MULTI RESPONSE OPTIMIZATION OF MACHINING PARAMETERS FOR DRILLING OF ALUMINIUM 2219 ALLOY USING TAGUCHI AND GREY RELATION ANALYSIS

LOKANATH M, SALEEMUDDIN S M, SURYA PRAKASH RVNR & ESWAR BALACHANDAR G

Assistant Professor, Department of Mechanical Engineering, AITS, Rajampet, AP-516126

ABSTRACT

Aluminium alloys are highly resistant to corrosion. Aluminum 2219 composite is a compound containing age-hardening copper. Aluminum 2219 composite is a stronger in strength used in economic supercritical installations, such as spacecraft rockets and storage tanks. The aluminum alloy requires excellent mechanical properties due to excellent corrosion resistance. The alloy is flexible over a temperature with good rupture hardness.

This article perceives the optimal solution criteria that improve the rate of reduction of material and surface finish while drilling. Drill diameter, spindle speed and type of coolant are the control parameters chosen for the study. Using Gray relational Analysis, this multi-response optimization is accomplished for optimal conditions to which high MRR and lowest surface content were generated.

KEYWORDS: *Drilling Parameters- MRR, Surface Roughness, Grey Relation Analysis and Aluminium Alloy*

Received: Jun 06, 2020; **Accepted:** Jun 26, 2020; **Published:** Aug 21, 2020; **Paper Id.:** IJMPERDJUN2020845

INTRODUCTION

DRILLING can be defined as a process where a multi-point tool is used to remove materials, which are objectionable to the development of such a desired hole. It concerns mainly those methods used in the piece of work to construct cylindrical holes. Hole have historically have been described as the most prominent machining process, requiring specialized techniques to achieve the maximum cutting parameters. In an industry the drilling machines are commonly used in metal removal operations. Hence it is important to optimize output and profitability at about the same time.

The effects of the drilling parameters on the surface roughness and the error of roundness were examined in the drilling of the Al6061 alloy with HSS twist drills. Taguchi Grey's analyzes of the experimental outcomes recorded [1]. The effect of multiple process variables on material removal rate and surface roughness on Al-TiBr, Al6082, mild steel material on radial drilling is investigated using Grey relational analysis [2,3,8]. The effect on the drilling machine on glass fiber reinforced polymer as work surface of speed, point angle and feed on surface roughness and separation component [4]. solving the multi-response optimization problem in CNC end milling by taguchi method [5,9,10]. Taguchi methods are frequently used in the experiment layout and interpretation of test data for optimization production parameters. [6,7].

Aluminum combinations are profoundly impervious to consumption. Aluminum 2219 composite is a compound containing age-solidifying copper. Aluminum 2219 composite is a higher quality combination utilized in monetary supercritical establishments, for example, shuttle rockets and capacity tanks. The aluminum compound

requires phenomenal mechanical properties because of superb consumption obstruction. The combination is adaptable over a temperature with great crack hardness.

EXPERIMENTAL METHODS

Materials and Methods

In this study, Al-2219 is used as the work piece material for drilling the hole on radial drilling process by using HSS drill bit, for measuring surface roughness Tool maker micro is used. The Specification of this work piece material are 75x75x12 mm³. The chemical composition of the material, physical properties & Mechanical properties are given in Table

Table

Chemical Element	% Present
Aluminum	91.5-93.8
Copper	5.8-6.8
Iron	0.3
Manganese	0.2-0.4
Silicon	0.2
Titanium	0.02-0.01
Vanadium	0.05-0.15
Zinc	0.1
Magnesium	0.02
Zirconium	0.10-0.25
Residuals	0.15

General Properties of AL-2219

Table

Physical Attributes	Value
Density	2.84 g/cm ³
Melting Point	543-643 °C
Thermal Expansion	23.5 x10 ⁻⁶ /K
Modulus of Elasticity	73.1 GPa
Thermal Conductivity	120 W/m.K
Tensile Strength	414Mpa
Proof stress	290 Mpa

Grey Relational Analysis

GRA uses a certain presumption of content. It summarizes conditions as black with no information, and white with perfect information. None of these individualistic outcomes, moreover, ever prevails in concerns of the real world. In particular, scenarios between contrasts, comprising Dispersed knowledge are represented as grey. A iteration of the GRA model, a GRA design based on Taguchi, is quite prominent in engineering. The process of GRA is shown in fig. The relational analysis emphasizes how to estimate and make the decisions, and generate reports that support vendor selection. This analytical model improves and confirms the Grey relationship among all parameters.

