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Research Article

Optimization of Wear Process Parameters of Al6061-Zircon Composites Using Taguchi Method

R. Vijayakumar,[1] J. S. Srikantamurthy,[2] Shanawaz Patil,[3] S. Rudresha,[2] A. Manjunatha,[4] T. Hemanth Raju,[4] and A. Haiter Lenin[5]

[1]*Department of Aeronautical Engineering, MVJ College of Engineering, Bangalore 560067, Karnataka, India*
[2]*Department of Mechanical Engineering, JSS Academy of Technical Education, Bangalore 560060, Karnataka, India*
[3]*School of Mechanical Engineering, Reva University, Bangalore 560064, Karnataka, India*
[4]*Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore 560103, Karnataka, India*
[5]*Department of Mechanical Engineering, Wollo University, Kombolcha Institute of Technology, Post Box No 208, Kombolcha, Ethiopia*

Correspondence should be addressed to A. Haiter Lenin; haiterlenina@gmail.com

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Aluminium metal matrix composites are utilised extensively in a variety of engineering applications, including those involving automobiles, aerospace, and other fields of engineering because of its superior tribological properties. In the present research work, an effort was made to investigate the wear behaviour of an aluminium alloy called Al6061 that was manufactured by a process called two-step stir casting. The alloy was strengthened with zircon particles. The zircon particles were varied in three different percentages: six percent, nine percent, and twelve percent. A pin-on-disc wear testing machine was used to investigate the wear behaviour of Al6061-Zircon composites at elevated temperature 100°C. Experiments were performed as per the design of the experiments that had been generated using Taguchi's method. In order to do the analysis on the data, L27 Orthogonal array was chosen. During the wear process, an investigation was conducted to determine the impact of applied load, speed, percentage of reinforcement, and sliding distance on the wear response parameter. An analysis of variance (ANOVA) table and a regression equation were established to facilitate this study. In order to conduct the study of the dry sliding wear resistance, the aim of this equation was to select the smallest possible features. The scanning electron micrographs of Al6061-Zircon composites show the presence of zircon particles. It also shows that the particles are distributed uniformly in the Al6061 matrix. The scanning micrographs of worn out surfaces of Al6061-Zircon composites show the presence of grooves on the wear surface moving parallel to the sliding direction. According to the outcomes, the factor with the major impact is the load, followed by speed, sliding distance, and the percentage of reinforcement. In conclusion, confirmation tests were conducted in order to validate the experimental results.

1. Introduction

Due to the obvious growing need for lightweight and high-performing materials in recent years, the focus of research has turned away from monolithic materials and toward composite material systems. Due to the superior mechanical and tribological characteristics that aluminium and aluminium alloys possess in comparison to base alloys, they have become increasingly popular in recent years as a result of their application in a variety of industries. Due of its light weight, high specific strength, excellent stiffness, and superior wear resistance, in particular aluminium-based particle reinforced multimaterial composites (MMCs) are gaining widespread acceptance. As a result, it finds the applications as of all-purpose production industries infavour of aerospace applications. For the optimum combination of favourable mechanical qualities, good formability, and strength, the aluminium alloy 6061 is the best choice among the many other series of aluminium alloys that are currently available. When compared to alternative processing techniques, the stir casting technique is discovered to be both simpler and more cost-effective as a manufacturing method. This is especially true when discontinuous reinforcements are utilised in the process. It is possible to achieve homogeneous dispersion by first preheating the reinforcement in a graphite crucible while ensuring that the environment is inert and using a two-step stirring operation. After conducting research into the impact of the size of particle and weight percentage on the wear properties of aluminium MMCs, the researchers arrived at the conclusion that sliding distance and load were the two criteria that were the most crucial to consider. The use of ultrasonic vibration on the composites during melting resulted in a more refined grain microstructure of the produced composite, as well as enhanced mechanical and tribological characteristics of the fabricated composite. The processes used in the production of MMC play a significant part in the enhancement of the material's mechanical and tribological characteristics. Powder metallurgy, friction stir processing, stir casting, and squeeze casting are only some of the techniques that have been developed for the synthesis of the particle reinforced aluminium matrix composites (Al MMCs). The stir casting method was considered to be the easiest and most cost-effective approach for the development of composites, according to both the professional opinion and the literary portrayal of the abovementioned processes and procedures. The actual process of stir casting begins with the melting of the base metal in a furnace of some kind, and then the use of a mechanical stirrer to continuously combine the solid particles with the liquid metal that has been melted. The stirrer is responsible for ensuring that the molten metal contains an even distribution of the particles. In stir casting procedures, the amount of time spent stirring is another factor that determines the quality of the final result. When dealing with reactions that are influenced by multiple variables, the Taguchi strategy is the superior technique to use. For the purpose of developing Al MMCs with improved mechanical characteristics and superior resistance to wear, researchers focus on both the experimental and analytical aspects of these materials. The frictional force was taken from DUCOM in order to determine the coefficient of friction, and the impacts of characteristics such as applied load and sliding distance were explored in order to determine how those parameters affected the response.

