Multi-Response Optimization of Process Parameters of WEDM using TOPSIS Approach

Nilesh T. Mohite
Mechanical department
D. Y.Patil College of Engineering &Technology
Kolhapur,India

Pratik P.Shinde
Mechanical department
D. Y. Patil College of Engineering &Technology
Kolhapur,India

Abhijit P. Kalantre
Mechanical department
D. Y.Patil College of Engineering &Technology
Kolhapur,India

Amar B. Shirage
Mechanical department
D. Y. Patil College of Engineering &Technology
Kolhapur,India

Shubhash T. Vhagade
Mechanical department
D. Y. Patil College of Engineering &Technology
Kolhapur,India

Rohit C. Kumbhar
Mechanical department
D. Y. Patil College of Engineering &Technology
Kolhapur,India

Abstract: **Present study deals with multi response optimization of process parameters during wire EDM of EN31. In this study, process parameters like pulse on time (TON), pulse off time (TOFF) and peak current (IP) are taken into consideration. Taguchi method is used for designing the experiment. In order to optimize the multiple responses like machining time and surface roughness, Technique for order preference by similarity to ideal solution (TOPSIS) method is used to get optimum parametric combination. Finally conformity test is performed to check the validity of the proposed approach.**

Keywords: TOPSIS, Optimization, Taguchi

1. INTRODUCTION

Wire electrical discharge machining is a non-traditional machining process which is based on material removal from a work piece by means of series of repeated electrical discharge between electrode and the work piece in the presence of dielectric fluid. A continuous travelling wire electrode which is controlled by the computer to follow a predefined path to cut a slot through the work piece to produce the required shape. High frequency alternating current is discharged from the wire to the work piece with very small gap through an insulated dielectric fluid. The heat of each electrical spark erodes away the material. These particles are flushed away from the cut with a stream of dielectric fluid with the help of nozzle. This dielectric also prevents the heat buildup in the work piece.

In the past several years researchers have used different methods to improve the machining characteristics during wire EDM of several materials. AmiteshGoswamiet.al.usedtaguchi based GRA method to investigate surface integrity, MRR and wire wear ratio for WEDM of Nimonic 80A. [1]. Neeraj Sharma et.al.used Response Surface Methodology to optimize process parameters for WEDM of HSLA steel. [2]. J.B. saedonet.al.appliedtaguchi based GRA method to perform multi objective response optimization for WEDM of titanium alloy. [3]. Brajesh Kumar Lodhiet.al.usedtaguchi technique to optimize machining parameters in WEDM of AISI D3 steel. [4]. BijayaBijetaNayaket.al.proposed Artificial Neural Network to investigate and optimize process parameters during WEDM of cryo treated Inconel 718. [5]. Neeraj Sharma et.al.used RSM with the help of Genetic Algorithm to optimize the process parameters during WEDM of HSLA steel. [6]. Ashish Goyal used ANOVA to optimize the process parameters during WEDM of Inconel 625 using cryo treated wire electrode. [7]. J.F. Oberholzeret.al.optimized the process parameters during WEDM of Aluminium 7075-T6 using ANOVA. [8]. Neeraj Sharma et.al optimized the process parameters for cryogenic treated D-2 Tool steel by using RSM and Genetic Algorithm. [9]. D.Sudhakaraet.al.appliedtaguchi Method to optimize the process parameters during WEDM of P/M cold worked Tool Steel. [10]. Vikaset.al.used Taguchi method to optimize process parameters during WEDM of EN19 & EN41. [11]. V.Kavimaniet.al.used Taguchi based GRA method to optimize process parameters of magnesium composites. [12]. G.Shrinivasraoet.al.used desirability approach to optimize process parameters during WEDM of α-β Titanium alloy. [13]. SachinSonawaneet.al.used principal component analysis integrated Taguchi method to optimize process parameters during WEDM of Nimonic-75 alloy. [14]. G.harinathGowdet.al.used NSGA algorithm to optimize process parameters during WEDM of SS304 steel. [15]. Somvir Singh nainet.al.used particle swarm optimization to optimize the parameters during WEDM of Udimet 605 alloy. [16]. RupeshChalisgaonkaret.al.usedutility concept methodology to optimize the parameters during WEDM of pure titanium. [17]. R.Ramkrishnanet.al.developed ANN model to optimize parameters of Inconel 718. [18]. Bijo Mathew et.al. Taguchi GRA method to optimize the parameters during WEDM of AISI 304 steel. [19].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

