Research Article

Optimizing the Parameters of Zirconium Carbide and Rice Husk Ash Reinforced with AA 2618 Composites

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Stir casting was utilized to generate the composites. The AA 2618–10wt% zirconium carbide 10wt% rice husk ash hybrid composite had the highest hardness value. In comparison to pure AA 2618, it had a 72% increase. The rule of mixture was used to compute theoretical density, whereas the Archimedes rule was utilized to evaluate real density. For AA 2618, AA 2618/zirconium carbide, and rice husk ash hybrid composites, simple carbide inserts were used for turning. Surface roughness, metal removal rate, and tool wear were among the numerous responses examined. RSM was utilized to analyze and optimize the test outcomes. Feed rate was the most critical issue for surface roughness and material removal rate. Tool wear was shown to be most strongly controlled by tool speed, whereas metal removal rate was found to be least significantly influenced by the weight percent of reinforcement.

1. Introduction

Aluminum alloy 2618 is a strong but lightweight alloy. For automotive and aerospace applications, this material meets the majority of the standards. In the mineral and chemical processing sectors, AA 2618 has found numerous uses. Particulates and fibers can be added to the matrix of composite materials made with the AA 2618 substance. Carbonates, oxides (Al₂O₃ and SiO₂), and nitrides are some of the ceramic materials used in reinforcing (Al₂O₃ and Si₃N₄). AA2618-based metal matrix composites (MMCs) may be made using these reinforcements [1–6]. Excellent mechanical qualities such as TS, compression strength, and wear resistance are just few of MMC’s advantages [7]. Aluminum-based composite engine blocks have replaced cast iron engine blocks in an effort to reduce vehicle weight and improve fuel economy [8, 9]. The manufacturing of MMCs is still a problem. Stir casting, squeeze casting, powder metallurgy, and diffusion bonding are among of the techniques used to create MMCs [10]. In terms of MMC production, stir casting is the preferred process due to its great efficiency and low cost [11]. Excess material is removed from the material matrix composites while the desired surface polish is provided via machining procedures.
However, the presence of strong ceramic reinforcements in MMCs makes machining them difficult.

A number of investigators have sought to develop distinct MMCs for diverse purposes. Using RHA and aluminum alloy, Ragupathi and Kumar [12] created a composite. The inclusion of RHA components increased the hardness, according to the research [13]. A graphite- and Al$_2$O$_3$-reinforced AA 2618 hybrid composite was created in [14, 15]. Composites were shown to have greater hardness, flexural strength, compression strength, and TS than pure AA 2618 [16]. The zirconium carbide-reinforced AA 2618 composite was made by [17] and reported having superior mechanical qualities than pure AA 2618 by AA2618/zirconium carbide composite. They found that the mechanical characteristics of the AA 2618-based hybrid composite were superior to those of AA 6061. It was discovered that [18, 19] the ricer husk ash- and graphite-based aluminum alloy hybrid compound had a rise in hardness at all weight percent of strengthened particles. It was made in [20, 21] with the help of ricer husk ash and fly ash. It was discovered that TS and hardness were at their highest at 20% ricer husk ash and 20% fly ash [22]. The AA 2618/zirconium carbide composite was described in [23, 24]. Increased ceramic phase content in a composite has been shown to increase its hardness [18]. In terms of outcome and fracture strength, the lowest particles of strengthening were shown to be the most effective. In [25–27], a nanocomposite of AA 2618 and Al2O3 was created. Al2O3-reinforced aluminum alloy 6061 exhibits superior mechanical characteristics compared to pure AA 6061. A zirconium carbide- and rice husk ash-based aluminum alloy hybrid composite was developed in [28, 29]. In a mixture of 10% zirconium carbide and 10% RHA, the greatest hardness was achieved [30–33].