The Taguchi method is a noteworthy method for the development of high-quality systems that depend on an orthogonal array, which is a trustworthy and methodical strategy for optimising designs in terms of performance, quality, and cost. In this case, the necessary number of experiments is represented as an orthogonal array. In the Taguchi experimental design method, there are five fundamental phases that are applied. Phase 1 is the planning of the experiment, Phase 2 is the design of the experiment, Phase 3 is the actual experiment, Phase 4 is the analysis of the results, and Phase 5 is the confirmation of the prediction. A best collection of well-balanced (minimum) experiments can be obtained by the use of orthogonal arrays. An appropriate orthogonal array (OA) is selected for the process, taking into account the process parameters and the levels at which they are specified and the tests are conducted in accordance with the OA's specifications. Different orthogonal arrays exist. "The signal to noise (S/N) ratios, which are divided into three different categories of quality attributes, like lower is better (LB), higher is better (HB), and nominal is the best, are used to evaluate the experiment's outcomes." The NB value is considered to be the best and this will be determined by how the process reacts; in this case, the reaction is wear, and since we want to minimise the response's value as much as possible, this will be the determining factor. LB characteristics will need to be used in this situation. The mathematical equation that represents the smaller the S/N ratio, the better it is represented by the number 1. In addition, an analysis of variance, also known as an ANOVA, was performed in order to calculate which of the two parameters was more influential than the other and how much of an impact each variable had on the total amount of wear. Both the S/N ratio and the ANOVA were utilised in order to locate the optimal parameter settings for the process. Following this, a confirmation test was carried out in order to establish beyond a reasonable doubt that these optimal combinations are, in fact, the most effective ones.

Following is a discussion of the literature review that has been performed out over the course of the past few years on the Taguchi method for optimising the wear process parameters of aluminium alloy-based composites. Mallik and Mallik [1] fabricated aluminium-based MMCs and optimised the wear parameters using the Taguchi technique. They found that "the applied load (59.04%), preceded by sliding distance (20.85%), and % of reinforcement had the biggest impact on the wear rate of hybrid MMCs (16.85%)." Bhaskar and Sharief [2] studied the wear characteristics of aluminium MMCs by utilising the Taguchi method. They came to the conclusion that with the deployment of DOE approach, sliding distance contributed 48.63 percent to the wear of composites, while load contributed 25.74 percent.

Sahin [3] studied on the production and wear characterisation of MMCs. They discovered that the size of the reinforcement was the most influential parameter on the wear, preceded by the % of reinforcement. When comparing the projected wear resistance to the actual wear resistance, there was found to be an excellent agreement at the level of confidence of 95%. Prakash et al. [4] carried out the Taguchi implementation in order to optimise the adhesive wear properties of aluminium MMCs. Their findings showed a reduction in the wear rate of MMCs brought about by the addition of reinforcement in comparison to matrix alloy. The rate of wear is shown to reduce with increasing sliding distance because of the smoothing out of asperities and the surface hardening that occurs at the surface. Sundaresan et al. [5] carried out the process optimization of aluminium-based composites, and from the wear study, it was found that by implementing the analysis of variance, the reinforcement percentage and the sliding velocity have more contribution for the wear behaviour. This was discovered through the work that they did on the process optimization of aluminium-based composites. Sutradhar and Sahoo [6] studied the wear characteristics of aluminium-based MMCs and carried out the optimization by using the Taguchi method. They came to the conclusion that the applied load (L) is found to impact the wear the most considerably, while speed (S) and time (T) have got some major influence as well. Ranaa et al. [7] examined the process parameters impact on the wear rate of aluminium-based MMCs. They came to the conclusion that for the composites produced at temperature ranges of 700°C to 750°C, this was found to be the optimal condition. Researchers discovered that a lower stirring speed of 50 rpm led to an increase in wear rates. Sahoo and Sutradhar [8] conducted research on the production and wear studies of aluminium MMCs using an optimization technique. They discovered that the composite exhibited reduced wear when the reinforcing weight percentage was increased. When the load was raised, the rate of wear on the composites also increased. Mohana sundararaju et al. [9] conducted research on the optimization of wear characteristics of aluminium-based MMCs using the Taguchi technique. Their findings showed that the integration of reinforcing particles into the produced composites gave the material a stronger resistance to wear. According to the findings, the load on wear rate and COF were the most important parameters to consider. Rana et al. [10] conducted research on the Taguchi implementation for aluminium-based composites. They observed that the load, followed by the sliding speed and the sliding distance, attributed most to the wear rate. The error connected with the study is 3.9 percent, and the error related with the confirmatory test is 5.8 percent accordingly. Chandramohan and Davim [11] carried out the Taguchi implementation to study wear characteristics of MMCs, and they came to the conclusion that the wear resistance of the material increases when reinforcement particles are incorporated into the aluminium matrix. When it came to the wear of composites, the sliding distance was the wear parameter that had the most significant impact on the wear.

The main objective of the current research is to produce Al6061-Zircon particulate composites by using a two-step stir casting process and to carry out a pin-on-disc wear test at elevated temperature 100°C. The Taguchi orthogonal design is utilised to determine the wear using design factors such as Zircon's weight percentage (expressed as a wt. percent), load, sliding distance, and speed. For the purpose of determining the wear, a multitribo tester is utilised. The Taguchi method is utilised so that the optimal combination of parameters may be determined, which in turn produces the optimal (or least) wear. The purpose of conducting an analysis of variance is to determine the degree to which individual factors and the interactions between them are significant.