BikashChoudhariet.al.used fuzzy logic methodology to optimize process parameters during WEDM of H21 tool steel. [20]. R.Soundararajanet.al.used RSM to optimize the parameters during WEDM of squeeze casted A413 alloy. [21]. Divyareddyet.al.used GRA method to optimize the parameters during WEDM of Ti50Ni48Co2 alloy. [22]. K.Dayakaret.al.used Taguchi method to optimize the parameters during WEDM of maraging steel 350. [23]. Siva Prasad arikatlaet.al.used RSM to optimize the parameters during WEDM of titanium alloy. [24]. V.Chengal Reddy et.al.used GRA method to optimize the parameters during WEDM of Aluminium HE30. [25]. Anshuman Kumar et.al used simulated annealing to optimize the parameters during WEDM of Inconel 718. [26]

Past study reveals that WEDM involves large number of input parameters that affect the quality characteristics, it is worthwhile to investigate the relative importance between the input and output parameters. Due to the complexity and nonlinearity involved in this process, good functional relationship with reasonable accuracy between performance characteristics and process parameters is difficult to obtain. To address this issue, the present study proposes Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model to determine the relationship between input parameters and performance characteristics. Most of the researchers have used Taguchi and GRA approach to optimize the process parameters. Multi attribute decision making techniques like TOPSIS, PROMETHEE have not been used to find the optimal setting of the parameters for EN31. Thus, the analysis of improvement in the process using multi attribute decision making techniques is desirable. In the present work, an attempt has been made to find out the optimum parameters through multi response optimization using TOPSIS to achieve minimum Machining Time (MT) and minimum surface roughness.

2. EXPERIMENTAL DETAILS AND METHODOLOGY

2.1 Setup:

Experiments were performed on Electronica supercut 734. Alloy Steel 300 of 200mm*200mm*7.5mm size has been used as a work piece material. Brass wire of 0.25 mm diameter is used as an electrode material.

2.2 Design of Experiments:

For present study Taguchi parameter design approach is used for design of experiment. Six process parameters are selected as control factors and other factors are kept constant.

Table 1 List of controlled and constant parameters

Controlled Parameters	**Constant Parameters**		
Pulse on Time	Work piece material	;	Alloy Steel 300
Pulse off Time	Work piece Thickness	;	7.5 mm
Peak current	Wire Electrode	;	Zinc coated Brass wire 0.25mm diameter
	Servo Feed	;s	2120mm/Min.

Table 2 Levels of controlled parameters

	Parameters	**Level 1**	**Level 2**	**Level 3**	**Unit**
A	Pulse on Time TON	108	116	124	µSec
B	Pulse off Time TOFF	40	45	50	µSec
C	Peak Current IP	70	150	230	Volt

By referring orthogonal arrays table, L9 array is selected for the present study. Parametric combination for experimentation is tabulated as follows.

Table 3 Parameter combination for experiments

Expt. No.	**TON**	**TOFF**	**IP**
1	110	40	70
2	110	45	150
3	110	50	230
4	115	40	150
5	115	45	230
6	115	50	70
7	120	50	70
8	120	45	70
9	120	50	150

2.3 Experimental Results

Table 4 Experimental results

Expt.No.	**Surface Roughness in (µ)**	**Material Removal Rate (mm^3 /Min.)**
1	1.944	5.695
2	2.579	5.475
3	1.894	4.417
4	3.985	7.402
5	3.853	8.195
6	2.298	5.663
7	3.164	8.394
8	4.019	8.683
9	3.823	6.538

3. MULTI RESPONSE OPTIMIZATION

In order to obtain the desired output with minimum usage of resources it is important to follow the optimum combination of process parameters. The optimum parameter combination for one response may be unfavorable for other responses. Therefore multi-objective optimization is necessary to obtain the optimum combination of parameters.

3.1 TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)

TOPSIS helps to determine the most suitable alternative from the given sets. The technique used in TOPSIS is that the selected solution should be nearest from the positive best solution and farthest from the negative best solution.

3.1.1 Step1

The normalized matrix is obtained by the following expression

$$R_{ij}=\frac{q_{ij}}{\sqrt{\sum_{i=1}^{m} q_{ij}^{2}}} \qquad j=1, 2, 3….$$

Table 5 Normalized matrix

Expt.No.	Surface Roughness in (µ)	Material Removal Rate (mm^3 /Min.)
1	0.094349	0.276399
2	0.125168	0.265722
3	0.091923	0.214373
4	0.193407	0.359246
5	0.187	0.397734
6	0.111530	0.274846
7	0.153561	0.407392
8	0.195057	0.421418
9	0.185544	0.317313

3.1.2 Step2

The weight of each attribute was assumed to be w_j (j=1, 2, 3...) The weighted normalized matrix can be obtained by

U= $w_j r_{ij}$

Where, $\sum_{j-1}^{n} w_j$ =1

Table 6 Weighted Normalized matrix

Expt.No.	Surface Roughness in (µ)	Machining Time (sec)
1	0.047175	0.1382
2	0.062584	0.132861
3	0.045961	0.107187
4	0.096703	0.179623
5	0.0935	0.198867
6	0.055765	0.137423
7	0.07678	0.203696
8	0.097528	0.210709
9	0.092772	0.158657

3.1.3 Step3

The positive and negative ideal solutions are obtained from following expressions.

