iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: V Month of publication: May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5480

Process Parameter Optimization of WEDM Machining Ondie Steel-D3 for Curved Shape Cut Using Regression Modeling Analysis

Siddharth Sharma[1], Anil kumar Sharma[2]
[1, 2]JIT, Jaipur.

Abstract: WEDM is the non conventional machining process to cut the work piece in high precis manner. In present study D3 Die material is used as work material and process parameters of WEDM are selected and experimentally investigated for selective response. In present research study four process parameters having each three levels, the process parameters are following: Ton, Toff, current and wire feed. The experiment tables are generate using Taguchi Method separately for both materials. In this research work three response parameters cutting time, material removal rate and surface roughness are selected. Signal to noise ratio analysis, analysis of variance and multi objective optimization is performed using stats software Mini-tab

Keywords: WEDM, TAGUCHI, ANOVA.

I. INTRODUCTION

Wire Electrical Discharge machining (WEDM) is a specialized thermal machining process capable of accurately machining parts of hard materials with complex shapes. WEDM has evolved as a simple means of making tools and dies to the best alternative of producing micro-scale parts with the highest degree of dimensional accuracy and surface finish. Copper wire is used in various applications which require very high tensile strength to provide a reasonable load carrying capacity in small diameter wire. The effect of process parameters on the material removal rate (MRR) and surface roughness is to be investigated experimentally in wire EDM. As the process depends of different parameters it is very tedious task to analyze the effectiveness of all the parameter for the process. So, different techniques are used to analyze the parameters for better utilization of the process. A Taguchi's standard orthogonal array is chosen for the design of experiments. Signal to noise ratio analysis, analysis of variance and multi objective optimization is performed using stats software Mini-tab

II. LITERATURE REVIEW

Wanga (01, 2018) did an experimental investigation to change of micro-WEDM to accomplish the exact creation of micro rigging with unblemished tooth profile, in particular right off the bat holding a sharp corner on the apparatus teeth where the preparing deformity exists and after that evacuating it continuously handling of micro-WEDM process. The static contact between the center dance of the installation and the micro apparatus with sharp corner is hypothetically researched utilizing ABAQUS software and experimentally turned out to be in great condition on X153CrMoV12 work piece material. The attainability of procedure were confirm and repeatability of the proposed methodology, five micro apparatuses with 10 gear number, 0.1 mm module and 2 mm tooth width were machined utilizing 50 µm distance across wire terminal, showing phenomenal similarity, machining blunder with under 1.5 µm and surface roughness with 0.9 µm.[1] Dabade et al. (02, 2016) completed an experimental work to break down the impact of machining parameters on MRR, Ra, Kerf and dimensional deviation amid machining on WEDM process. Inconel 718 super compound material was utilized for experiment reason. From the watched information, it was inferred that beat on time was the most noteworthy factor for MRR, SR, Kerf and Dimensional deviation.[2] Krishnan (03, 2017) introduced the work which was centered around machining of titanium combination by vibrating the wire a sidelong way with the fluctuated recurrence of excitation to improve the material expulsion rate and to acquire the basic kerf width in Wire Electrical Discharge Machining (WEDM) process. The examination was done on the WEDM procedure of Ti-6Al-4V with cutting wire being energized parallel way by utilizing a mechanical shaker. Surface uprightness, roughness and material expulsion rate were investigated on machined surface. It was uncovering that a low recurrence of 100 Hz has brought about improved MRR. The white layer shaped at a recurrence of 100 Hz is sensibly high contrasted with machining by without vibration (WOV) in the two wires, while it is as yet lesser for other recurrence machining condition. Moreover, the white layer shaped was insignificantly less while machining by zinc covered metal wire contrasted with the machining by a normal metal wire. [3]

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Gong et al. (04, 2016) displayed the Breakdown Voltage (BV) conduct in low speed WEDM procedure of Ti-6Al-4V material in deionized water. It was discovered that real BV is approx. 320V, however from the experiment diverse outcomes were gotten. From the experimental outcomes, it very well may be presumed that the release hole must have various air pockets and flotsam and jetsam that assumed a critical job in voltage conduct. [4]

III. EXPERIMENTAL WORK

The input parameters for present study is chosen from previous literature which is discussed in chapter 2, but machine factors are also consider in this research study. Simple half circular cut is chosen for cut using WIRE EDM machine. All technical specifications of machine with limitations is considered in this chapter. Machine which is used for this study is Maxicut–e WEDM (see figure 3.1). EN-08 and Die steel D3 are chosen for experiment using WEDM machining. The machine is installed in CIPET, Jaipur. This study is based on design of experiment (DOE) method named Taguchi method. The important performance measures in WEDM are metal removal rate (MRR), cutting time and surface roughness. In WEDM operations, MRR determines the economics of machining and rate of production whereas surface roughness denotes degree of precision and dimensional accuracy.