2. Materials and Experimental Details

2.1. Materials. In this study, the base metal was an aluminium alloy called Al6061 and zircon was employed as the reinforcing material. Aluminium alloy with a precipitation-hardening number 6061, often known as Al6061, contains magnesium and silicon as its primary alloying components. It is very widely extruded and possesses excellent mechanical qualities. It also demonstrates excellent weldability. It is the most commonly used aluminium alloy, and its applications are extremely diverse due to its extensive use. Table 1 presents the fundamental elements that make up the Al6061 aluminium alloy.

Numerous rare earth elements, titanium minerals, monazite, and other minerals make up the majority of zirconium silicate ($ZrSiO_4$), along with a minor quantity of hafnium. Zircon was discovered to be an excellent potential option for use as a reinforcing material in composites based on aluminium, zinc, and lead. Table 2 shows the chemical composition of Zircon.

Table 3 shows the chemical composition of Zircon physical and mechanical characteristics of Al6061 and Zircon.

2.2. Fabrication of Al6061-Zircon Particulate Composites. The quantity of zircon particles was increased from 6 to 12 weight percent, with each increase being a step of 3 weight percent. In order to produce the Al6061-$ZrSiO_4$ composites, the stir casting method was utilised. A first measured amount of aluminium Al6061 was kept in a crucible composed of silicon carbide, which was then put in a furnace (electrical resistance) operating at a temperature of around 750 degrees Celsius. After properly degassing the melt with solid hexachloroethane, zircon particles with a particle size of sixty microns were weighed and added to the vortex of the melting process at a temperature of seven thousand five hundred degrees (C2Cl6). Reinforcing particles were preheated to a temperature of 2000 degrees Celsius before being added to the melt using a two-stage reinforcement mixing procedure. This was conducted before the particles were put to the melt. This technique of incorporating reinforcement into an Al6061 alloy matrix in two stages will result in an enhancement in both the wettability of the matrix and the hardness of the reinforcement. In addition to this, it assists in the even distribution of the particles. Continuous stirring took place before, during, and after the addition of zircon particles to the liquid. The stirring speed was normally kept at 200 rpm during the whole composite production process. After five minutes of stirring, molten metal containing particles was poured into a cast iron die measuring 150 mm in length and 20 mm in diameter. The length of the die was measured in millimetres. It had been five minutes since the stirring had begun. Then, machining was carried out for the developed castings. The developed composites were subjected to a wear test utilising a pin-on-disc machine.

2.3. Wear Testing Experimental Details. Figure 1 shows the Ducom Pin-on-disc tribometer was utilised in the wear tests that were carried out. The samples, which have dimensions of 8 millimetres in diameter and 30 millimetres in height, are forced up against a rotating steel roller. The equipment is set up in such a manner that the revolving roller will take on the role of the counter face material, while the stationary plate will take on the role of the test sample. At one end of the loading lever is a counter weight, and at the other end of the lever is a loading pan that is hanged for the purpose of

Table 1: Al6061 alloy chemical composition.

Elements	Al	Mg	Si	Fe	Cu	Zn	Ti	Mn	Cr
Percentage	Balance	0.9	0.50	0.50	0.30	0.20	0.10	0.10	0.25

Table 2: Zircon chemical composition.

Composition	ZrO_2	SiO_2	HfO_2	Al_2O_3	Fe_2O_3	MgO
Content (weight %)	67.22	30.85	1.39	0.11	0.029	0.014

Table 3: Physical and mechanical characteristics of Al6061 and zircon.

Material/Properties	Density (g/cm^3)	Melting point (°C)	UTS (MPa)	Elastic modulus (GPa)
Al 6061	2.7	650	290	70
Zircon	4.56	2550	330	95

placing the dead weight. The load sensor is located quite near to where the loading lever is pivoting. It is a multipurpose piece of equipment that was created to investigate wear under sliding conditions. The majority of the time sliding takes place between a pin that is immovable and a disc that is turning. Even after the contact surface of the arm has worn away due to wear and tear, the arm will continue to remain in touch with the disc because of the load. This will continue to be the case even after the arm has been subjected to wear and tear. This arm movement generates a signal that is utilised in the process of determining the maximum wear, while the friction coefficient is constantly measured as wear increases. This allows the maximum wear to be determined. During this process, the predicted level of wear is determined. Electronic single-pan scale with a resolution of 0.0001 g is used to determine the weight of each sample both before and after the experiment. This was conducted after giving each specimen a thorough washing with acetone solution. Because of this, it is to calculate the amount of weight loss that had been sustained by each specimen.

Table 4 shows the levels and process parameters.

A sliding wear test was carried out with a variety of parameters, including the applied weight, speed, sliding distance, and % of reinforcement, and these factors were varied across three distinct levels. On the basis of the run order that was determined using the Taguchi model, a total of 27 separate tests were carried out. Wear is the response that the model provides. In an OA, the first, second, third, and fourth column are designated for applied load, speed, sliding distance, and % of reinforcement. The final column is designated for the wear response. The reduction of wear is the primary focus of this model. A tabulation of the responses was performed, and an analysis of variance was performed on the findings (ANOVA). Table 5 shows the L 27 Orthogonal array with wear.