$U^+ = \{(\sum_i^{max} u_{ij} \mid j \in J), (\sum_i^{min} \mid j \in J \mid i=1, 2, m)\}$

$= \{u_1^+, u_2^+, u_3^+, u_4^+, \ldots \ldots u_n^+\}$

$U^- = \{(\sum_i^{min} u_{ij} \mid j \in J), (\sum_i^{max} \mid j \in J \mid i=1, 2, m)\}$

$= \{u_1^-, u_2^-, u_3^-, u_4^-, \ldots \ldots u_n^-\}$

3.1.4 Step4

Separation between alternatives from positive ideal solution is expressed as

$S_i^+ = \sqrt{\sum_{j=1}^{n} (u_{ij} - u_j^+)^2}$, i=1, 2, 3……m

Separation between alternatives from negative ideal solution is expressed as

$S_i^- = \sqrt{\sum_{j=1}^{n} (u_{ij} - u_j^-)^2}$, i=1, 2, 3……m

Table 7 Separation from positive ideal and negative ideal solution

Expt.No.	S_i^-	S_i^+
1	0.088279	0.031037
2	0.085331	0.030586
3	0.115655	0
4	0.031097	0.088441
5	0.012509	0.103272
6	0.08435	0.031786
7	0.021901	0.101311
8	0	0.115655
9	0.052269	0.069573

3.1.5 Step5

Relative closeness of the alternative to the positive ideal solution is given by

Pi = $\frac{S_i^-}{S_i^+ + S_i^-}$ i=1, 2….m

Table 8 Closeness co-efficient

Expt.No.	Pi	Rank
1	0.739876	2
2	0.736141	3
3	1	1
4	0.260142	6
5	0.108037	8
6	0.726304	4
7	0.177754	7
8	0	9
9	0.428991	5

From the analysis it is clear that experiment no. 7 is the best multiple performance characteristics having highest preference order followed by expt. No.4 and expt.no.5 The optimum parametric combination can be determined by considering the higher values of preference order.

4. CONCLUSION

In the present investigation multi response optimization technique is used to optimize the process parameters during WEDM of EN31.The optimum combination of parameters using TOPSIS approach are TON3 TOFF1 IP3 (i.e. third level of TON, first level of TOFF, third level of IP) for experiment no. 7. The machining time and surface roughness is 6.25 min. and 3.3 micron respectively at optimum levels. It can be stated that TOPSIS approach can be useful to optimize multi-response characteristics for any manufacturing process.

5. REFERENCES

[1] D. Sudhakara and G. Prasanthi, "Application of Taguchi method for determining optimum surface roughness in wire electric discharge machining of P/M cold worked tool steel (Vanadis-4E)," Procedia Engineering, vol. 97, pp. 1565-1576, 2014.

[2] G. Srinivasarao and D. Suneel, "Parametric Optimization of WEDM on α-β Titanium Alloy using Desirability Approach," Materials Today: Proceedings, vol. 5, pp. 7937-7946, 2018.

[3] R. Soundararajan, A. Ramesh, N. Mohanraj and N. Parthasarathi, "An investigation of material removal rate and surface roughness of squeeze casted A413 alloy on WEDM by multi response optimization using RSM," Journal of Alloys and Compounds, vol. 685, pp. 533-545, 2016.

[4] S. A. Sonawane and M. L. Kulkarni, "Optimization of machining parameters of WEDM for Nimonic-75 alloy using principal component analysis integrated with Taguchi method," Journal of King Saud University-Engineering Sciences, vol. 30, pp. 250-258, 2018.

[5] N. Sharma, R. Khanna and R. D. Gupta, "WEDM process variables investigation for HSLA by response surface methodology and genetic algorithm," Engineering science and technology, an international journal, vol. 18, pp. 171-177, 2015.

[6] N. Sharma, R. Khanna and R. Gupta, "Multi quality characteristics of WEDM process parameters with RSM," Procedia Engineering, vol. 64, pp. 710-719, 2013.

[7] N. Sharma, A. Singh, R. Sharma and others, "Modelling the WEDM process parameters for cryogenic treated D-2 tool steel by integrated RSM and GA," Procedia Engineering, vol. 97, pp. 1609-1617, 2014.