To ensure that the finished product has an appealing appearance, it is necessary to identify the mechanical properties for improved surface quality at a cheaper cost. Commercialization of MMCs is hampered by their machinability. In their wear investigation, [34] employed diamond inserts to machine Silicon carbide-based aluminum alloy composites. When machining MMCs, Nguyen et al. [35] investigated how ceramic particles affect surface roughness. TiN-coated WC carbide tools were used in [36] to cut the silicon carbide-based aluminum alloy compound. They looked at the machinability of the final composite in relation to the reinforcing particle. At a high percentage of reinforcement, high tool wear was observed [37]. SR and TW were found to be lower in the AA 2618/SiC composite when machining pure AA 2618 [38]. RSM was used to mill the Al$_2$O$_3$- and Gr-reinforced aluminum alloy 6061 hybrid compound to determine surface roughness. This study found that speed was the most critical component in the machining of an aluminum alloy 6061/Al$_2$O$_3$/Gr hybrid compound. Cutting parameters for the AA2618/SiC composite were adjusted in [39] to reduce power consumption and maximize tool life. While machining the AA 2618/SiC nanocomposite, Liu et al. and He et al. [40, 41] used RSM as a tool. SiC was used as a reinforcing agent in the composite. As feed rate increased while machining polymer matrix composites using Taguchi’s approach, Shojaie-Bahaabad and Hasani-Arefi [42] discovered that surface roughness increased. Cutting parameters for cutting forces were optimized in [43] for machining AA 2618-T6. The RSM was used in [44] to reduce the surface roughness of AA 5052 during machining. The cutting forces and surface roughness of SiC- and zirconium carbide-based hybrid composites were measured in [45]. The RSM technique was used to optimize the design. Ouyang et al. [46] used polycrystalline diamond cutting inserts to measure the surface roughness of an AA 2618/SiC composite while it was being turned.

As a continuation of the prior work, we are conducting this study. The AA 2618/zirconium carbide/rice husk ash hybrid composite was the subject of prior research that concentrated on its manufacturing and characterization. An in-depth examination of the material’s machining characteristics is required before it can be made commercially available. Nothing about milling (turning) an AA 2618/zirconium carbide/rice husk ash hybrid composite has been documented, according to the literature.

### 2. Materials and Methods

For making a composite, different materials are used, and their purpose is listed in Table 1.

### 3. Sample Preparation

#### 3.1. Stir Casting from the Bottom-Up.

Bottom-pouring-type stir casting machines were used to make the workpiece. AA 2618, AA 2618–5% zirconium carbide composite, and AA 2618–10% zirconium carbide composite were the three types of workpieces made. A flow rate of 10 liters per minute of 99.99% pure argon gas was used during the casting process. In a graphite crucible, the material begins to melt at 485°C. Reinforcement particles were preheated at 300°C for 40 minutes before zirconium carbide and rice husk ash additions were made in melted pure AA 2618 to remove moisture. Silicon and oxygen are included in rice husk ash’s silica (SiO$_2$). AA 2618 and reinforcement particles form a weak contact, which causes a wettability issue when the matrix and reinforcement material are mixed together. Prior to the addition of zirconium carbide and rice husk ash particles, mechanical stirring was carried out at 415 rpm. Vibratory action produced by the machine’s reinforcement feeder attachment adds the preheated reinforcement particle to the melted AA2618. After 4 minutes of stirring, the AA 2618 and reinforcement particles were thoroughly mixed (zirconium carbide and rice husk ash). It was necessary to use an attached permanent mold of die steel that had a rectangular cavity of 20×10×250 mm, and two cylindrical cavities of 25×250 mm and 18×250 mm to pour the AA 2618 melt into. When pouring molten metal into the mold during casting, it was crucial that the mold’s screws were properly tightened to ensure a suitable vacuum. By heating the mold to 450°C, the temperature gradient was eliminated. After the mold had cooled, the samples were taken out. Figure 1 shows the stir casting setup.
4. Mechanical Performance and Characterization

4.1. Mechanical Characteristics

4.1.1. Hardness. In order to determine hardness of the samples, we turned to the Mitutoyo HM 100 series of Vicker’s hardness tester. Stress was applied for 15 seconds at a rate of 5 N, according to ASTM E-384. Here was a calculation of the mean of three hardness values.

4.1.2. Impact Strength. The specimens’ impact resistance was determined using Charpy/Izod pendulum testing machines with 200 J capacity, in accordance with ASTM D 256 standards. Specimens have a 10 x 10 mm cross-sectional area.

4.1.3. Density. The principle of mixtures connection was used to compute the theoretic density of the fabricated composite; it is an approach for estimating the whole properties of composite material given matrix and reinforcing characteristics. (1) is the formula used to determine density.

\[
p_c = \rho_b \times W_b + \rho_r \times W_r + \left[1 - (W_b + W_r)\right] \times \rho_m.
\]

4.2. Machining of the Composite. A CNC lathe (turning machine) was used in this study to perform a slew of turning experiments. As-cast AA 2618, AA 2618/10% zirconium carbide composite, and AA 2618/10% zirconium carbide/10% rice husk ash composite were used in the machining process. Turning operations were carried out using titanium carbide inserts. A single insert has a total of eight cutting edges. Each process only made use of one edge. 27 trials were carried out using a total of seven inserts. Table 2 contains the characteristics of the tool inserts provided by the provider.

