International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

Optimization of Machining Parameters on 7075 Aluminum Alloy using Taguchi and ANOVA for Surface Roughness

T.Vijaya Babu, P.Satyanarayana Raju, M.Ashok Kumar, KVP Chakradhar

Abstract**:** ***Optimization of the parameter to provide best solution to reduce the tool wear , surface roughness, cutting forces presented using optimization technique .In present work an experimental study is made. In this Taguchi design of experiment methodology for optimization of parameters on 7075Aluminium alloy using tungsten coated electrode . Experiments were conducted based on L27 standard orthogonal array with three processes parameters are cutting speed, feed, depth of cut . Electrical discharge machining is generally calculated on the basis of Surface Roughness (SR),Tool wear rate (TWR) and cutting force (CF) .The ANOVA(Analysis Of Variance) is used to study the performance characteristics in turning operation . ANOVA placed an important role for producing higher roughness . Finally the software ,MINITAB 17 was used and results obtained .***

Keywords ***: 7075 Alumimium alloy, SR, Taguchi, ANOVA .***

I. INTRODUCTION

Taguchi method is developed by Dr, Genichi Taguchi . Taguchi method is statistical method to to improve the product quality .In this method two stages are involved : system design ,parameter design , by using Taguchi design to reduce the number of experiments .It also best technique for high quality system design .The manufacturing industries are continuously challenged for achieving higher productivity within less time . Engineers faced a problem to find out the optimal parameters for the output and to increase the output by using available resources . 7075 Aluminum alloy is widely used in non- ferrous material in engineering applications .It is used for manufacturing of gears , regulating valve parts , meter shaft , aircraft, keys, gearsand defense applications .Analysis of Variance is used to study the performance characteristics .Aluminum alloy used in advanced applications because of high strength ,durability ,low density ,machinability and relatively lower cost . Productivity play main role in today's manufacturing market. Taguchi method is used to improve the product quality . EDM (Electrical Discharge Machining) is a non-traditional manufacturing process used in industry for machining of all types of materials .In EDM material is removed by melting and vaporization of work material due to occurring electrical sparks with in a dielectric medium .

Manuscript received on January 02, 2020.
Revised Manuscript received on January 15, 2020.
Manuscript published on January 30, 2020.

* Correspondence Author

T.Vijaya Babu*, Mechanical Engineering , Vardhaman College of Engineering , Shamshabad , Hyderabad, India. Email: drtvb@vardhaman.org

P.Satyanaraya Raju, Mechanical Engineering , Vardhaman College of Engineering , Shamshabad , Hyderabad, India. Email: srpenmatsa@vardhaman.org

M.Ashok kumar, MechanicalEngineering , Vardhaman College of Engineering , Shamshabad , Hyderabad, India. Email: mak864@vardhaman.org.

KVP Chakradhar, Mechanical Engineering , Vardhaman College of Engineering , Shamshabad , Hyderabad, India. Email: chakradharkvp@vardhaman.org