Factor And Their Levels For Orthogonal Array

Factor	Symbol	Unit	L-I	L-II	L-III						
Ton	A	Micro sec	2	3	4						
Toff	B	Micro sec	9	8	7						
Wire Feed	C	Mm/sec	6	6.5	7						
Current	D	A	6.5	7	7.5						

Each three level parameter has two degree of freedom (DOF) (number of levels – 1), the total DOF required for four variables each at three levels is8(i.e.) 4× (3–1). As per Taguchi's method the total DOF of selected OA must be greater than or equal to the total DOF required for the experiment (Roy,2001). So an L9 OA (a standard three-level OA) having 8 DOF was selected for the present analysis (Table 4.2). The typical L9 orthogonal array layout with factors is shown in Table 4.3.

Table 4.2
Coded Table For L9 Orthogonal Array

Run	A	B	C	D					
1	1	1	1	1					
2	1	2	2	2					
3	1	3	3	3					
4	2	1	2	3					
5	2	2	3	1					
6	2	3	1	2					
7	3	1	3	2					
8	3	2	1	3					
9	3	3	2	1					

Real Values For L9 Orthogonal Array

Run	Ton	Toff	WF	Current
1	2	9	6	6.5
2	2	8	6.5	7
3	2	7	7	7.5
4	3	9	6.5	7.5
5	3	8	7	6.5
6	3	7	6	7
7	4	9	7	7
8	4	8	6	7.5
9	4	7	6.5	6.5

In present chapter theory of design of experiment and its application of DOE in present thesis is present. In present research study Taguchi method is used for generating the experiments runs which is called as Orthogonal Array.

IV. RESULT AND DISCUSSION

The present research work is the experimental analysis of process parameters of wire EDM machining on two different type of Steels (Die Steel-D3 and EN-08) for three type of responses (cutting time, material removal rate and surface roughness). All experiment table are generated by taguchi method and the factor and levels are present in table 5.1 for both materials

Output Results For D3 Work Piece

RUN	Ton	Toff	WF	Current	Cutting Time	MRR	Ra
	µsec	µsec	Inch/sec	A	sec	gm/min	µ-m
1	2	9	6	6.5	1301	0.626	2.56
2	2	8	6.5	7	1362	0.601	3.66
3	2	7	7	7.5	1511	0.470	2.76
4	3	9	6.5	7.5	1217	0.558	2.55
5	3	8	7	6.5	1148	0.598	3.74
6	3	7	6	7	1120	0.635	3.48
7	4	9	7	7	1251	0.637	2.85
8	4	8	6	7.5	909	0.906	3.67
9	4	7	6.5	6.5	1327	0.590	3.91

In this section first of all the relation of factor and response are present in plot view and then the results are analysis using taguchi Signal to Noise ratio analysis (S/N ratio which is discussed in previous chapter 4)

A. Experimental Results of AISI D3 DIE Steel

In present section interaction plots among factors and response variables are present for test pieces D3 tool steel and the figure are present here from figure 5.1 to figure 5.3 for full interaction plots for response variable CT, MRR and surface roughness

