International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-09, Dec 2019

Optimization of Process Parameter in EDM for Titanium Based Alloy by Using Taguchi Based Grey Relational Analysis and Metaheuristics

[1]Pradeep Kumar Yadav, [2]Suryanarayan Panda, [3]Babul Das

[1]P.G. Scholar, [2,3]Assistant Professor, Department of Production Engineering, BIT Sindri, Dhanbad, India. [1]kumarpradeep.cit123@gmail.com, [2]snpanda.bit@gmail.com, [3]babuldas11@gmail.com

ABSTRACT-Titanium based Alloy is mostly used in area of automobile, marine, aerospace, biomedicine etc. in various form of components, die and products. The work has been done in order to optimize various machining parameters on Electric Discharge Machine (EDM) in which Titanium base is used as work-piece. Pulse on time (T_{on}), discharge current (Ip) and Pulse off time (T_{off}) are used as control parameter. Material removal rate (MRR) and Surface roughness is the response parameter in this experiment. In the design of experiment Taguchi technique (L9 orthogonal array) was used and Taguchi Methods for optimization. The analysis of optimum process parameter has been done using grey relational grade. The analysis of higher material removal rate and better surface finish yields optimum values of process parameters. The proposed research compares the optimum values of input parameters found from the conventional Taguchi based grey relational analysis and metaheuristic. The validation of output results done through experimental investigation. The proposed method can be used for other engineering process optimization which will be beneficial in the scope in production technology.

Keywords: Grey Relational Analysis, S-N Ratio, Metaheuristics.

I. INTRODUCTION

In the modern day's surface finish and good dimensional accuracy is an important characteristic of any machining operation. To achieve dimensional accuracy, surface finish, high quality, high production rate, economical in terms of cost and increase the performance of product with less impact on the environment the non-traditional machining process should be used. EDM is thermoelectric process in which heat energy of a spark is capable of melting and vaporization of material from localized area on the electrodes, i.e. tool and work-piece in presence of dielectric fluid. Dielectric should be used for coolant and insulator. It is also used for washed away the material from work-piece which should be machined by the EDM. Electric discharge machining (EDM) is the unconventional machining process use to manufacture component with labyrinthine shape and profiles irrespective of hardness. It should be use where machining by the traditional process should be very difficult. The Electric discharge machining should be also used for making tools, dies and other parts where dimensional accuracy is very important. Singh and Kumar et al. [1] Carried out experimental observations to optimize the EDM process parameters to obtained the desired level of surface roughness on titanium alloys. He observed that by ANOVA discharge current has more influence on the surface roughness, then pulse off time and least effected by the plus on time.. Zeilmann et al [2] Work on prediction of Surface roughness of AISI H13 under different pulse on time and depths by ANOVA technique and he concluded that surface is worse for the both pulse on time and cavity depth is increases. The cracks concentration is increases and cracks tends to be larger in surface the Ton time is increased. In the center of craters can be found light attached rubble. Jaydev Rana et al. [3] Is worked on the Multi-objective optimization of EDM parameter for reliable machining by using input process parameters likes voltage, discharge current and pulse on time. An optimization technique that uses Vikor Index has been used to optimize the MRR, TWR, Ra and OC and he concludes that the effect of the current on the overall behavior of EDM is highest. C.J. Luis *et al.* [4]] in this experiment authors study about the material removal rate (MRR) and tool wear (TW) on the die-sinking EDM of siliconized or reaction-bonded silicon carbide (SiSiC) has been done. In this study input process parameter like pulse on time, duty cycle, voltage and dielectric flushing pressure and output is MRR and TW. Nakka Nagaraju *et al.* [5] is work on the prediction of Optimization of Process Parameters of EDM Process Using Fuzzy Logic for investigating Material Removal Rate and Surface Finish and he also used the