II. LITERATURE SURVEY

Payaghan et al., [1] results revealed that pulse current and on time are significant factors in MRR. The value of MRR steadily increases with increase in values of current and pulse on time. **Gopalakannan** et al., [2] stated that material removal rates, SR and tool wear rates are incremented as with increment in pulse current and on time. **Nanimina** et al., [3] results revealed that MRR is increasing as the levels of pulse on time and current are growing. However, TWR showed decreasing trend with increase in above parameters. **Karthikeyan & Sornakumar** [4] observed that MRR and SR are increased by the increase in current. The material removal rate was found to be decreasing with increase in the percent weight of silicon carbide. **Nagit** et al., [5] found that an increase in pulse duration will results in increased electrode wear and increased material removal rates. EWR was also found to be more with small values of diameter. High value of pulse-on time decreased the dimensional accuracy. **Adrian** et al., [6] stated that an increase in electrode diameter increase the MRR and reduce the tool wear rate. Increasing pulse on time gives more tool wear rates. Also, increase in pulse on time increase metal removal rate. **Lin** et al., [7] assisted the standard EDM with magnetic force and obtained better MRR, SR and lesser TWR. Assisted magnetic force helped to expel debris from the machining gap more easily and quickly. **Yilmaz** et al.,[8] machined Inconel 718 and Ti-6Al-4V with single and multichannel electrodes and revealed that single channel electrodes give better MRR but had made more damage to surface. **Ahamed** et al., [9] stated that MRR and SR are increasing as current is increasing, while MRR decreased as pulse on time increased. MRR showed rise with increasing pulse off time levels. **Khan** [10] found that the increase in current and gap voltage values increased the electrode wear rates. Wear ratio was also found to be increasing with increasing current.**Mohan** et al., [11] found that the positive polarity gives high MRR and increase in current levels increased the MRR further. TWR also increased with increase in current levels, while decreased pulse on time values decreased the SR.**Karthikeyan** et al., [12] reported that the increase in current increases MRR, TWR and SR. Also, increase in pulse time, decreases the MRR, TWR and slightly increases the surface roughness.**Muller & Monaghan** [13] reported increasing MRR with increasing pulse on time and current levels, but upto an optimal value.**Hocheng** et al., [14] stated that MRR was proportional to input current and pulse on time values. They recommended short pulse on time and large current combination to obtain minimal crater size while machining. **Ramulu & Taya** [15] found that material removal rate show growth with increase made in the power of the electrode while machining 2124 Aluminium MMC. **S. S. Mahapatra** et al. [16] investigated Optimization of WEDM process parameters using Taguchi method. Machining operation in WEDM is a challenging one because of more responses like metal removal rate (MRR), surface finish (SF) and cutting width (KERF). The relationship between control factors and responses are recognized by nonlinear regression analysis through mathematical model, GA and , a popular revolutionary approach were employed to multiple objectives optimisation. **Spedding and Wang** [17]formed a mathematical models to forecast material removal rate Ra and MRR during WEDM of D-2 tool steel for various machining conditions. **Zahid A.Khan** et al.[18] carried out multi objective optimization of WEDM Control process parameters using Taguchi Grey Relational Analysis method. Taguchi's L 16 Orthogonal Array have been used for conducting experiments and investigates the effect of the WEDM process parameters on the average surface roughness and the KERF width of the stainless steel (SS 304).

III. EXPERIEMTAL PROCEDURE

The tests on the work piece were conducted on ELECTRONICA EZEE Cut NXG WEDM Machine shown in fig 1. 7075 aluminium is used to this experiments . DOE are designed by full factorial design experiments . In this work turning of 7075 alumimum alloy , experiments were conducted by considering these main processes parameters such as speed , feed , depth of cut at 3 level –low, medium and high .According to the 3 level full factorial design of experiments 27 were designed and conducted .CNC machine play an main role in modern machining industry .

Figure 1. Electronica Ezee Cut Nxg Wedm Machine

Table 1 : Chemical composition 7075 Aluminium alloy

Element	Weight (%)
Aluminium	87.1-91.4
Zinc	5.1-6.1
Copper	1.2-2.0
Chromium	0.18-0.28
Iron	Max 0.5
Magnesium	2.1-2.9
Manganese	Max 0.4
Silicon	Max 0.4
Titanium	Max 0.2
Other	0.05

Table 2 : Mechanical Properties of 7075 Aluminium alloy.

Property	Value	Units
Ultimate strength	572	Mpa
Yield strength	503	Mpa
Fatigue strength	159	Mpa
Shear strength	331	Mpa
	150	BHN
	53.5	Rockwell A
	87	Rockwell A
Hardness	175	Vickers
Density	2.8	gm/cm^3

Retrieval Number: C6170098319/2020©BEIESP
DOI:10.35940/ijrte.C6170.018520
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Elongation	9-Mar	%
Modulus of elasticity	71.7	GPa
Poisson's ratio	0.33	-
Thermal conductivity	130	W/m-K
Melting point	477-635	^{0}C

1. **Control factors** : Experiments were planned using 3 level full factorial design .These cutting parameters are : cutting speed (m/min), feed (mm/sec) , depth of cut (mm) and over all 27 experiments were conducted .
2. **Instruments used for measuring weight of work piece in initial and final weight** .