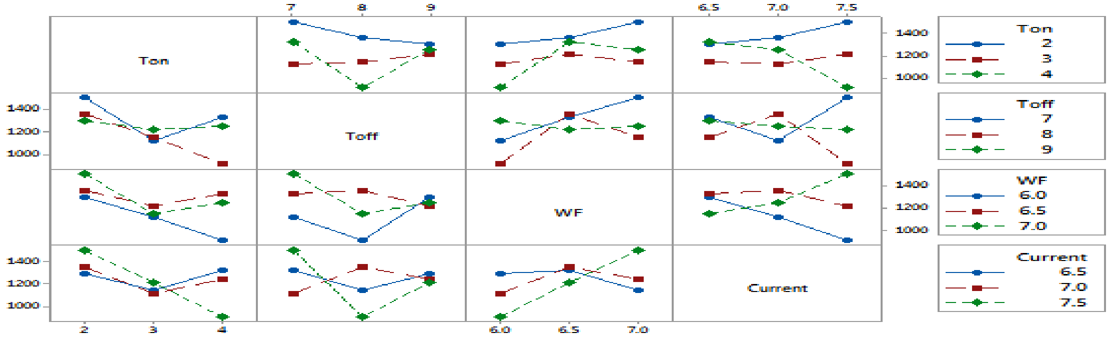

Fig 5.1 Interaction plot for cutting time (CT) for Die steel-D3

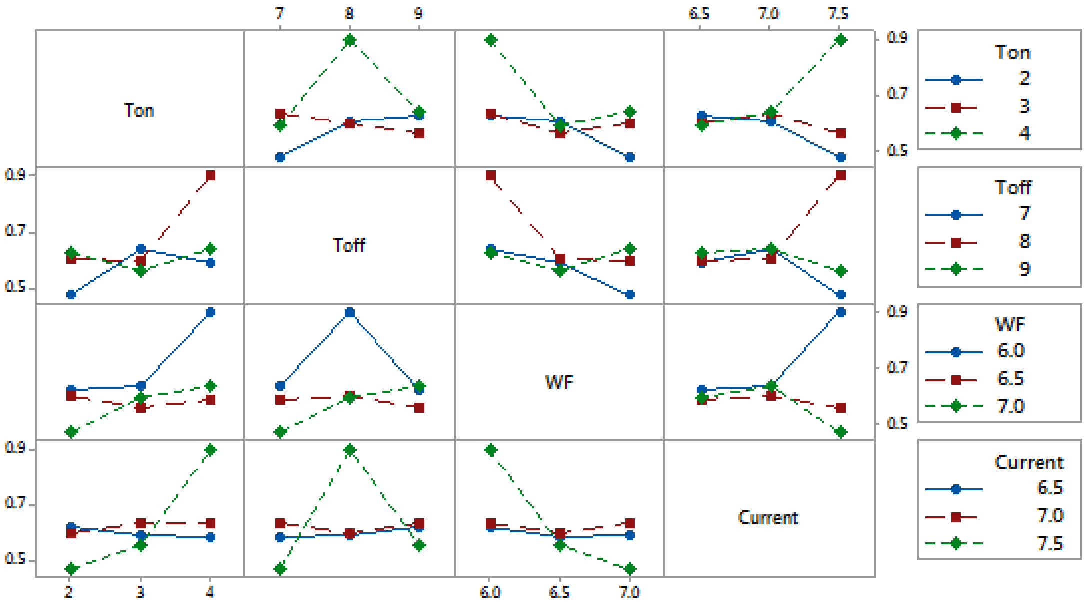

Fig 5.2 Interaction plot for material removal rate (MRR) for Die steel-D3

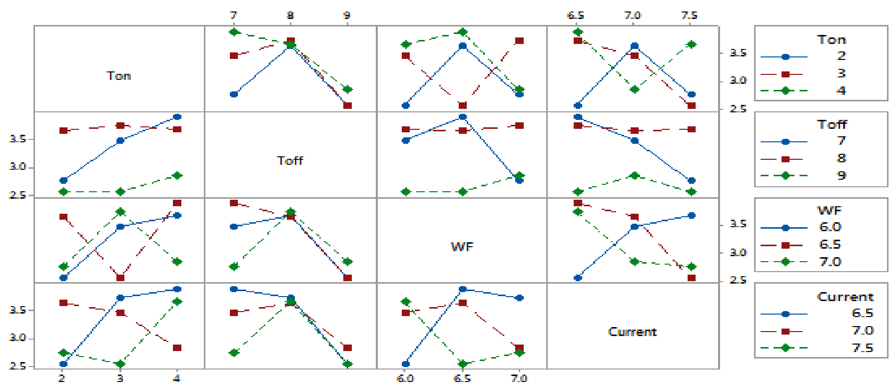

Fig 5.3 Interaction plot for Surface Roughness (Ra) for Die steel-D3

B. Analysis of Experimental Results Using Taguchi Method for AISI D3 DIE Steel

In previous chapter theory background of signal to noise ratio is discussed and in this chapter the analysis using S/N ratio is present for D3 steel test pieces and the individual S/N ratio is present in table 5.4 for CT response variable for D3 steel

S/N Ratio (Smaller Is Better) For Ct For D3 Steel

Run	Ton	Toff	WF	Current	Cutting Time	S/N ratio
	µsec	µsec	Inch/sec	A	sec	
1	2	9	6	6.5	1301	-62.2855
2	2	8	6.5	7	1362	-62.6835
3	2	7	7	7.5	1511	-63.5853
4	3	9	6.5	7.5	1217	-61.7058
5	3	8	7	6.5	1148	-61.1988
6	3	7	6	7	1120	-60.9844
7	4	9	7	7	1251	-61.9451
8	4	8	6	7.5	909	-59.1713
9	4	7	6.5	6.5	1327	-62.4574

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

"smaller is better" option is selected for this response variable and the rank identified using this S/N ratio analysis is present in table 5.5 and figure 5.4 for D3 steel work piece and response variable CT. The best ranked factor among all factors are Pulse on time whereas least ranked factor is current applied to WEDM machine.