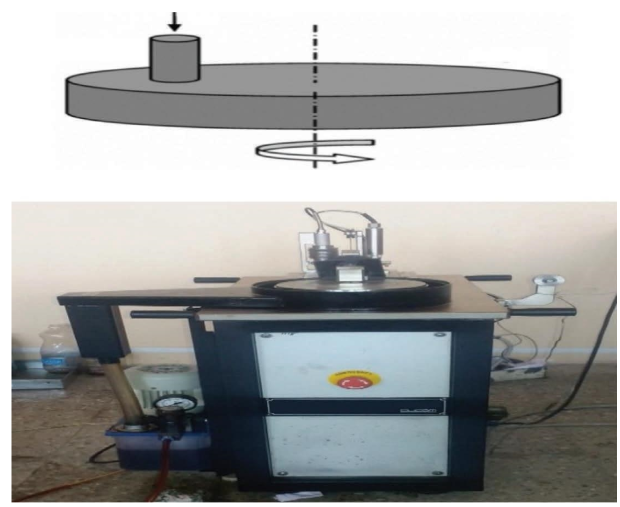


Figure 1: Pin-on-disc experimental setup.

3. Results and Discussion

3.1. Microstructural Characterization of Al6061-Zircon Composites. Figures 2(a)–2(e) show the SEM micrographs of Al6061 Matrix, Al6061-3% Zircon, Al6061-6% Zircon, Al6061–9% Zircon, and Al6061-12% Zircon at 500x magnification. The distribution of the particles, secondary phases of Al 6061 alloy are visible in the SEM. Figures 2(b)–2(e) show the presence of Zircon reinforcement particles. Figures 2(b)–2(e) show the irregular shaped white needle like structures, which are formed during precipitation of Mg_2Si during solidification of the MMC. These secondary phases increase the strength of the composite due to strong adherence at the grain boundary.

The black regions with tetragonal shape indicate the Zircon reinforcement particulates. The distribution of these zircon particulates is uniform in the matrix. Figures 2(d) and 2(e) indicate the SEM images for 9% and 12% weight fraction of zircon particles reinforced Al6061/Zircon composite with large Zircon portions. The precipitate Magnesium Silicate is formed due to the reaction between Si and Magnesium. The secondary phase aluminium silicate is formed due to the reaction between aluminium and silicon.

Table 4: Levels and process parameters.

Level	Load (N)	Speed (rpm)	Sliding distance (m)	Percentage of reinforcement weight (%)
1	10	200	500	6
2	20	400	1000	9
3	30	600	1500	12

Table 5: L 27 orthogonal array with wear.

Sl. No.	Load	Speed	Sliding	Percentage of reinforcement	Wear in microns
1	10	200	500	6	85
2	10	200	1000	9	79
3	10	200	1500	12	72
4	10	400	500	9	94
5	10	400	1000	12	88
6	10	400	1500	6	82
7	10	600	500	12	105
8	10	600	1000	6	108
9	10	600	1500	9	112
10	20	200	500	6	67
11	20	200	1000	9	64
12	20	200	1500	12	56
13	20	400	500	9	80
14	20	400	1000	12	74
15	20	400	1500	6	67
16	20	600	500	12	86
17	20	600	1000	6	89
18	20	600	1500	9	92
19	30	200	500	6	55
20	30	200	1000	9	51
21	30	200	1500	12	49
22	30	400	500	9	67
23	30	400	1000	12	61
24	30	400	1500	6	56
25	30	600	500	12	77
26	30	600	1000	6	73
27	30	600	1500	9	70

3.2. Microstructural Studies of Worn Out Surfaces of Al6061-Zircon Composites. Figures 3(a)–3(c) represent the worn out surfaces of the developed Al6061-Zircon composites. It also shows the SEM micrographs of wear tracks of the matrix and composite. This represents the cavities and large grooved regions on the wear surfaces and particles have been pulled out due to the change from a mild to severe wear resulted by an increase in the sliding distance due to a greater plastic flow on the pin surface of the specimen. The particle pull-out was due to the poor particle/matrix bonding. The presence of groove on the wear surface was observed moving parallel to the sliding direction. Figures 3(b) and 3(c) show the deeper grooves with the larger delaminated area on the worn surface. It is seen clearly from the figure the presence of adhesive wear during the sliding.

3.3. Response Table for Wear. The impact of each control component on wear was calculated with an S/N response table utilising MINITAB 16.1 Software. These control parameters included load, speed, distance, and weight percentage. The control factor with the most significant impact is identified by calculating the delta value and is defined as the disparity between the control factor's minimum and maximum *S*/*N* ratios.

The response of the *S*/*N* ratio for wear is provided in Table 6, which demonstrates that, out of all the parameters, Load has the most significant impact, preceded by speed, sliding distance, and Wt. % for the composites that have been manufactured. Table 6 also reveals that weight percentage has the least significant impact.

Figure 4 demonstrates that the optimal conditions for wear are Al 6061 with 9 percent Zircon. As a result, the optimal setting of control factors for a composite with improved wear resistance has been determined.

Figure 5 depicts the impact of control factors interacting with one another. It is common knowledge that interactions do not take place when the interaction plots lines are parallel to one another, whereas significant interactions between parameters take place when the lines cross one another.