MRR =(Wc – Wf) /ρ x T mm ^{3} /sec
W_c = Initial weight of work piece (gm)
W_f = final weight of work piece (gm)
T= machining time (sec)
ρ = density of material (kg/m^3)

3.Taguchi approach : It used to determine the quality of characteristics . Loss function value are connected to S/N ratio. ' Signal ' represents the desired values for output characteristics and 'Noise ' represents the undesirable value for output characteristics . These categories are used to analyze S/N ratio i.e lower is better , nominal is better ,higher is better .

Table 3 : Parameters with Levels

S.No	Parameters	Units	Level 1	Level 2	Level 3
1	Cutting speed	rpm	150	200	250
2	feed	mm/rev	0.1	0.15	0.2
3	Depth of cut	mm	0.25	0.5	1

Table 4: Response table for Material Removal Rate (MRR)

Level	Cutting speed	Feed rate	Depth of cut
1	4.606	6.606	5.236
2	5.426	5.152	5.268
3	5.862	4.135	5.39
Delta	1.257	2.471	0.154
Rank	2	1	3

Table 5: Machining conditions of for full factorial design .

	Cutting speed	Feed rate	Depth of cut	Surface roughness	Tool wear
1	200	0.2	1	1.5	0.31
2	200	0.1	0.25	1.23	0.21
3	150	0.1	0.5	1.59	0.14
4	200	0.1	1	1.62	0.11
5	250	0.2	1	1.29	0.27
6	250	0.15	0.25	1.85	0.28
7	150	0.1	0.25	1.45	0.16
8	150	0.15	0.5	1.78	0.28
9	200	0.15	1	1.65	0.26
10	250	0.1	0.5	1.15	0.13
11	250	0.15	0.5	1.72	0.27
12	150	0.15	0.25	1.82	0.3
13	250	0.15	1	1.24	0.21
14	200	0.15	0.25	1.89	0.35
15	150	0.2	0.25	2.12	0.35
16	200	0.2	0.25	2.31	0.4
17	250	0.1	0.25	1.15	0.15
18	150	0.2	0.5	1.98	0.33
19	250	0.2	0.25	2.5	0.35
20	200	0.1	0.5	1.39	0.18
21	150	0.2	1	1.7	0.27
22	250	0.2	0.5	2.1	0.32
23	250	0.1	1	1.14	0.07
24	200	0.15	0.5	1.78	0.32
25	150	0.1	1	2.13	0.08
26	200	0.2	0.5	2.04	0.37
27	150	0.15	1	1.89	0.22

Table 6 : Response table for Machining time

Level	Cutting speed	Feed rate	Depth of cut
1	1.829	1.428	1.813
2	1.712	1.736	1.726
3	1.571	1.949	1.573
Delta	0.258	0.521	0.24
Rank	2	1	3

IV. RESULT AND DISCUSSIONS :

Minitab 17 statistic software has been used for analysis of experiential work .It provides for calculation results of S/N ratio .The objective of present work is to reduce the machining time and increase the MRR and SR in turning processes operation.

a) Analysis for Signal -to- noise ratio

Larger is better performance characteristics is selected to obtain material removal rate .Smaller the better performance characteristics is selected to obtain machining time .