Methodology

Figure 1: Approach used for Optimization Radial Drilling Process.

Design of Experiment

The investigational design for the machining parameters using the L27 orthogonal array of the drilling machine can be used for this study. The radial drilling machine was customized to the drilling process of Spindle speed of 830rpm, 1250rpm & 18975 rpm, HSS tool with diameter of 9.5 mm, 10mm & 10.5mm and the coolant like oil, kerosene, Water was used.

Geometry of HSS Drill Bit

Table 1: HSS Drill Bit

Tool Dia (mm)	Flute Length (mm)	Total Length (mm)	Point Angle (degrees)	Helix Angle (degrees)
9.5	115	175	118	30
10	121	184	118	30
10.5	128	195	118	30

Table 2: Process Parameters and their Levels

Input	Level 1	Level 2	Level 3
Speed (rpm)	830	1250	1895
Tool diameter(mm)	9.5	10	10.5
Type of coolant	Water	Kerosene	Oil

In any drilling machining operation, surface roughness (SR) and material removal rate (MRR) are two essential parts of a material. The array having a three control parameter and three levels are shown in table 1. This process, all

identified quantities are determined more essential based on the maximum the better and the minimum the better. In the present study spindle speed, Coolant and drill bit have been selected as design factor the other parameter have been assumed to be constant. This experiment focused on the maximum, intermediate and minimum values observed of MRR and SR together. Every experimental study in each set value was implemented with three easy analyses. Next, by comparing the standard analysis and the grey relational analysis, the optimization of the measured parameters was estimated.

Figure 2: Shows Aluminium 2219 ALLOY, Radial Drilling Machine and Work Pieces After Drilling.

Drilling Experimental Values

By doing the experiment the cutting speed is measured as per the L27

Table 3: Design of Experiments

S.NO	Spindle Speed in rpm	Tool Diameter in mm	Cutting Environment
1	830	9.5	Water
2	830	9.5	Kerosene
3	830	9.5	Oil
4	830	10	Water
5	830	10	Kerosene
6	830	10	Oil
7	830	10.5	Water
8	830	10.5	Kerosene
9	830	10.5	Oil
10	1250	9.5	Water
11	1250	9.5	Kerosene
12	1250	9.5	Oil
13	1250	10	Water
14	1250	10	Kerosene
15	1250	10	Oil
16	1250	10.5	Water
17	1250	10.5	Kerosene
18	1250	10.5	Oil
19	1895	9.5	Water
20	1895	9.5	Kerosene
21	1895	9.5	Oil
22	1895	10	Water
23	1895	10	Kerosene
24	1895	10	Oil
25	1895	10.5	Water
26	1895	10.5	Kerosene
27	1895	10.5	Oil

Experimental Output Response Values

Table 4: Experimental Results

S.NO	Spindle Speed in rpm	Tool Diameter in mm	Coolant type	MRR (mm ³ /min)	Ra (μm)
1	830	9.5	Water	179.48	2.357
2	830	9.5	Kerosene	191.38	2.177
3	830	9.5	Oil	179.48	2.56
4	830	10	Water	161.79	3.183
5	830	10	Kerosene	199.49	2.858
6	830	10	Oil	193.99	2.678
7	830	10.5	Water	312.59	2.691
8	830	10.5	Kerosene	206.95	2.884
9	830	10.5	Oil	220.8	2.979
10	1250	9.5	Water	177.25	6.521
11	1250	9.5	Kerosene	194.21	4.665
12	1250	9.5	Oil	185.002	2.781
13	1250	10	Water	237.97	3.169
14	1250	10	Kerosene	215.19	3.889
15	1250	10	Oil	188.49	8.074
16	1250	10.5	Water	249.37	3.128
17	1250	10.5	Kerosene	237.25	3.18
18	1250	10.5	Oil	216.47	6.617
19	1895	9.5	Water	179.33	5.798
20	1895	9.5	Kerosene	192.09	2.879
21	1895	9.5	Oil	179.33	8.89
22	1895	10	Water	186.13	3.224
23	1895	10	Kerosene	198.73	6.274
24	1895	10	Oil	198.73	8.295
25	1895	10.5	Water	219.07	3.796
26	1895	10.5	Kerosene	191.36	4.229
27	1895	10.5	Oil	219.07	3.834