[8] J. B. Saedon, N. Jaafar, M. A. Yahaya, N. Saad and M. S. Kasim, "Multi-objective optimization of titanium alloy through orthogonal array and grey relational analysis in WEDM," Procedia Technology, vol. 15, pp. 832-840, 2014.

[9] A. K. Roy, K. Kumar and others, "Effect and Optimization of Machine Process Parameters on MRR for EN19 & EN41 materials using Taguchi," Procedia Technology, vol. 14, pp. 204-210, 2014.

[10] V. C. Reddy, N. Deepthi and N. Jayakrishna, "Multiple response optimization of wire EDM on aluminium HE30 by using grey relational analysis," Materials Today: Proceedings, vol. 2, pp. 2548-2554, 2015.

[11] D. Reddy, H. Soni and S. Narendranath, "Experimental Investigation and Optimization of WEDM process parameters for Ti50Ni48Co2 Shape Memory Alloy," Materials Today: Proceedings, vol. 5, pp. 19063-19072, 2018.

[12] R. Ramakrishnan and L. Karunamoorthy, "Modeling and multi-response optimization of Inconel 718 on machining of CNC WEDM process," Journal of materials processing technology, vol. 207, pp. 343-349, 2008.

[13] J. F. Oberholzer, G. A. Oosthuizen and P. De Wet, "Optimal machine parameters to maximize the accuracy of producing aluminum dovetails using WEDM," Procedia Manufacturing, vol. 7, pp. 472-477, 2017.

[14] B. B. Nayak and S. S. Mahapatra, "Optimization of WEDM process parameters using deep cryo-treated Inconel 718 as work material," Engineering Science and Technology, an International Journal, vol. 19, pp. 161-170, 2016.

[15] S. S. Nain, D. Garg and S. Kumar, "Investigation for obtaining the optimal solution for improving the performance of WEDM of super alloy Udimet-L605 using particle swarm optimization," Engineering science and technology, an international journal, vol. 21, pp. 261-273, 2018.

[16] B. Mathew, J. Babu and others, "Multiple process parameter optimization of WEDM on AISI304 using Taguchi grey relational analysis," Procedia Materials Science, vol. 5, pp. 1613-1622, 2014.

[17] B. K. Lodhi and S. Agarwal, "Optimization of machining parameters in WEDM of AISI D3 steel using Taguchi technique," Procedia CIRP, vol. 14, pp. 194-199, 2014.

[18] A. Kumar, H. Mishra, K. Vivekananda and K. P. Maity, "Multi-objective optimization of wire electrical discharge machining process parameterson Inconel 718," Materials Today: Proceedings, vol. 4, pp. 2137-2146, 2017.

[19] V. Kavimani, K. S. Prakash and T. Thankachan, "Multi-objective optimization in WEDM process of Graphene--SiC-Magnesium composite through hybrid techniques," Measurement, 2019.

[20] A. Goyal, "Investigation of material removal rate and surface roughness during wire electrical discharge machining (WEDM) of Inconel 625 super alloy by cryogenic treated tool electrode," Journal of King Saud University-Science, vol. 29, pp. 528-535, 2017.

[21] G. H. Gowd, M. G. Reddy, B. Sreenivasulu and M. Ravuri, "Multi objective optimization of process parameters in WEDM during machining of SS304," Procedia Materials Science, vol. 5, pp. 1408-1416, 2014.

[22] A. Goswami and J. Kumar, "Investigation of surface integrity, material removal rate and wire wear ratio for WEDM of Nimonic 80A alloy using GRA and Taguchi method," Engineering Science and Technology, an International Journal, vol. 17, pp. 173-184, 2014.

[23] K. Dayakar, K. V. M. K. Raju and C. R. B. Raju, "Prediction and optimization of surface roughness and MRR in wire EDM of maraging steel 350," Materials Today: Proceedings, 2019.

[24] B. Choudhuri, R. Sen, S. K. Ghosh and S. C. Saha, "Modelling of surface roughness and tool consumption of WEDM and optimization of process parameters based on fuzzy-PSO," Materials Today: Proceedings, vol. 5, pp. 7505-7514, 2018.

[25] R. Chalisgaonkar and J. Kumar, "Multi-response optimization and modeling of trim cut WEDM operation of commercially pure titanium (CPTi) considering multiple user's preferences," Engineering Science and Technology, an International Journal, vol. 18, pp. 125-134, 2015.

[26] S. P. Arikatla, K. T. Mannan and A. Krishnaiah, "Parametric optimization in wire electrical discharge machining of titanium alloy using response surface methodology," Materials Today: Proceedings, vol. 4, pp. 1434-1441, 2017.