b) **Response table for machining time**

S =0.298941 R-sq =50.19% R-sq(adj) = 35024% R-sq(pred)=9.22%

(c) **Regression Equations**

Surface roughness = 1.7041 + 0.1248 cutting speed_150 + 0.0081 cutting speed_200

- 0.1330 cutting speed_250
- 0.2763 feed rate_0.10

+ 0.0315 feed rate_0.15
+ 0.2448 feed rate_0.20

+ 0.1093 depth of cut_0.25 + 0.0215 depth of cut_0.50

- 0.1307 depth of cut_1.00

Cutting force = 13.94 - 2.19 cutting speed_150 + 0.34 cutting speed_200

+ 1.85 cutting speed_250 + 4.31 feed rate_0.10 - 0.50 feed rate_0.15

- 3.82 feed rate_0.20 - 0.33 depth of cut_0.25 - 0.12 depth of cut_0.50

+ 0.45 depth of cut_1.00

Tool wear = 0.247778 - 0.01111 cutting speed_150 + 0.03111 cutting speed_200

- 0.02000 cutting speed_250 - 0.11111 feed rate_0.10 + 0.02889 feed rate_0.15

+ 0.08222 feed rate_0.20 + 0.03556 depth of cut_0.25 + 0.01222 depth of cut_0.50

- 0.04778 depth of cut_1.00

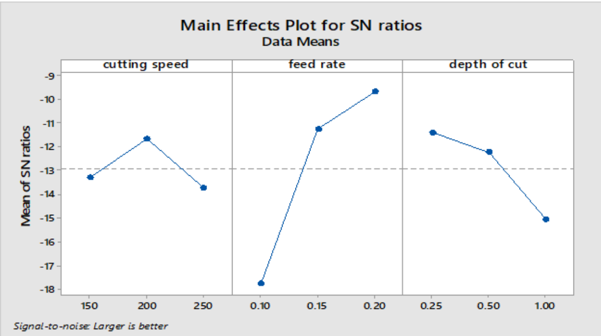

Figure 2. Main effect and S/N ratio for MRR

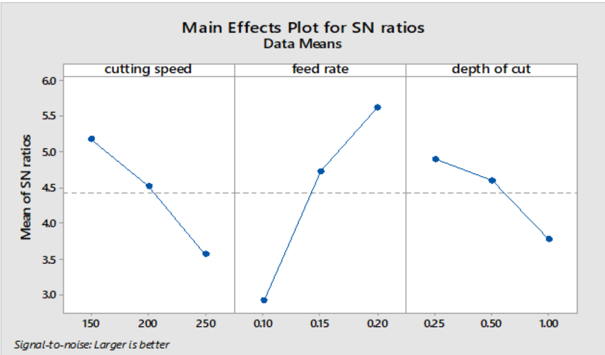

Figure 3.: Main effect plots for machining time

a) Analysis Of Variance (ANOVA)

The experimental results of surface roughness values were analyzed. The percentage of individual parameters were well determined using ANOVA. Taguchi cannot create and find the effect of individual parameters on entire processes . Using MINITAB17 software and ANOVA module is used to investigate the effect of parameters .

Table 7 : ANOVA –Result for surface roughness

Source	DOF	Adj SS	Adj MS	F-value	P-value
Cutting speed	2	0.2999	0.14996	1.68	0.212
Feed rate	2	1.2354	0.61769	6.91	0.005
Depth of cut	2	0.2654	0.13271	1.49	0.25
Error	20	1.7873	0.08937		
Total	26	3.5881			

b) Analysis for Signal -to- noise ratio

Larger is better performance characteristics is selected to obtain material removal rate .Smaller the better performance characteristics is selected to obtain machining time .

S =0.0050553 R-sq =99.77% R-sq(adj) =99.71% R-sq(pred)=99.59%.

Table 7 shows the results of ANOVA for surface roughness .From the results , it is observed that the feed is the most significant parameter followed by cutting speed and depth of cut has less significant in controlling the surface roughness values . P-Value of feed (0.005) which is less than 0.05.It means the feed influence significantly on work piece surface roughness between three cutting parameters.