 DOI : 10.35291/2454-9150.2019.0558

ISSN : 2454-9150 Vol-05, Issue-09, Dec 2019

Taguchi method by input machining parameters, i.e. discharge voltage and Inter Electrode Gap (IEG), discharge current and pulse on time on the Material Removal Rate (MRR), Tool Wear Rate and Surface Roughness (Ra). He used work- piece material as AISI 304 Stainless Steel. Shashikant *et al.* [6] is work on the prediction of optimization value for minimum tool wear rate improving the machining process in EDM by Taguchi method. The author has considered the four input parameters through a series of experiments to finding maximum MRR. They used wok-piece material as EN19 and EN41 respectively. Apurba kumar *et al.* [7] studies about the effects of various input process parameters like Discharge Current Pulse on time, Voltage and Pulse off time on the surface roughness by using Grey Taguchi approach on EN41 material. He Conclude that discharge current has large impact on the surface roughness parameter. J.Udaya Prakash *et al.* [8] performed the experiments for Optimization of Wire EDM Process Parameters for Machining Hybrid Composites (356/B4C/Fly Ash) using Taguchi Technique. Gaurav and Kadam *et al.* [9] Is work to optimize the maximum MRR by input parameters like discharge current, Pulse duration, Pulse interval time, Erosion diameter and he conclude that current is the most effective parameter on the MRR. Work-piece Material used as Mild Steel. F.L. Amorim *et al.* [10] Performed the experiment for the influence of generator actuation made and process parameters on the performance of finish EDM by using tool steel and results that minimum average surface roughness was reach at discharge current at 3A.

II. EXPERIMENTAL SETUP

For this experiment the whole work can be down by Electric Discharge Machine, model AGIETRON COMPACT 1 EDM (die-sinking type) with servo head (constant gap) and positive polarity for electrode was used to conduct the experiment Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94˚C) was used as dielectric fluid.. Cylindrical shaped Cu tool of diameter 9.88mm is used as the electrode. The work-piece use in the experiment is Ti6Al4V of rectangular shape 100mm X 100mm X 5mm. To measure MRR, Precision balance weight machine is used. This machine load capacity is 700 gram and accuracy is 0.002 gram. The surface roughness is measured by using the portable surface roughness tester of model SURFTEST SJ-210 Series. The experimental setup and machined work-piece are shown in figure1. In table 1 chemical composition of work-piece is given.