3.4. Analysis of Variance. The analysis of the impact on wear caused by characteristics viz load, speed, sliding distance, and % of reinforcement was performed with an ANOVA. Throughout the entirety of the process, the investigation was carried out at a level of significance of 0.05 or lower at all times.

The findings of the ANOVA for wear as a reaction to the factors are presented in abovementioned Table 7. The variable with the most importance was load, which contributed 52.22 percent of the total, followed by speed, sliding distance, and wt. %. As a result, this aspect demonstrates the significant development in the results.

3.5. Regression Analysis. In order to calculate the data in accordance with the characteristics of the produced composites, regression analysis is utilised. The regression equation is utilised in order to make projections regarding the wear taking into account the various elements. Through the use of the multiple linear regression approached, it was possible to determine the correlation that exists between the control factors and the wear. These control elements include load, speed, sliding distance, and wt. % of reinforcement. The wear is calculated using the following regression equation:

$$\begin{aligned}\text{WEAR} = {} & 87.3519 - 1.01667\,\text{LOAD} + 0.0222222\,\text{SPEED} \\ & + 0.000777778\,\text{SLI DISTANCE} + 0.537037\,\text{PERCENT}.\end{aligned} \quad (1)$$

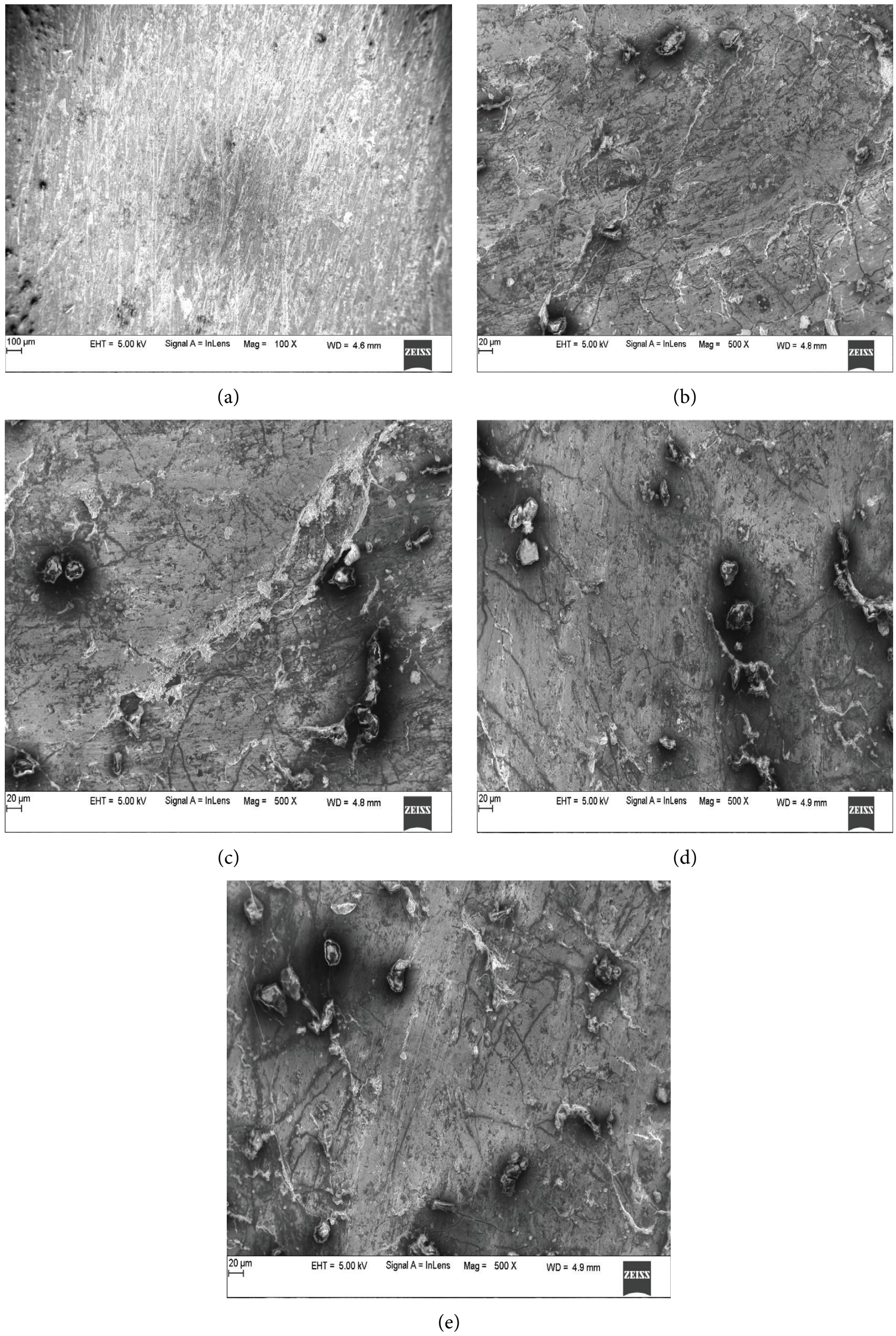
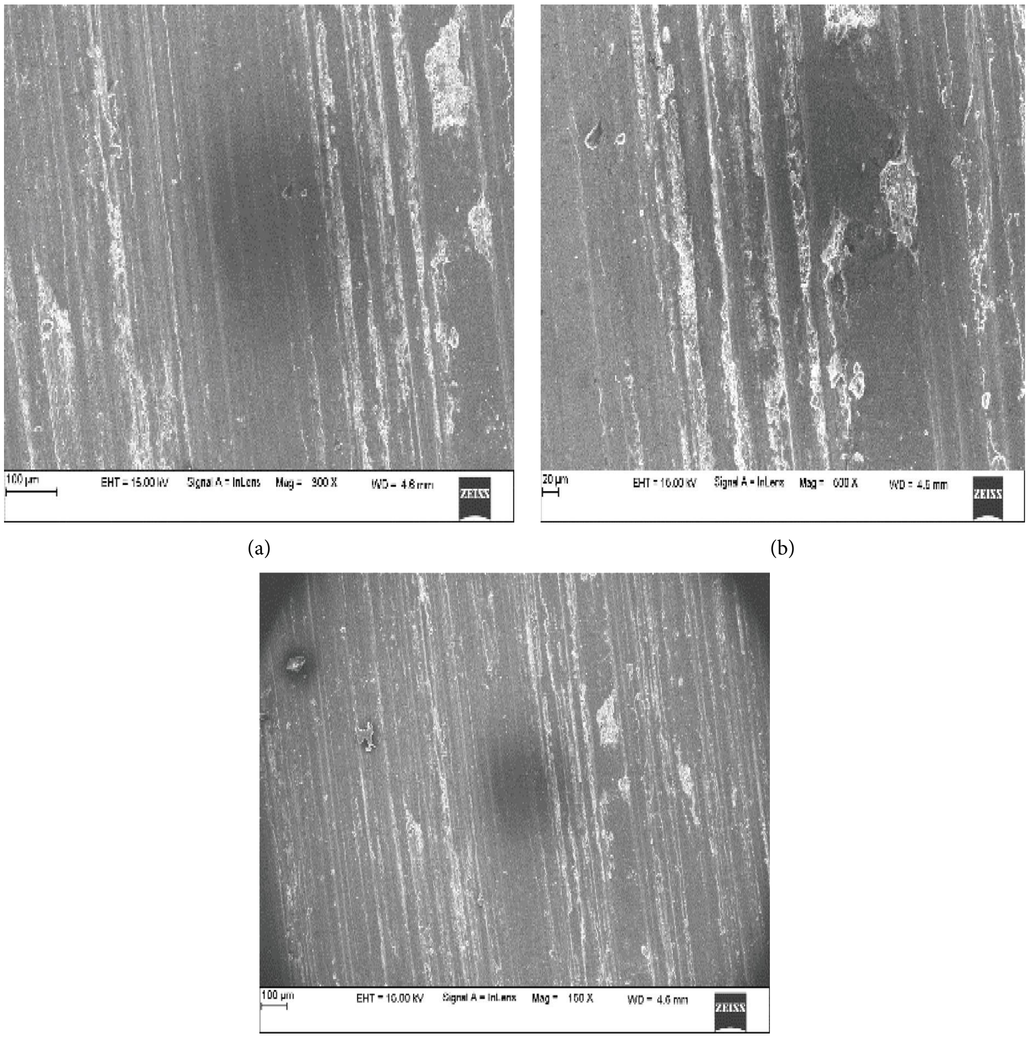