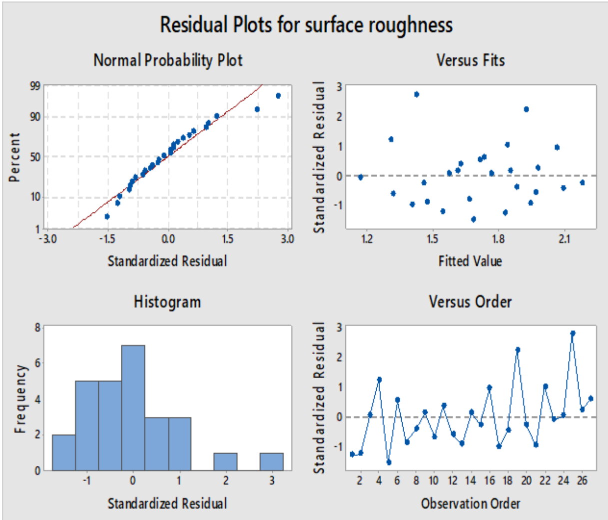

Figure 4 . Residual Plots for Surface Roughness

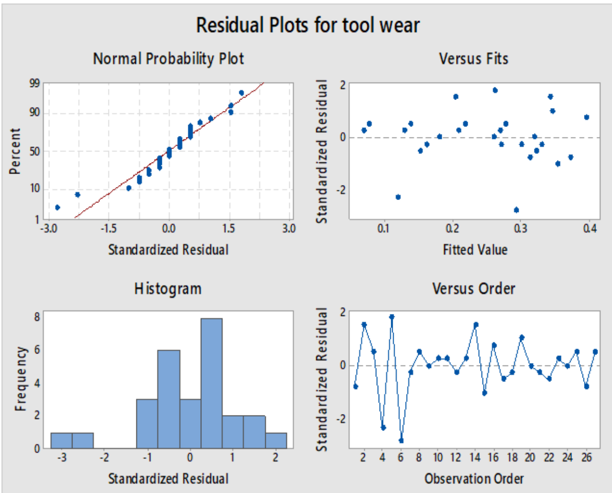

Figure 5. Residual plots for Tool Wear

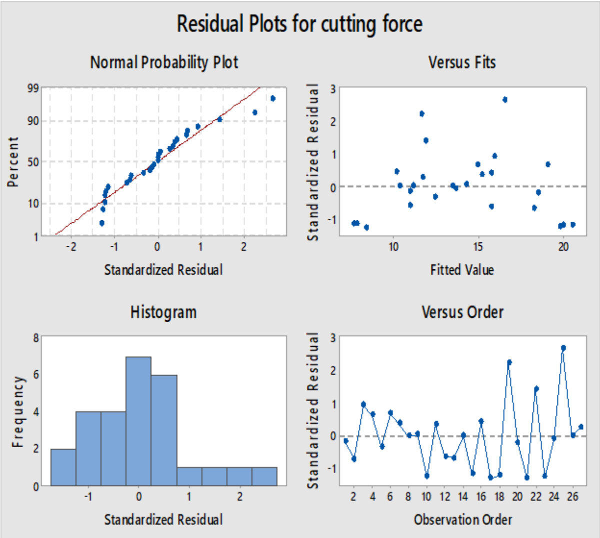

Figure 6. Residual plots for cutting force

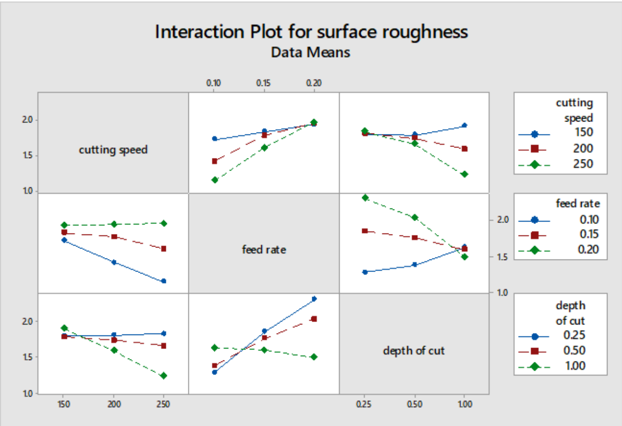

Figure 7. Interaction plots for Surface Roughness

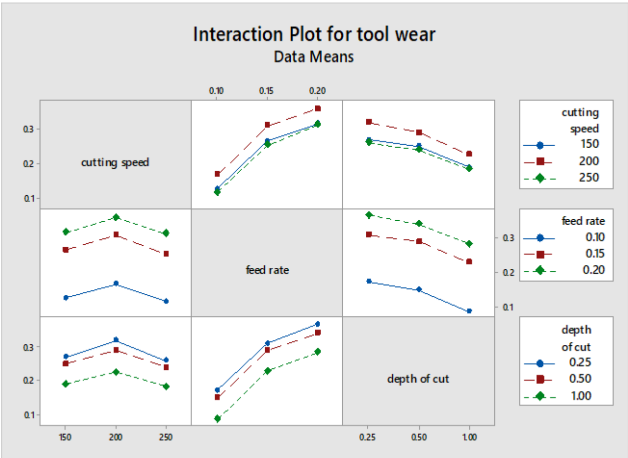

Figure 8 . Interaction plots for Tool wear

V. CONCLUSION

1. It is observed that the speed is most influence the MRR and less significance of depth of cut .In case of machining time speed is most significance parameter followed by feed rate . The combination of cutting parameters to achieve a high material removal rate (MRR) and low surface roughness (SR) is obtained .

2. From Taguchi results , the optimal combinations of cutting parameters for low surface roughness was found.

3. From ANOVA results , for achieving minimum surface roughness values , fed has high influence followed by speed and depth of cut has low influence .

REFERENCES

1. Payaghan, N. S., Ubale, S, B. and Kadam, M. S. (2014), "Modeling and Analysis of Effects of Machining Parameters on MRR in EDM Process of Copper Tungsten Metal Matrix Composite (MMC)", International Journal of Engineering Research & Technology, Vol. 3 Issue 6, pp: 1343-13492.
2. Gopalakannan, S., Senthilvelan, T. and Kalaichelvan, K. (2012), "Modeling and Optimization of EDM of Al 7075/10wt% Al2O3 Metal Matrix Composites by Response Surface Method", Advanced Materials Research, Vols. 488-489, pp: 856-860
3. Nanimina, A., Abdul, R., Ahamd, F., Zainuddin, A. and Jason, S.H. (2010), "Effect of EDM on aluminum metal matrix composites", Journal of applied science, vol. 39, pp: 1-5
4. Karthikeyan, M. and Sornakumar, T. (2010), "EDM studies on aluminum alloy-silicon carbide composites developed by vortex technique and pressure die casting", Journal of minerals and material characterization & Engineering, Vol. 9, No. 1, pp: 77-88
5. Nagit, G., Adrian I. and Negoescu, F. (2009), "Tool wear investigation in electric discharge machining of aluminum matrix composite materials", The Annals Of 'Dunărea De Jos" University Of Galaţi, vol. 5, pp: 225-228
6. Adrin, I., Nagit, G. and Florin N., (2009). "Tool wear investigation in EDM of aluminum matrix composites", The annas of Duharea De Jos,University of galati, ISSN 1221-4566, pp: 225-228