4.2.1. Experimental Arrangement. The studies are performed in dry-cutting circumstances on a CNC turning machine. A consistent power source was maintained throughout the process. There is a complete breakdown of each component’s input and output variables shown.

4.2.2. Variables Chosen for Both Input and Output. The basic objective of the machining industry is to maximize output while minimizing surface roughness and TW. Work carried out by [47] was used to establish the input values for carbide inserts used during workpiece machining. Table 3 displays the values of the input factors.

5. Calculation of Responses

5.1. Surface Roughness (Ra) Evaluation. In terms of surface roughness, the more peaks and valleys there are greater the value of Ra. Contact type SR tester Mitutoyo SJ-301 measured the surface roughness. Surface roughness was measured with a cutoff length of 800 μm. The surface roughness of machined tasters was measured three times with the average of the three readings.

5.2. Measurement of Material Removal Rate. Equation (2) was used to compute the material removal rate.

\[
\text{Material Removal Rate} = \frac{(W_{bm} - W_{am})}{T},
\]
where $W_{bm}$ is the weightage before machining (gms), $W_{am}$ is the weightage after machining (gms), and $T$ is the turning time (sec).

6. Results and Discussion

6.1. Hardness Impact. Table 4 shows the outcomes of hardness testing on several compound samples. The hardness was demonstrated to increase with the addition of zirconium carbide and rice husk ash. An example of this variance can be seen in Figure 2.

6.2. Impact on Impact Strength. The inclusion of hard zirconium carbide particles improved the impact strength of AA 2618. Amplified plastic deformation energy was the cause of the observed increase. The materials required higher energy to fracture when AA 2618/zirconium carbide and 2618/zirconium carbide/rice husk ash are used. Figure 3 depicts the impact strength effect of reinforcing.

6.3. Effect on Density. In comparison to pure AA 2618, the density of AA 2618/zirconium carbide/rice husk ash particles is lower. According to the findings, there was just a little discrepancy between the composite’s theoretical and actual density as shown in Figure 4. Rice husk ash particle density is lower than zirconium carbide particle density and AA 2618 matrix density. As a result, the density of the final composite is reduced owing to the presence of rice husk ash particles.

6.4. Machinability of the Composite. Computed numerical control (CNC) lathe machines are employed during experiments to test for machinability. Surface roughness, tool wear, and material removal rate were all measured. Results from each trial were analyzed three times. This study presents the average of the measured responses. Table 5 displays the findings of the experiments.

6.5. Study of Responses

6.5.1. Surface Roughness Analysis. We used a changed cubic model for surface roughness investigation. A power transformation is used to simplify the model, with $y' = (y + k)$ and $\lambda = 0.95$ and $k = 0$. To fit the data, we utilized the values of $k$ and $\lambda$. ANOVA was applied to validate the importance of the model selected. Surface roughness has an important effect on overall surface quality, according to the results of an ANOVA in Table 6.

6.5.2. Study of Tool Wear. The tool wear is modelled using a modified cubic model. The model with $y' = 1/\text{Square root}(y + k)$ was reduced using inverse square root transformation, with $k$ selected to be 2.5 in order to rise the importance of the model. ANOVA was employed to verify the model’s suitability. Table 7 displays the analysis of variances for the tool wear model.

6.5.3. Analysis of MRR. The data fitting in the model was carried out using only the quadratic model, which did not require any transformations. Table 8 displays that the ANOVA table supported the selected model.