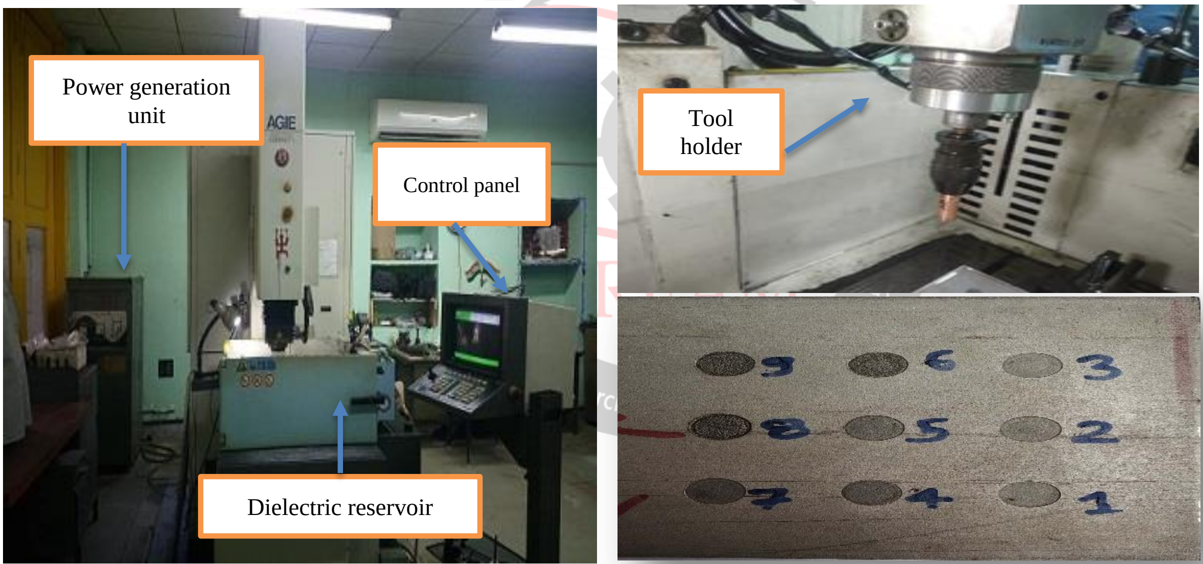

Fig1 machine setup and machined work-piece

Table 1 chemical composition of Ti6Al4V

Element	Ti	Al	V	Fe	O	C
Weight %	90	6	4	0.25	0.2	0.08

III. METHODOLOGY

In this experiment different set of the different set of parameters in different level has been selected accordance with orthogonal matrix L_9 to study the outputs as material removal rate and surface roughness. Current, Pulse ON time and Pulse OFF time are considered as input parameters at three different levels, whereas the effect of these independent parameters have been studied on the performance response characteristics as MRR and surface roughness.

3.1 Taguchi based Grey Relational Analysis

Taguchi developed various techniques to enhance the path in the design of experiment. He stated that the most suitable approach to improve quality was to outlining and incorporating it with the item. There is regular requirement of Information

 DOI : 10.35291/2454-9150.2019.0558

pre-preparing as these may be variation in unit and rang in one information succession. It is likewise essential when the succession diffuse range is very wide or objective heading in the groupings are distinct nature. In this work, a linear normalization of the experiment outcomes for MRR and surface roughness were performed, called as the grey relational generation. The normalized output parameter relating to the larger-the-better criterion can be formulated as (Eqn.1) and smaller-the-better criterion can be formulated as (Eqn.2).

$$Z_{ij} = \frac{y_{ij} - \min(y_{ij}, i = 1,2,....n)}{\max(y_{ij}, i = 1,2,...n) - \min(y_{ij}, i = 1,2,...n)} \quad (1)$$

$$Z_{ij} = \frac{\max(y_{ij}, i = 1,2......n) - y_{ij}}{\max(y_{ij}, i = 1,2...n) - \min(y_{ij}, i = 1,2...n)} \quad (2)$$

3.2 Statistical Analysis

The experiments were conducted for studying the different parametric relation, thus by selecting different levels of input parameters the interaction can be analysed using orthogonal array and required output performance parameter can be noted down. The different levels of inputs shown in table.2

Table 2 Control factor and Levels

Factors	Level1	Level2	Level3
Current	8	9	10
T_{on}	17	57	97
T_{off}	8	10	12

As the objective is to obtain the material removal rate and surface roughness and, the required quality characteristic for MRR is larger and R_a is lower. Investigating tests were performed as per L_9 orthogonal array, entrusting different values of the levels to the process factors and the results found. The representation of S/N Ratio values from the output Values was the introductory step. The primary step is to represent the original response in terms of S/N ratio using two different conditions as, for maximum MRR "larger the better" Eqn.3 and for minimum Surface roughness "smaller is better" Eqn.4 is used. Then the deviation sequence and grey relational coefficient is being calculated as Eqn.5 after calculating the normalized values of s/n ratios which dictate the accordance between best values and normalized test outcomes.

$$s/n_{HB} = -10\log\left[\left(\frac{1}{n}\right)\left(\frac{1}{y_{ij}^2}\right)\right] \quad (3)$$

$$s/n_{LB} = -10\log\left[\left(\frac{y_{ij}^2}{n}\right)\right] \quad (4)$$

$$\xi_i(k) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{0i}(k) + \zeta\Delta_{\max}} \quad (5)$$

Where, Δ_{0i} (k) is the deviation sequence for the reference sequence and comparability sequence

$$\Delta_{0i}(k) = \left\| y_0(k) - y_i(k) \right\| \quad (6)$$

$$\Delta_{\min} = \min_{\forall j \varepsilon i} \min_{\forall k} \left\| y_0(k) - y_j(k) \right\| \quad (7)$$

$$\Delta_{\max} = \max_{\forall j \varepsilon i} \max_{\forall k} \left\| y_0(k) - y_j(k) \right\| \quad (8)$$

ζ is distinguishing or identified coefficient generally taken as 0.5, y_0(k) and are original sequence and comparability sequence respectively. Then was determination of grey relational grade by equating the grey relational grade relating to each performance criterion as Eqn.9.