7. Lin, Y., Chen, Y., Wang, D. and Lee, H. (2009), "Optimization of machining parameters in magnetic force assisted EDM based on Taguchi method", journal of materials processing technology, vol., 209, pp: 3374–3383
8. Yilmaz, O., Bozdana, A.T., Okka, M.A. and Filiz, I.H. (2009), "A comparative investigation of the effects of single and multi-channel electrodes in EDM fast hole drilling of aerospace alloys", 5th International Conference and Exhibition on Design and Production of MACHINES and DIES/MOLDS, 18-21 JUNE 2009 Pine Bay Hotel - Kusadasi, Aydin, TURKEY
9. Ahamed A. R., Asokan, P. and Aravindan, S. (2009), "EDM of hybrid Al–SiCp–B4Cp and Al– SiCp– Glassp MMCs", Int J Adv Manuf Technol, vol. 44, pp: 520–528
10. Khan, A. A. (2008),"Electrode wear and material removal rate during EDM of aluminum and mild steel using copper and brass electrodes", Int J Adv Manuf Technol, vol. 39, pp: 482–487
11. Mohan, B., Rajadurai, A. and Satyanaray, K. G. (2002), "Effect of SiC and rotation of electrode on electric discharge machining of Al-SiC composite", Journal of Material Science, vol. 124, pp: 297–304
12. Karthikeyan, R., Raju, S. and Nagavazen, R.S. (2001). "Optimization of EDM characteristics of SiC/LM 25 Al composite using goal programming", Journal of material science technology, Vol. 17, pp: 57-60
13. Muller, F. and Monaghan, J. (2000), "Non conventional machining of particle reinforced aluminum matrix composites", International journal of machine tools and manufacture, vol 40, pp: 1287-1300
14. Hocheng, H., Lei, W. T. and Hsu, H.S. (1997), "Preliminary study of material removal in electricaldischarge machining of SiC/Al", Journal of Materials Processing Technology, vol. 63, pp: 813–818
15. Ramulu, M. and Taya, M. (1989),"EDM machining of SiCw/Al Composite", Journal of Material Science, volume 24, pp: 1103–1108
16. Mahapatra, S.S. & Amar Patnaik (2006). "Optimization of wire electrical discharge machining (WEDM) process parameters using Taguchi method", international journal of advanced manufacturing technology. pp. 1-15.
17. surface characterization of wire electrical discharge machining process", Precision Engineering, 20(1), 5-15.
18. Zahid A. Khan, Arshad N. Siddiquee, Noor Zaman Khan , Urfi Khan, G. A. Quadir (2014). "Multi response optimization of Wire electrical discharge machining process parameters using Taguchi based Grey Relational Analysis" , Procedia Materials Science 6, pp. 1683-1695.

