.J. Ross
[9] P.J. Ross Taguchi techniques for quality engineering: loss function, orthogonal experiments, parameter and tolerance design', , McGraw-Hill, 1996
[10]Dr. Soupayan Mitra, Nishant International Journal for Research in Engineering Application & Management ISO3297:2007 Volume 02,Issue 10 jan 2017
[11] B.Kiran Kumar , A.V.S Ram Prasad , V Sridhar Parametric optimization for mrr and surface roughness in WEDM using Taguchi Method. Journal of Engineering and Technology Research 2014, 2 (6):43-52