Figure 2: SEM images of Al6061 alloy and Al6061-Zircon composite specimens at 500x magnifications for different wt. % of Zircon, (a) Al6061 at 500x (b) Al6061 + 3% Zircon at 500x, (c) Al6061 + 6% Zircon at 500x (d) Al6061 + 9% Zircon at 500x, and (e) Al6061 + 12% Zircon at 500x.

The normal probability graph for wear in microns is indicated in Figure 6. This graph indicates that the errors associated with the experiments are negligible as the points are nearer to the line.

3.6. Confirmation of Experiment. The goal of this last step in the DOE process is to validate the optimal amounts of the parameters that were selected earlier in the process. Experiments to confirm the findings were carried out using the



(a) (b)

(c)

Figure 3: SEM micrographs of worn out surfaces Al6061-Zircon composites with different %, (a) 6% of Zircon, (b) 9% of Zircon, and (c) 12% of Zircon.

Table 6: Response table for wear.

Level	Load	Speed	Sliding distance	Wt. %
1	−39.15	−36.01	−37.87	−37.40
2	−37.39	−37.30	−37.46	−37.72
3	−35.36	−38.99	−36.98	−37.19
Delta	3.39	2.99	0.89	0.52
Rank	1	2	3	4

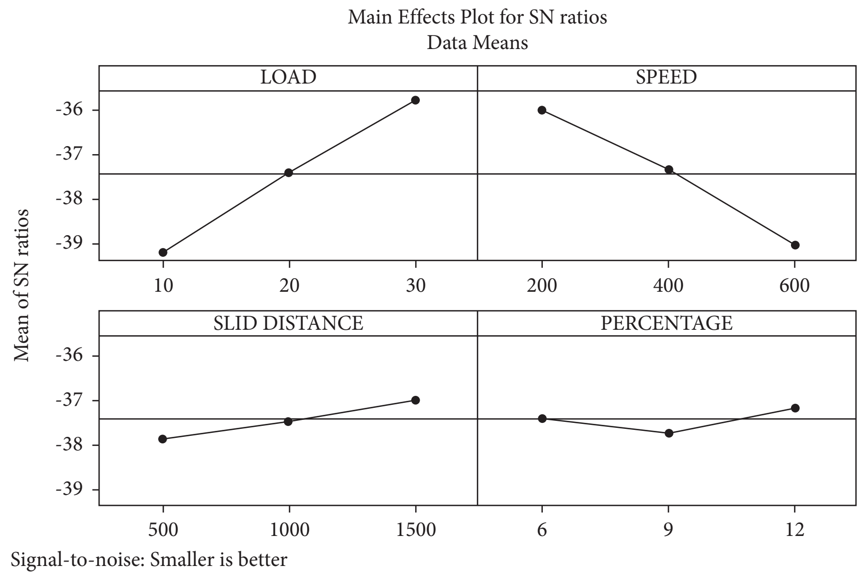


Figure 4: Influence of control factors on COF (S/N ratio).

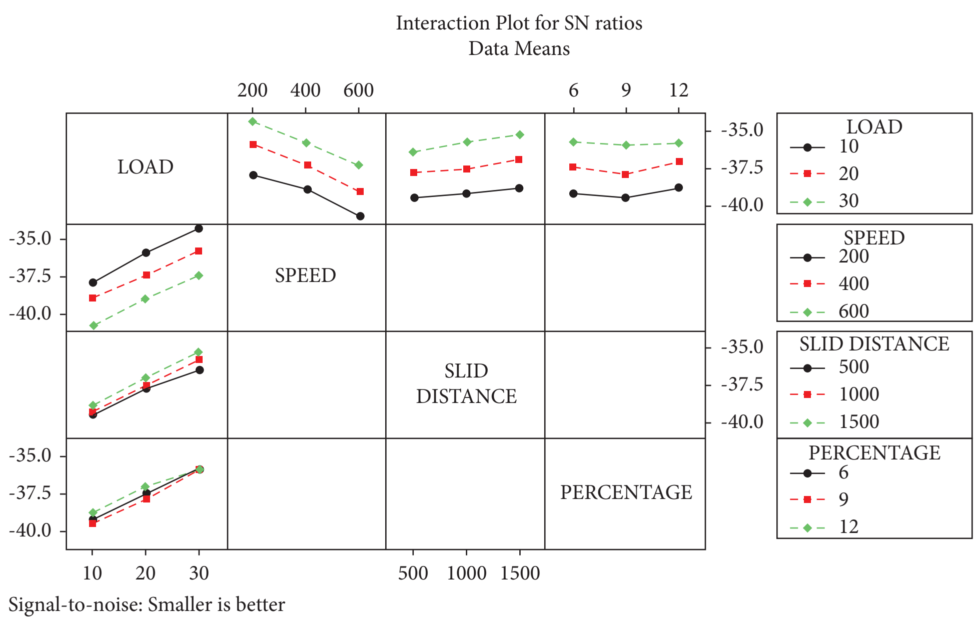


Figure 5: Interaction plots for COF.

Table 7: Results of ANOVA for COF.

Source	DF	Seq. SS	Adj. SS	Adj. MS	*F*	*P*	Cont. (%)	Remarks
Load	2	3952.30	3952.30	1976.15	110.24	≤0.001	52.22	Significant
Speed	2	3092.07	3092.07	1546.04	86.25	≤0.001	40.86	Significant
Sliding distance	2	200.07	200.07	100.04	5.58	0.043	2.64	Significant
Percentage	2	96.52	96.52	48.26	2.69	0.146	1.27	Insignificant
Load ∗ Speed	4	70.15	70.15	17.54	0.98	0.484	0.92	Insignificant
Load ∗ Sliding distance	4	6.81	6.81	1.70	0.10	0.980	0.08	Insignificant
Load ∗ Percentage	4	41.70	41.70	10.43	0.58	0.688	0.55	Insignificant
Error	6	107.56	107.56	17.93			1.42	
Total	26	7567.19					100	

(Note: "F = fisher values, DF = degrees of freedom; Adj MS = adjusted mean squares; Seq SS = sequential sum of squares; Adj SS = adjusted sum of squares.")

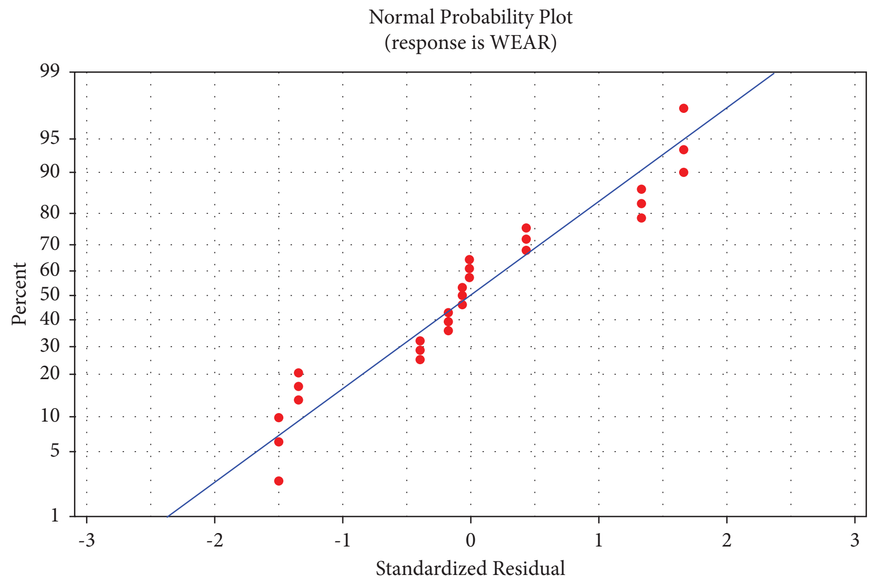


Figure 6: Normal probability plots for COF.