DOI : 10.35291/2454-9150.2019.0558

ISSN : 2454-9150 Vol-05, Issue-09, Dec 2019

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k) \tag{9}$$

IV. RESULT AND DISCUSSION

Table 3 shows the experimental observations of Ti6Al4V material at various operating conditions. MRR and Ra are obtained through their respective examinations and they are tabulated.

Table 3 Experimental Result

Expt No	Current(A)	Pulse ON Time (µs)	Pulse OFF Time (µs)	MRR (mm³/min)	Surface Roughness (µm)	Normalized S/N ratio		Deviation Sequence		Grey Relational Coefficient		Grey Relational Grade	Rank
						MRR (mm³/min)	Surface Roughness (µm)	MRR (mm³/min)	Surface Roughness (µm)	MRR (mm³/min)	Surface Roughness (µm)		
1	8	17	8	4.686	4.179	0.0000	0.1736	1.0000	0.8264	0.3333	0.3769	0.3551	9
2	8	57	10	12.472	3.422	0.4652	0.0000	0.5348	1.0000	0.4832	0.3333	0.4083	8
3	8	97	12	17.435	3.812	0.6308	0.0938	0.3692	0.9062	0.5753	0.3555	0.4654	7
4	9	17	10	19.524	3.932	0.6868	0.1207	0.3132	0.8793	0.6148	0.3625	0.4887	6
5	9	57	12	18.948	5.982	0.6720	0.4852	0.3280	0.5148	0.6039	0.4927	0.5483	4
6	9	97	8	24.826	6.468	0.8056	0.5531	0.1944	0.4469	0.7200	0.5280	0.6240	3
7	10	17	12	25.438	3.863	0.8176	0.1053	0.1824	0.8947	0.7327	0.3585	0.5456	5
8	10	57	8	29.576	9.047	0.8921	0.8446	0.1079	0.1554	0.8226	0.7629	0.7928	2
9	10	97	10	36.785	10.819	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.000	1

Table 4.6 Mean S/N ratio table for MRR and Surface roughness

level	Current	Ton	Toff	current	Ton	Toff
1	20.165	22.556	23.688	-11.577	-12.017	-15.922
2	26.420	25.629	26.348	-7.369	-15.118	-14.421
3	29.614	28.013	26.163	-17.184	-16.174	-12.966
Delta	9.449	5.547	2.66	9.815	4.157	2.956
Rank	1	2	3	1	2	3