AUTHORS PROFILE

Dr. T.Vijaya babu is currently working as Professor in theDepartment of Mechanical Engineering, Vardhaman College of Engineering, Hyderabad, Telangana, India. He has more than 17 years of experience in teaching and 5 years in Industry . He had completed his PhD from DTU, Delhi. His area of research was in unconventional machining processes . His area of interest is Manufacturing and Materials. He has published around 25 journals in scopus indexed, UGC recognized and other reputed journals. He is life member in Indian Society for Technical Education.

Dr. M. Ashok Kumar is currently working as Professor in the Department of Mechanical Engineering, Vardhaman College of Engineering, Hyderabad, Telangana, India. He has more than 20 years of experience in teaching and 10 years in Industry. He had completed his PhD at Osmania University, Hyderabad, Telangana, India. His area of research was in composite materials. His area of interest is Manufacturing and Materials. He has published around 10 journals in scopus indexed, UGC recognized and other reputed journals. He is a life member of Indian Society for Technical Education.

Dr. K. V.P. Chakradhar is currently working as Professor in the Department of Mechanical Engineering, Vardhaman College of Engineering, Hyderabad, Telangana, India. He has more than 15 years of experience in teaching. He had completed his PhD at Andhra University, Visakhapatnam, Andhra Pradesh, India. His area of research was in composite materials. His area of interest is Manufacturing and Materials. He has published around 20 journals in scopus indexed, UGC recognized and other reputed journals. He has to his credit google scholar citations of 107 with h-index 7 and i-10 index 6. He has around 15 scopus citations. He had published a book chapter titled “Studies on the properties of clay-reinforced epoxy/polyester composite” in the book “Mechanical Engineering for Sustainable Development: state-of-the-art research” published by Apple Academic Press/ Taylor and Francis). He had reviewed many international journals and is a reviewer for Scopus Indexed Journal “Journal of Engineering Science and Technology”, School of Engineering, Taylor University, Malaysia. He is life member in Indian Society for Technical Education

Mr. P. Satyanarayana Raju is currently working as Assistant Professor in Department of Mechanical Engineering, Vardhaman College of Engineering, Hyderabad, Telangana. He has a M.Tech in Industrial Engineering and Management from Jawaharlal Nehru Technological University (JNTU), Hyderabad. He has more than two years of experience in academics, teaching various management and industrial engineering subjects. Apart from this he has more than 25 years of rich and diversified industrial experience in the areas of manufacturing and information technology. He is currently pursuing PhD from KL deemed to be University, Guntur in Mechanical engineering. He is a life member of Indian Society for Technical Education.