6.6. Impact on Tool Wears. Analysis of variance tables demonstrated that cutting speed was the maximum relevant component, tracked by feed, cutting depth, and strengthening weight percentage. The tool wear was found to be larger when the feed rate and depth of cut were both at their lowest points. Its less of a problem when the feed and cut depth are at their maximum. It has been found that cutting speed is the more critical factor in determining TW. The wear on a tool rises as the cutting speed rises. The rate at which the tool and workpiece rub against each other increases the amount of heat generated. Cutting tool materials lose thermostability and become increasingly worn when the rate of heat generation increases at the tooltip. Figure 5 depicts the process of tool wear. There are two mechanisms in action when a carbide tool’s tip comes into contact with an aluminum alloy 2618 workpiece that is rotating. As you wear it, the tip changes colour. When the tip comes into contact with the AA 2618/zirconium carbide composite, the wear increases. When hard ZrC particles interact with the tooltip wear increases. In the AA 2618/ZrC/rice husk ash hybrid composite, less tool wear was observed. The machinability of the material has improved as a result of rice husk ash reinforcement.
6.7. Optimization of Responses. Maximizing or eliminating a desired or unwanted quantity is the primary goal of optimization. As part of this study, there are three outcomes as follows: surface roughness, TW, and material removal rate. All responses are considered during multiresponse optimization, which ensures that all input parameters are optimized simultaneously. Desirability analysis is used to improve this. Table 9 shows the optimization objective and input ranges.

Figure 6 shows that the optimal parameters for favorable replies were 0 percent reinforcement, 198.96 m/min speed, 0.324 mm/rev feed rate, and 2 mm depth of cut. At these

| S. no. | ZrC (wt%) | Rice husk ash (wt%) | Total reinforcement (wt%) | Hardness (HV) |
|--------|-----------|----------------------|--------------------------|--------------|
| 1      | 0         | 0                    | 0                        | 71 ± 4       |
| 2      | 5         | 5                    | 10                       | 106 ± 3      |
| 3      | 10        | 10                   | 20                       | 122 ± 5      |
Table 5: Output of the experiments.

| Standard order units | Run order | A-reinforcement (wt %) | B-speed (m/min) | C-feed (mm/rev) | D-depth of cut (mm) | Ra (μm) | Tool wear (μm) | MRR (g/min) |
|----------------------|-----------|------------------------|-----------------|-----------------|---------------------|--------|---------------|-------------|
| 19                   | 1         | 0                      | 210             | 0.6             | 1.5                 | 0.98   | 69.6          | 8           |
| 23                   | 2         | 10                     | 190             | 0.4             | 2                   | 0.78   | 56            | 14.5        |
| 20                   | 3         | 20                     | 210             | 0.6             | 1.5                 | 1.6    | 60.7          | 10          |
| 7                    | 4         | 10                     | 210             | 0.2             | 2                   | 1.4    | 31            | 16          |
| 17                   | 5         | 0                      | 210             | 0.2             | 1.5                 | 0.92   | 18.6          | 9.5         |
| 12                   | 6         | 20                     | 210             | 0.4             | 2                   | 1.41   | 62            | 12.5        |
| 8                    | 7         | 10                     | 210             | 0.6             | 2                   | 1.03   | 89.9          | 8           |
| 2                    | 8         | 20                     | 190             | 0.4             | 1.5                 | 1.3    | 35            | 9           |
| 25                   | 9         | 0                      | 210             | 0.4             | 1.5                 | 1.03   | 41.5          | 11.5        |
| 6                    | 10        | 10                     | 210             | 0.6             | 1                   | 1.41   | 29.6          | 15          |
| 13                   | 11        | 10                     | 190             | 0.2             | 1.5                 | 0.75   | 17.8          | 15          |
| 4                    | 12        | 20                     | 210             | 0.4             | 1.5                 | 0.78   | 42.2          | 7           |
| 5                    | 13        | 10                     | 210             | 0.2             | 1                   | 0.55   | 10            | 18.5        |
| 24                   | 14        | 10                     | 230             | 0.4             | 2                   | 1.46   | 65            | 8.5         |
| 2                    | 15        | 10                     | 210             | 0.4             | 1.5                 | 0.82   | 39.8          | 20          |
| 26                   | 16        | 10                     | 210             | 0.4             | 1.5                 | 1.06   | 41.2          | 19          |
| 1                    | 17        | 0                      | 190             | 0.4             | 1.5                 | 1.2    | 35.3          | 9.5         |
| 15                   | 18        | 10                     | 190             | 0.6             | 1.5                 | 1.22   | 53.9          | 11          |
| 14                   | 19        | 10                     | 230             | 0.2             | 1.5                 | 1.25   | 21.8          | 10.5        |
| 3                    | 20        | 0                      | 230             | 0.4             | 1.5                 | 1.06   | 42            | 4.5         |
| 9                    | 21        | 0                      | 210             | 0.4             | 1                   | 0.85   | 18.8          | 16.5        |
| 18                   | 22        | 20                     | 210             | 0.2             | 1.5                 | 0.8    | 20            | 10.5        |
| 22                   | 23        | 10                     | 230             | 0.4             | 1                   | 1.02   | 21.56         | 7.5         |
| 11                   | 24        | 0                      | 210             | 0.4             | 2                   | 0.65   | 59.58         | 15          |
| 10                   | 25        | 20                     | 210             | 0.4             | 1                   | 0.74   | 20            | 11          |
| 21                   | 26        | 10                     | 190             | 0.4             | 1                   | 0.65   | 18            | 13          |
| 16                   | 27        | 10                     | 230             | 0.6             | 2                   | 1.6    | 65.64         | 4.5         |
### Table 6: Surface roughness (Ra) ANOVA result.