RESULT AND DISCUSSION

Taguchi's Signal-to-Noise Ratio Analysis on Responses Variables

Scientific analysis of the experimental results obtained via Taguchi experimental design was conducted out using quantitative software MINITAB 16 as shown in table 5.7. In this step, S / N ratios are measured for drilling action response and the optimum configuration of input parameters is calculated based on the quality requirement. Surface roughness will be low for better quality while drilling the response characteristics, hence smaller S / N ratios for these parameters are regarded. Whereas for machining the material removal is higher, consideration given to larger S / N ratios.

Signal-To-Noise Ratio for the Smaller-The-Better: Surface Roughness

$S/N = -10 \log (\text{mean square of the response})$

$$S / N = -10 \log_{10} \left(\frac{1}{n} \sum y^2 \right)$$

Larger-The-Better: MRR

$S/N = -10 \log (\text{mean square of the inverse of the response})$

$$S / N = -10 \log_{10} \left(\frac{1}{n} \sum \frac{1}{y^2} \right)$$

Table 5: S/N Ratio for Response Variables

S.NO	MRR	Ra
1	45.0803	-7.4472
2	45.6379	-6.7572
3	45.0803	-8.1648
4	44.1790	-10.0567
5	45.9984	-9.1212
6	45.7556	-8.5562
7	49.8995	-8.5983
8	46.3173	-9.1999
9	46.8800	-9.4814
10	44.9717	-16.2863
11	45.7654	-13.3770
12	45.3435	-8.8840
13	47.5304	-10.0184
14	46.6564	-11.7968
15	45.5058	-18.1418
16	47.9369	-9.9053
17	47.5041	-10.0485
18	46.7080	-16.4132
19	45.0731	-15.2656
20	45.6701	-15.0533
21	45.0731	-18.9780
22	45.3963	-10.1679
23	45.9653	-15.9509
24	45.9653	-18.3763
25	46.8117	-11.5865
26	45.6370	-12.5248
27	46.8117	-11.6730

Grey Relation Analysis**Normalization of S/N Ratio Values**

For S / N ratio normalization, higher is better for MRR (a) lower is better for surface Roughness (b)

$$x_i^* = \frac{x_i^o(k) - \min x_i^o(k)}{\max x_i^o(k) - \min x_i^o(k)} \quad x_i^* = \frac{\max x_i^o(k) - x_i^o(k)}{\max x_i^o(k) - \min x_i^o(k)}$$

Calculation of Grey Relational Coefficient (GRC)

GRC demonstrates the relation between the best and the actual normalized S / N ratio for all sequences. If the two sequence align at all stages, then their coefficient of Grey relation is 1. The grey relational coefficient $\zeta_i(k)$ for the k_{th} performance characteristics in the i_{th} experiment can be expressed as :

$$\xi_i(k) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{oi}(k) + \zeta \Delta_{\max}}$$

Δ_{oi} is the deviation sequence and the comparability sequence ζ is identification coefficient ζ range from 0 to 1.

The smaller is a value of prevalence and the larger is the prominent ability. Typically, $\zeta = 0.5$ is used for grey relational coefficient for 27 sequences of comparability as shown in table.

Calculation of Grey Relational Grade (GRG)

It is acceptable to take the estimated value of the grey relational coefficients as the grey relational grade, after the grey relational coefficient is obtained. The grey relational grade is defined as follows:

$$\gamma_i = 1/n \sum_{k=1}^n \xi_i(k)$$

The grey relational grade γ_i reflects the degree of similarity between the sequence of reference and the sequence of comparability.