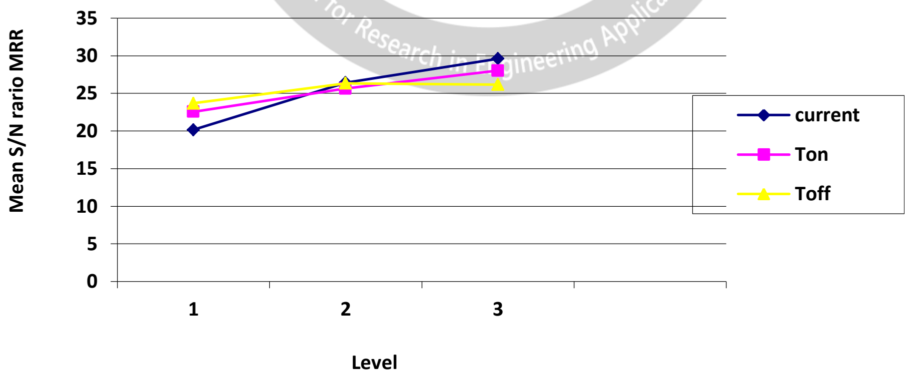

Chart 1 Mean S/N ratio of MRR

 DOI : 10.35291/2454-9150.2019.0558

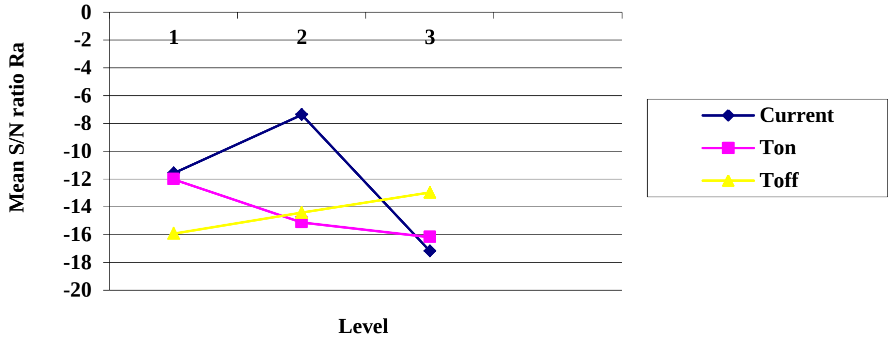

Chart 2 Mean S/N ratio of Ra

V. CONCLUSION

Experimental investigation on Electric Discharge machining of Titanium alloy will be done for the output process parameter MRR and R_a using the cylindrical shape copper tool. The experiments were performed under the different parameters setting of Pulse on time (T_{on}), Pulse off time (T_{off}) and Discharge current (I). L_9 orthogonal array based on Taguchi design was conducted for linear regression was used for analysis the result and theses responses were partially validated experimentally

- Finding the result for MRR discharge current is the most influencing factor and then pulse on time and last pulse off time. The maximum value of MRR is 36.785 mm^3/min at the input parameter I= 10A, Ton= 97µs and Toff= 10µs.
- For the Surface Roughness the most influencing factor is Current then Pulse on time and least influence of Pulse off time on the Surface Roughness. Minimum Ra value is 3.422.

REFERANCES

[1] Shailendra Kumar Singh, Narinder Kumar, Optimizing the EDM Parameters to Improve the Surface Roughness of Titanium Alloy (Ti-6AL-4V), *International Journal of Emerging Science and Engineering (IJESE)*, ISSN: 2319–6378.

[2] Zeilmann, R. P, Ivaninski, Webber, Surface integrity of AISI H13 under different pulse time and depths by EDM process, *Procedia CIRP* 71(2018) 472-477.

[3] Uttam Kumar Mohanty, Jaydev Rana, Abhay Sharma, Multi-objective optimization of electro-discharge machining (EDM) parameter for sustainable machining, *Proceedings* 4 (2017) 9147–9157.

[4] C.J. Luis, I. Puertas, G. Villa, Material removal rate and electrode wear study on the EDM of silicon carbide, *Journal of Materials Processing Technology* 164–165 (2005) 889– 896.

[5] Nakka Nagaraju, Sadu Venkatesu and N.G. Ujwala, Optimization of Process Parameters of EDM Process Using Fuzzy Logic and Taguchi Methods for Improving Material Removal Rate and Surface Finish, *Proceedings* 5 (2018) 7420–7428.

[6] Vikas, Shashikant, A.K.Roy and Kaushik Kumar, Effect and Optimization of Machine Process Parameters on MRR for EN19 & EN41 materials using Taguchi, *Procedia Technology* 14 (2014) 204 – 210.

[7] Vikas, Apurba Kumar Roy, Kaushik Kumar, Effect and Optimization of various Machine Process Parameters on the Surface Roughness in EDM for an EN41 Material using Grey Taguchi, *Procedia Materials Science* 6 (2014) 383 – 390.

[8] J.Udaya Prakash, S.Jebarose Juliyana, P.Pallavi, & T.V.Moorthy, Optimization of Wire EDM Process Parameters for Machining Hybrid Composites (356/B4C/Fly Ash) using Taguchi Technique, *Materials Today: Proceedings* 5 (2018) 7275–7283.

[9] Gaurav Raghav, B.S. Kadam, Manjeet Kumar, Optimization of Material Removal Rate in Electric Discharge Machining Using Mild Steel, *International Journal of Emerging Science and Engineering (IJESE)*, ISSN: 2319–6378.

[10] F.L. Amorim, W.L. Weingaertner, The influence of generator actuation mode and process parameters on the performance of finish EDM of a tool steel, *Journal of Materials Processing Technology* 166 (2005) 411–416.

 DOI : 10.35291/2454-9150.2019.0558