| Source | SS    | DOF | Mean square | F value | P value prob > F |
|--------|-------|-----|-------------|---------|-----------------|
| Model  | 1.73  | 16  | 0.11        | 15.40   | <0.0001         |
| A      | 0.097 | 1   | 0.097       | 13.81   | 0.0042          |
| B      | 0.055 | 1   | 0.055       | 7.79    | 0.0193          |
| C      | 0.35  | 1   | 0.35        | 48.96   | <0.0002         |
| D      | 0.16  | 1   | 0.16        | 21.18   | 0.0010          |
| AB     | 0.035 | 1   | 0.035       | 4.95    | 0.0506          |
| AC     | 0.12  | 1   | 0.12        | 15.70   | 0.0028          |
| AD     | 0.17  | 1   | 0.17        | 22.49   | 0.0009          |
| BC     | 9.601E-004 | 1 | 9.601E-004 | 2.23    | 0.2956          |
| BD     | 0.022 | 1   | 0.022       | 3.98    | 0.1155          |
| CD     | 0.29  | 1   | 0.29        | 41.66   | <0.0002         |
| B²     | 0.036 | 1   | 0.036       | 3.72    | 0.0829          |
| C²     | 0.080 | 1   | 0.080       | 9.97    | 0.0103          |
| D²     | 5.398E-004 | 1 | 5.398E-004 | 0.64    | 0.2246          |
| AB²    | 0.065 | 1   | 0.065       | 10.34   | 0.0027          |
| BC²    | 0.16  | 1   | 0.16        | 21.98   | 0.0012          |
| BD²    | 0.31  | 1   | 0.31        | 40.44   | <0.0002         |
| Residual | 0.072 | 10  | 7.985E-004  |         |                 |
| Lack of fit | 0.050 | 8  | 5.972E-004 | 0.34    | 0.8954          |
| Error  | 0.040 | 2   | 0.016       |         |                 |
| Total  | 1.81  | 27  |             |         |                 |

### Table 7: Tool wear results on ANOVA.

| Source | SS    | DOF | Mean square | F value | P value prob > F |
|--------|-------|-----|-------------|---------|-----------------|
| Model  | 0.25  | 17  | 0.25        | 8.86    | 0.0005          |
| A      | 6.956E-007 | 1 | 6.956E-007  | 4.52E-004  | 0.9478         |
| B      | 0.027 | 1   | 0.027       | 17.17   | 0.0021         |
| C      | 8.634E-004 | 1 | 8.634E-004  | 4.98    | 0.0500         |
| D      | 7.140E-005 | 1 | 7.140E-005  | 0.41    | 0.5417         |
| AB     | 4.594E-005 | 1 | 4.594E-005  | 0.31    | 0.5967         |
| AC     | 3.394E-005 | 1 | 3.394E-005  | 0.23    | 0.6486         |
| AD     | 4.485E-006 | 1 | 4.485E-006  | 0.28    | 0.6008         |
| BC     | 0.023 | 1   | 0.023       | 15.10   | 0.0037         |
| BD     | 10.058E-006 | 1 | 10.058E-006 | 0.058   | 0.8132         |
| CD     | 3.784E-004 | 1 | 3.784E-004  | 3.41    | 0.1527         |
| A²     | 0.023 | 1   | 0.023       | 15.34   | 0.0037         |
| B²     | 0.075 | 1   | 0.075       | 49.31   | <0.0002        |
| C²     | 0.018 | 1   | 0.018       | 13.36   | 0.0057         |
| B²C    | 0.015 | 1   | 0.015       | 9.14    | 0.0128         |
| BC²    | 7.014E-004 | 1 | 7.014E-004  | 5.57    | 0.0585         |
| C²D    | 6.719E-004 | 1 | 6.719E-004  | 5.38    | 0.0632         |
| Residual | 0.016 | 10  | 1.53E-004   |         |                 |
| Lack of fit | 8.869E-003 | 8 | 1.336E-004  | 0.46    | 0.8309         |
| Pure error | 6.513E-004 | 2 | 3.857E-004  |         |                 |
| Cor total | 0.27  | 26  |             |         |                 |
Table 8: ANOVA for material removal rate.