Table 6: Grey Relational Grade

S.NO	Normalization of S/N ratio values MRR	Ra	Grey Relational coefficient MRR	Ra	Weighted Grey Relational grade	Rank
1	0.1576	0.0565	0.3725	0.3464	0.3594	27
2	0.255	0	0.4016	0.3333	0.3675	25
3	0.1576	0.1152	0.3725	0.3611	0.3668	26
4	0	0.27	0.3333	0.4065	0.3699	24
5	0.318	0.1934	0.423	0.3827	0.4029	20
6	0.2756	0.1472	0.4084	0.3696	0.389	22
7	1	0.1507	1	0.3705	0.6864	1
8	0.3738	0.1999	0.444	0.3846	0.4143	19
9	0.4722	0.2229	0.4865	0.3915	0.439	18
10	0.1386	0.7797	0.3673	0.6942	0.5307	7
11	0.2773	0.5417	0.4089	0.5218	0.4653	15
12	0.2036	0.174	0.3857	0.3771	0.3814	23
13	0.5859	0.2669	0.547	0.4055	0.4762	11
14	0.4331	0.4124	0.4686	0.4597	0.4642	16
15	0.2319	0.9316	0.3943	0.8796	0.637	4
16	0.6569	0.2576	0.5931	0.4024	0.4978	9
17	0.5813	0.2693	0.5442	0.4063	0.4753	12
18	0.4421	0.7901	0.4726	0.7044	0.5885	5
19	0.1563	0.6962	0.3721	0.6221	0.4971	10
20	0.2607	0.6788	0.4034	0.6089	0.5062	8
21	0.1563	1	0.3721	1	0.6853	2
22	0.2128	0.2791	0.3884	0.4095	0.399	21
23	0.3123	0.7523	0.421	0.6687	0.5448	6
24	0.3123	0.9508	0.421	0.9104	0.6657	3
25	0.4602	0.3952	0.4809	0.4526	0.4667	14
26	0.2549	0.4719	0.4016	0.4864	0.444	17
27	0.4602	0.4023	0.4809	0.4555	0.4682	13

It is clearly observed from above in Table 6 according to the design of the experiment conducted. That specification of the drilling parameters for experiment No. 7 has the highest level of grey relation. Experiment No. 7 is, therefore, the optimized setting of the machining constraints for minimum surface roughness and maximum material

removal rate among the 27 experiments. In contrast to evaluating the optimum drilling parameters for surface roughness and MRR, the Taguchi method approach table was used to estimate the mean grey relational grade for each level of the drilling variables. The process is: I group the grey relational grades in the orthogonal array by factor level between each column, ii) take the average of them.

The grey relational grade for factor A at level 1 for example can be determined as $\gamma A1 = (0.3594 + 0.3675 + 0.3668 + 0.3699 + 0.4029 + 0.3890 + 0.6864 + 0.4143 + 0.4390) = 0.4216$.

For each stage of the drilling parameters the grey relational grade values were determined using the same approach is shown in Table 6. A higher grey relational grade value corresponds to better quality regardless of the performance characteristics level. Therefore, the optimal level of the machining parameters is the level based on the grey relational grade value given in Table 6.5, the optimal machining performance for both the surface roughness and the MRR is determined at 1895 rpm spindle speed (level 3), 10.5 mm Toll diameter (level 3) and oil as coolant (level 3) combination. The optimal drilling parameter levels can be shortly given as A3, B3 and C3.

Table 7: The Response Table for Grey Relational Grade

	Level 1	Level 2	Level 3	Max-Min
Spindle Speed(A)	0.4216	0.5018	0.5196	0.098
Toll Diameter(B)	0.4612	0.4831	0.5031	0.041
Cutting Environment(C)	0.4759	0.4538	0.5130	0.0592

The difference between the maximum and minimum value of the grey relation grade of the drilling parameters as described in Table 7 is as adopts: 0.098 for spindle speed, 0.041 for tool diameter and 0.0592 for cutting environment. This comparison will give the level of significance of the controllable factors over the multi performance characteristics. The average of these values among 0.098, 0.041 and 0.0592 is 0.098, was the most effective controllable factor. The value shows that the speed of the spindle has the strongest effect on the multi-performance characteristics associated with other parameters of the drilling. The order of importance of the controllable factors in the drilling process for the multi-performance characteristics, in sequence order as factor A (spindle speed), B (Toll diameter) and C (type of coolant) (i.e. $0.098 > 0.0592 > 0.041$) among attributes spindle speed for the drilling was strongly affected.