Table 8: Results of experiment.

Exp no.	Load (N)	Speed (rpm)	Distance (m)	Percentage of reinforcement (%)
1	15	250	600	6
2	25	500	1200	9
3	35	750	1800	12

Table 9: Results of confirmation test.

Exp no.	Experimental wear in microns	Regression model equation	Error (%)
1	86	83.02	3.58
2	82	79.49	3.15
3	77	75.45	2.05

chosen mix of factors and level settings. The outcomes of the experiments that were carried out are summarised in Table 8, which may be found as follows:

The outcome of the confirmatory test is tabulated in Table 9.

The results of confirmatory test indicate that the errors associated with the experimental wear in microns and regression model Equation wear are negligible.

4. Conclusions

The following conclusions are drawn from this study's findings:

(1) A successful adaptation of stir casting was made to fabricate Al6061-6 percent Zircon, Al6061-9 percent, and Al6061-12 percent composites.

(2) Zircon particles can be included into the Al6061 matrix to produce the composite material with an even higher resistance to wear than it already possesses. This is one of the contributing components that help make the composite more resistant to wear over time.

(3) The scanning micrographs of Al6061-Zircon composites show the presence of zircon particles. It also shows that the particles are distributed uniformly in the Al6061 matrix.

(4) The scanning micrographs of worn out surfaces of Al6061-Zircon composites show the presence of grooves on the wear surface moving parallel to the sliding direction. It also shows the deeper grooves with the larger delaminated area on the worn surface. It is seen clearly from the figure the presence of adhesive wear during the sliding.

(5) Based on the response table, it is seen that load has the most significant impact, preceded by speed, sliding distance, and wt. % for the composites that have been manufactured. The load has the greatest impact on the wear (52.22 percent), preceded by the sliding distance (40.86 percent), speed (2.64 percent), and weight % (weight percent) (1.27 percent).

(6) The regression equation was established for this investigation, and it was used to the problem of predicting the coefficient of friction developed in composites under intermediate conditions with a level of accuracy that was considered acceptable.

Data Availability

All data generated or analysed during this study are included within this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] U. S. Mallik and U. Mallik, "Dry sliding wear behavior of Al/Gr/SiC hybrid metal matrix composites by Taguchi techniques," *Materials Today: Proceedings*, vol. 4, no. 10, pp. 11175–11180, 2017.

[2] H. B. Bhaskar and A. Sharief, "Wear behaviour of aluminium/$Be_3Al_2(SiO_3)_6$ metal matrix composites by using taguchi technique," *Journal of Minerals and Materials Characterization and Engineering*, vol. 11, no. 7, pp. 679–684, 2012.

[3] Y. Sahin, "The prediction of wear resistance model for the metal matrix composites," *Wear*, vol. 258, no. 11-12, pp. 1717–1722, 2005.

[4] U. Prakash, S. A. Prasad, and H. Ravindra, "Study of parametric influence on dry sliding wear of Al-SiCp MMC using taguchi technique," *Materials Today: Proceedings*, vol. 2, no. 4-5, pp. 1825–1832, 2015.

[5] T. K. Sundaresan, U. Marimuthu, and P. Manickaraj, "Wear behavior of reinforced aluminum- red mud metal matrix composites," *Advances in Tribology*, vol. 2016, Article ID 9082593, 7 pages, 2016.

[6] G. Sutradhar and P. Sahoo, "Wear behavior of Al-5%Sic composites by using taguchi technique," *Journal of Tribology Research*, vol. 2, no. 1, pp. 33–40, 2011.

[7] R. S. Ranaa, A. H. Ansari, and P. K. Bharti, "Wear characteristics of Al6061-SiC composites," *Journal of Materials and Environmental Science*, vol. 5, no. 5, pp. 2028–2508, 2014.

[8] P. Sahoo and G. Sutradhar, "Wear behavior of Al-TiB_2 composites by using Taguchi method," *IOP Conference Series: Materials Science and Engineering*, vol. 149, pp. 1–9, 2016.

[9] N. Mohana sundararaju, P. G. Venkatakrishnan, and V. Karthik, "Wear behaviour of Al7075-Al_2O_3- B_4C composites using Taguchi technique," *IOP Conference Series: Materials Science and Engineering*, vol. 314, pp. 1–6, 2018.

[10] R. S. Rana, R. Purohit, and S. Rana, "Optimization of wear performance of a 5083/10 Wt. % sic p composites using taguchi method," *Procedia Materials Science*, vol. 6, pp. 503–511, 2014.

[11] G. Chandramohan and J. P. Davim, "Dry sliding wear behaviour of metal matrix composites by using taguchi technique," *Materials and Design*, vol. 28, pp. 1393–1398, 2007.