Like cutting time, S/N ratio is calculated for MRR also using "larger is better"option. The results are present n table 5.6 for MRR S/N ratio results. The rank identification for this response variable is present in table 5.7 and figure 5.5. The results for MRR is that the best ranked factor is wire feed and least ranked factor is current

S/N Ratio (Larger Is Better) For Mrr For D3 Steel

Run	Ton	Toff	WF	Current	Cutting Time	S/N ratio
1	2	9	6	6.5	0.626	-4.06851
2	2	8	6.5	7	0.601	-4.42251
3	2	7	7	7.5	0.470	-6.55804
4	3	9	6.5	7.5	0.558	-5.06732
5	3	8	7	6.5	0.598	-4.46598
6	3	7	6	7	0.635	-3.94453
7	4	9	7	7	0.637	-3.91721
8	4	8	6	7.5	0.906	-0.85744
9	4	7	6.5	6.5	0.590	-4.58296

Like MRR, S/N ratio is calculated for surface roughness (Ra) also using "smaller is better"option. The results are present in table 5.8 for RA S/N ratio results. The rank identification for this response variable is present in table 5.9 and figure 5.6.

S/N Ratio (Smaller Is Better) For Ra For D3 Steel

Run	Ton	Toff	WF	Current	Cutting Time	S/N ratio
1	2	9	6	6.5	2.56	-8.1648
2	2	8	6.5	7	3.66	-11.2696
3	2	7	7	7.5	2.76	-8.8182
4	3	9	6.5	7.5	2.55	-8.1308
5	3	8	7	6.5	3.74	-11.4574
6	3	7	6	7	3.48	-10.8316
7	4	9	7	7	2.85	-9.0969
8	4	8	6	7.5	3.67	-11.2933
9	4	7	6.5	6.5	3.91	-11.8435

C. Regression Modeling analysis of AISI D3 DIE Steel

In present section linear and non linear regression modeling equations are made using MS excel software for CT response variable for D3 steel material. The comparison among these regression modeling equations are present in table 5.10, from which it is analysis that non linear regression modeling equation is more useful than linear modeling equation.

Residual Error Comparison Among Linear And Non Linear Equations For Ct

Run	Ton	Toff	WF	Current	Cutting Time	Residual-Linear	Residual-Non Linear
	µsec	µsec	Inch/sec	A	sec		
1	2	9	6	6.5	1301	53.056	45.125
2	2	8	6.5	7	1362	9.056	-2.209
3	2	7	7	7.5	1511	53.056	30.838
4	3	9	6.5	7.5	1217	33.222	47.404
5	3	8	7	6.5	1148	-210.278	-185.605
6	3	7	6	7	1120	-53.278	-40.651
7	4	9	7	7	1251	61.889	71.220
8	4	8	6	7.5	909	-95.111	-115.743
9	4	7	6.5	6.5	1327	148.389	148.049

1) *Linear Equation:* CT=902-114.5Ton-31.5Toff+193WF-46Current
2) *Non Linear Equation:* $CT=684.25Ton^{-0.227}*Toff^{-0.206}*WF^{-0.960}*Current^{-0.249}$

Residual Error Comparison Among Linear And Non Linear Equations For Mrr

Run	Ton	Toff	WF	Current	MRR	Residual-Linear	Residual-Non Linear
	µsec	µsec	Inch/sec	A	gm/min		
1	2	9	6	6.5	0.626	-0.003889	-0.004073
2	2	8	6.5	7	0.601	0.049111	0.059196
3	2	7	7	7.5	0.470	-0.003889	0.002793
4	3	9	6.5	7.5	0.558	-0.107556	-0.111089
5	3	8	7	6.5	0.598	0.070444	0.065069
6	3	7	6	7	0.635	-0.045556	-0.050455
7	4	9	7	7	0.637	-0.004222	0.004124
8	4	8	6	7.5	0.906	0.111778	0.089312
9	4	7	6.5	6.5	0.590	-0.066222	-0.050272