| Source | SS         | Degrees of freedom | Mean square | $F$ value | $P$ value prob $> F$ |
|--------|------------|--------------------|-------------|-----------|----------------------|
| Model  | 10329.27   | 14                 | 10329.27    | 1422.41   | <0.0001              |
| A      | 2.19       | 1                  | 2.19        | 4.22      | 0.0628               |
| B      | 156.53     | 1                  | 156.53      | 299.70    | <0.0001              |
| C      | 4938.68    | 1                  | 4938.68     | 9329.50   | <0.0002              |
| D      | 4898.29    | 1                  | 4898.29     | 9435.23   | <0.0002              |
| AB     | 0.064      | 1                  | 0.064       | 0.3       | 0.7347               |
| AC     | 0.050      | 1                  | 0.050       | 0.078     | 0.7962               |
| AD     | 0.013      | 1                  | 0.013       | 0.024     | 0.8813               |
| BC     | 15.99      | 1                  | 15.99       | 29.86     | 0.0003               |
| BD     | 11.38      | 1                  | 11.38       | 20.98     | 0.0009               |
| CD     | 405.01     | 1                  | 405.01      | 781.29    | <0.0002              |
| $A^2$  | 5.97       | 1                  | 4.97        | 8.56      | 0.0095               |
| $B^2$  | 5.09       | 1                  | 4.09        | 8.86      | 0.0162               |
| $C^2$  | 0.79       | 1                  | 0.79        | 1.50      | 0.2458               |
| $D^2$  | 0.28       | 1                  | 0.28        | 0.56      | 0.4730               |
| Residual | 7.24     | 12                 | 0.53        |           |                      |
| Lack of fit | 5.59   | 10                 | 0.47        | 0.61      | 0.7846               |
| Error  | 1.66       | 2                  | 0.83        |           |                      |
| Total  | 10345.60   | 26                 |            |           |                      |

Figure 5: Mechanism of tool wear in AA 2618, AA 2618/ZrC composite, and AA2618/ZrC/RHA hybrid composite.

Table 9: Optimization goal and input ranges.

| Inputs  | Goal         | Minimum limit | Maximum limit | Significance |
|---------|--------------|---------------|---------------|-------------|
| A       | In limit     | 0             | 20            | 10          |
| B       | In limit     | 190           | 230           | 5           |
| C       | In limit     | 0.2           | 0.6           | 5           |
| D       | In limit     | 1             | 2             | 5           |
| Roughness | Min     | 0.56          | 1.2           | 5           |
| Tool wear | Min     | 5             | 25            | 5           |
| MRR     | Min         | 10            | 89.9          | 5           |
input values, we were able to achieve the desired results of 0.612 m SR, 6.725 m TW, and 89.23 g/min mass removal rate.

### 7. Conclusion

The stir casting process was used to succeed in making the AA2618-zirconium carbide-rice husk ash hybrid compound. The bulk hardness of the hybrid composite was used to evaluate its mechanical and machining properties. The trials and RSM led to the following conclusions:

(i) As the weight percent of reinforcement rises, so does the hardness. AA 2618-10wt% zirconium carbide –10wt% rice husk ash composite had the maximum hardness value. Pure AA 2618 has a 72% greater concentration. For this reason, hardness has been improved by adding a ceramic phase to AA 2618.

(ii) Surface roughness and MRR are strongly influenced by the feed rate. The weight percent of reinforcement is believed to be the least influencing component for MRR, while speed is the greatest affecting factor for TW.

(iii) Optimization parameters were 0% reinforcement, 199.85 km/h, 0.29 mm/rev, and 1.5 millimeter of depth of cut, which were recorded.

### Data Availability

The data used to support the findings of this study are included in the article. Further datasets or information are available from the corresponding author upon request.

### Conflicts of Interest

The authors declare that they have no conflicts of interest.

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