CONCLUSIONS

Subsequent ends can be drawn from the impact of penetrating machining parameters on reaction factors including material expulsion rate (MRR) and surface completion, on AL-2219 materials. The ideal setting which decides the most elevated conceivable MRR and the least harshness of the surface is A3-B3-C3. The shaft speed is 830 rpm, the distance across of a device is 10.5 mm and the water is coolant. The most noteworthy dark social evaluation of 0.6864 was watched for test run 7 as appeared in the perception of the normal dim social evaluation, showing an ideal mix of control factors. The surface completion standard compels the MRR while choosing the ideal mix of MRR and surface completion. Based on the normal GRG acquired in the current work, the impact of the GRG of procedure parameters are positioned as Spindle speed-I, drill width - II and coolant stream III.

REFERENCES

1. Reddy Sreenivasulu and Dr. Ch. SrinivasaRao, "Application of Grey Relational Analysis for Surface Roughness and Roundness Error in Drilling of Al 6061 Alloy", *International Journal of Lean Thinking* Volume 3, Issue 2, pp. 67-78, December 2012.

2. B. Shivapragash, K. Chandrasekaran, C. Parthasarathy and M. Samuel, "Multi Response Optimizations in Drilling Using Taguchi and Grey Relational Analysis", *International Journal of Modern Engineering Research*, Vol.3, Issue.2, pp-765-768, March-April. 2013.
3. Devireddy, Krishnaja., et al. "Analysis of the influence of friction stir processing on gas tungsten arc welding of 2024 aluminum alloy weld zone." *Int. J. Mech. Prod. Eng. Res. Dev* 8.1 (2018): 243-252.
4. Nisha tamta and RS jadoun, "A Review on Optimization of Cutting Parameters in Drilling using Taguchi Method", *International Journal of Engineering Trends and Technology (IJETT)*, V29(2),82-86 November 2015. ISSN:2231-5381
Merchant, M. E., "Recent progress in metal removal research at Cincinnati", *Int. J.M.T.D.R.*
5. Abolusoro, Olatunji P., and Esther T. Akinlabi. "Wear and corrosion behaviour of friction stir welded aluminium alloys-an overview." *Int J Mech Prod Eng Res Dev* 9 (2019): 967-82.
6. Shunmugesh K, Panneerselvam. K and Jospaul Thomas, "Optimising Drilling Parameters Of GFRP By Using Grey Relational Analysis", *International Journal of Research in Engineering and Technology*, Volume: 03 Issue: 06, pp. 302- 305, Jun-2014.
7. K. Taraman, Multi machining output—multi independent variable turning research by responsesurface methodology, *International Journal of ProductionResearch* 12 (1974) 233–245.
8. Chu, NGOC-HUNG, and V. D. Nguyen. "The Multi-Response Optimization of Machining Parameters in the Ultrasonic Assisted Deep-Hole Drilling Using Grey-Based Taguchi Method." *Int. J. Mech. Prod. Eng. Res. Dev* 8 (2018): 417-426.
9. K. Lipin and p.govindan , "A Review on Multi Objective Optimization of Drilling Parameters Using Taguchi Methods", *AKGEC International Journal of Technology*, Vol. 4, No. 2,june2010
10. J. Siva Subramanian et al, "Study on Drilling Process Parameters - Review", *International Journal of Engineering Research & Technology (IJERT)*,ISSN: 2278-0181 ICONNECT - 2k18 Conference Proceedings
11. D. Kumar, L.P. Singh and G. Singh, , *Operational Modeling For Optimizing Surface roughness in Mild Steel Drilling Using Taguchi Technique*, *International Journal of Research in Management*, Vol. 2, No. 3, 2012, pp. 66-77.
12. Joshi, Jyoshna, and Onkar Sonare. "Optimisation of Wire EDM Process Parameters on D3 Tool Steel using Principal Component Analysis." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 7.2 (2013): 31-40.
13. B. Shivapragash, K. Chandrasekharan, C. Parthasarathy and M. Samuel, Multiple Response Optimizations in Drilling Using Taguchi and Grey Relational Analysis, *International Journal of Modern Engineering Research*, Vol. 3, No. 2, 2013, pp.765-768.
14. K.P. Patel, Experimental Analysis On Surface Roughness Of CNC End Milling Process Using Taguchi Design Method, *International Journal of Engineering Science and Technology*, Vol. 4, No. 2, 2012, pp.540-545