1) *Linear Equation:* MRR=.960+0.0727Ton+0.0210Toff-0.154WF+0.0400Current
2) *Non Linear Equation:* $MRR=2.46Ton^{0.351}*Toff^{0.343}*WF^{1.742}*Current^{0.400}$

Residual Error Comparison Among Linear And Non Linear Equations For Ra

Run	Ton	Toff	WF	Current	Ra	Residual-Linear	Residual-Non Linear
	µsec	µsec	Inch/sec	A	µ-m		
1	2	9	6	6.5	2.56	-0.340556	-0.360526
2	2	8	6.5	7	3.66	0.659444	0.688265
3	2	7	7	7.5	2.76	-0.340556	-0.317966
4	3	9	6.5	7.5	2.55	-0.122222	-0.233461
5	3	8	7	6.5	3.74	0.352778	0.362075
6	3	7	6	7	3.48	-0.187222	-0.166282
7	4	9	7	7	2.85	-0.208889	-0.225699
8	4	8	6	7.5	3.67	0.331111	0.377453
9	4	7	6.5	6.5	3.91	-0.143889	-0.130970

1) *Linear Equation:* Ra=9.09+0.242Ton-0.365Toff-0.154WF-0.40Current
2) *Non Linear Equation:* $Ra=92.741Ton^{0.205}*Toff^{0789}*WF^{-0.199}*Current^{-0.805}$

Optimal Solution For Die Steel (D3)

Response	Ton	Toff	WF	Current
	µsec	µsec	Inch/sec	A
Cutting Time	4	8	6	7.5
MRR	4	8	6	7.0
Ra	2	9	7	7.5

V. CONCLUSION

This paper has presented an investigation on optimization and the effect of machining parameters on surface roughness and MRR in WEDM operations. The control factors considered for the studies are Pulse-on, Pulse-off, Current and Spark voltage. Process parameters were selected based on Taguchi's L'18 orthogonal array. ANN is used to predict the response variable viz., surface roughness,MRR. Back propagation feed forward neural network (BPNN) is used to build and train the network. The main out come of this research is that the most important factor for all three response variables are pulse on time where as other factors show different results for each response respectively. The combined result from CD function optimization for D3 steel work piece is Ton is on 4, Toff is on 9, Wire Feed is on 6 and the last factor current must be on 7.5 for combined effect of response parameters.

REFERENCES

[1] Wang, Y., Chen, X., Wang, Z., & Dong, S. (2018). Fabrication of micro gear with intact tooth profile by micro wire electrical discharge machining. Journal of Materials Processing Tech., 252, 137–147.
[2] Dabade, U. A., & Karidkar, S. S. (2016). Analysis of response variables in WEDM of Inconel 718 using Taguchi technique. Procedia CIRP, 41, 886–891.
[3] Radhakrishnan, P., Vijayaraghavan, L., & Babu, N. R. (2017). Assessment of material removal capability with vibration-assisted wire electrical discharge machining. Journal of Manufacturing Processes, 26, 323–329.
[4] Gong, Y., Su, Y., Cheng, J., Wang, C., Liu, Y., & Zhu, Z. (2016). Modeling and experimental study on breakdown voltage (BV) in low speed wire electrical discharge machining (LS-WEDM) of Ti-6Al-4V.International Journal of Advanced Manufacturing Technology, 1–16.
[5] Shakeri, S., Ghassemi, A., Hassani, M., & Hajian, A. (2016). Investigation of material removal rate and surface roughness in wire electrical discharge machining process for cementation alloy steel using artificial neural network. The International Journal of Advanced Manufacturing Technology, 82(1–4), 549–557.
[6] Manjaiah, M., Laubscher, R.F., Kumar, A., & Basavarajappa, S. (2016). Parametric optimization of MRR and surface roughness in wire electro discharge machining (WEDM) of D2 steel using Taguchi-based utility approach. International Journal of Mechanical and Materials Engineering, 11(1).
[7] Sonawane, S.A., & Kulkarni, M.L. (2016). Experimental study and optimization of WEDM of Ti-6Al-4V using Taguchi method, 6(5), 1686–1691.
[8] Gaikwad, V., & Jatti, V. S. (2016). Optimization of material removal rate during electrical discharge machining of cryo-treated Ni-Ti alloys using Taguchi's method. Journal of King Saud University - Engineering Sciences, 0–6.
[9] Padhi, P.C., Mahapatra, S.S., Yadav, S.N., & Tripathy, D.K. (2016). Multi-objective optimization of wire electrical discharge machining (WEDM) process parameters using weighted sum genetic algorithm approach. Journal of Advanced Manufacturing Systems, 15(2), 85–100.