

Research Article

Experimental Investigation on Metal Matrix Nanocomposite: Aluminium Alloy 6061 and 7075 with SiC and Fly Ash

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Aluminium metal matrix nanocomposites (AMMNCs) have been recognized as a promising material with excellent structural and functional characteristics that can be suggestively personalized to satisfy industrial demands as well as design requirements for a wide range of applications, including those in defense, marine, automobiles, and aerospace. Particularly, these industries are using an increasing number of components manufactured by AMMNCs. When compared to monolithic materials, components manufactured from aluminium-based composites have better qualities such as tribological behaviors, hardness, stiffness, strength, and higher strength to weight ratio. Therefore, this article addresses the experimental investigation on aluminium-based metal matrix nanocomposites (MMNCs) with silicon carbide (SiC) and fly ash (FA) as a reinforcement material with distinct ratios. Here aluminium alloy 6061 and 7075, hereafter referred as AA6061 and AA7075, are considered as base material. The final workpieces obtained using the process of stir casting and machining are tested to compute the output response parameters like yield strength (YS), wear rate (WR), hardness, impact strength (IS), and ultimate tensile strength (UTS). In addition, the scanning electron microscopy (SEM) images also studied for examining the distribution of reinforcement material particles in base metal.

1. Introduction

As a result of the presence of reinforced parts, metal matrix composites (MMC) [1] are very advantageous, when it comes to achieving higher mechanical and wear qualities. The MMC has more extensive qualities in connection with the enormous significance. In comparison to these MMCs, aluminium matrix composites (AMC) [2], attract the most response owing to their high strength, suitable temperature of casting, lightweight, and other features. The goal that drives the development of MMCs is to create materials that combine the benefits of metal matrices with those of

ceramic-reinforced composites. The AMCs are now being put to use in a wide variety of applications [3, 4], some of which include drive shafts, connecting rods, brake rotors, and cylinder liners in automobiles. The superior strength-to-weight ratio of AMCs makes it possible for them to find widespread use in aircraft engineering. The increasing demand, particularly in the aerospace industry, gives intensity to the continuous exploration for the opportunities of improving the useful properties [5], with the tribological ones, in direction to learn new information about the mechanisms and instruments of wear and tear and the functioning possibilities of mechanism parts through the use of

composites. MMCs can make use of a wide range of metals and their alloys, but aluminium alloys [6] have found widespread application in the military, the transportation sector, and the aerospace industry due to their thermal conductivities, higher electric, high resistance to corrosion, low density, superior strength, and improved wear resistances, fatigue, and flaw.

Aluminum is the predominant component in the composition of Al alloys and Cu, Magnesium, Silicon, Manganese, Nickel, Lead, Tin, Zinc, and Cr are the primary alloying elements [7, 8]. Aluminum is favored more than other metals due to its low weight, yet it is not possible to provide all of the necessary strength with aluminium alone. As a consequence of this, several reinforcing materials like Al_2O_3 , SiC, Si₃N₄, B₄C, and others are added in order to increase the material's strength and tribological qualities [9]. When choosing an alloy for a certain application, it is important to take into account factors like as the application's UTS, ductility, density, workability, wear resistance, and corrosion resistance, among other factors. In the field of engineering, one of the most important variables that goes into deciding the final qualities is the process of making composites [10]. Dispensation, in general, refers to the process of introducing reinforcement into a metal matrix while maintaining a uniform distribution of the reinforcement throughout the matrix.

1.1. Objective. Studying the UTS behavior of AA6061 and AA7075-SiC/FA MMC of aluminium alloy of grade LM6 with addition of changing percentage composition of SiC particles and FA generated by stir casting process is the challenge that has to be solved. The alloys in question are AA6061 and AA7075. Additionally, the UTS, YS, IS, hardness, and wear-like mechanical characteristics will be taken into account throughout this process. For the purpose of accomplishing the aforementioned goals, an experimental setup is built, in which all of the essential inputs are accounted. The purpose of the experiment is to investigate the influence that a change in the percentage composition will have on the ability to anticipate the MMCs' innate mechanical characteristics.

(i) To make an AMC material that is efficient in terms of cost by employing stir casting to combine FA and Al-Si alloy with matrix particles like SiC as a reinforced phase

(ii) To conduct an examination of the material's microstructural features after it has been cast

(iii) The measures of the prepared AMCs are referred to as UTS, YS, IS, WR, and hardness

This article is organized as follows: section 2 deals with the related work. Section 3 deals with the materials and methods used, section 4 deals with the experimental investigation, and section 5 concludes the article followed by references.

2. Related Work

This section deals with the detailed review analysis of MMCs with respect to the volume percentage, size, type, and forms of reinforcement. In addition, the survey also focused on

AMCs, with recent developments [11]. Recently, different types of alloys such as A356, AA7000, 6000, 2000 are widely used in AMCs by considering different reinforcement types such as C, AlN, Al₂O₃, B₄C, and SiC. Further, morphologies platelets, long fibres, short fibres, and particulates are also considered in the reinforcement. The large composite systems [12] were created by combining these reinforcements with a variety of matrices in the appropriate proportions. In addition, a wide variety of processing methods [13], including hot extrusion, squeeze casting, stir casting, and powder metallurgy were used for better performance.

In [14], authors introduced the aluminium alloy (AA6061) matrix composite. The stir casting technique is used to create the hybrid aluminum-based MMNC samples as the process of carrying out the reinforcing element progresses. Microstructure and hardness characteristics are investigated in samples of manufactured MMNC based on aluminium. In [15], authors used the aluminum-8006 alloy, which is a member of the family of aluminium that is wrought and is characterized by its high strength, great resistance to corrosion, and low weight. Forming, welding, and adhesive bonding are all possible with the AA8006 alloy. However, the preferred techniques of welding, such as laser welding, TIG welding (tungsten inert gas welding), and ultrasonic welding, come at a higher cost. In [16], authors considered the friction stir welding and the researchers hope to cut down on the cost of welding without sacrificing the quality of the joints that are welded. Zirconia, a reinforcing agent that is compatible with aluminium alloys, it is used as particles during the welding process in order to increase the performance of the recently discovered AA8006 alloy. In [17], authors focused on optimization of process meters; the number of samples that need to be characterized in order to optimize the process parameters will be reduced. The welded samples were included in the corrosion testing to confirm that the welding process did not introduce any outside materials that are corrosive and that no external corrosive elements were introduced.

In [18], authors conducted the pin-on-disc wear test, which was used in order to determine how well eutectic Al-7075-CNT-Gr composites performed when subjected to dry sliding wear. According to the findings, the friction and wear coefficients both steadily decreased as the weight percent of graphite components increased. When the sliding speed was raised from 1 m/s to 2 m/s at 49 N, the composite showed a considerable improvement in its resistance to wear. In [19], authors changed the loads in pin-on-disc wear test, which did not change throughout this testing. When compared to 7075-7.5 wt percent Gr amalgamated, which had a much higher coefficient of friction (COF), the sliding speed was raised from 1 m/s to 2 m/s while the force was held constant at 49 N. Following the results of the test, the researchers investigated the factors that led to the worn surfaces of the specimens. In [20] authors conducted the wear test, the layer of oxides and iron that had been mechanically mixed together served as an efficient tribolayer, which increased the wear resistance even when subjected to extraordinary sliding speeds. In [21], authors investigated the impact that Al₂O₃ reinforcement has on the dry sliding

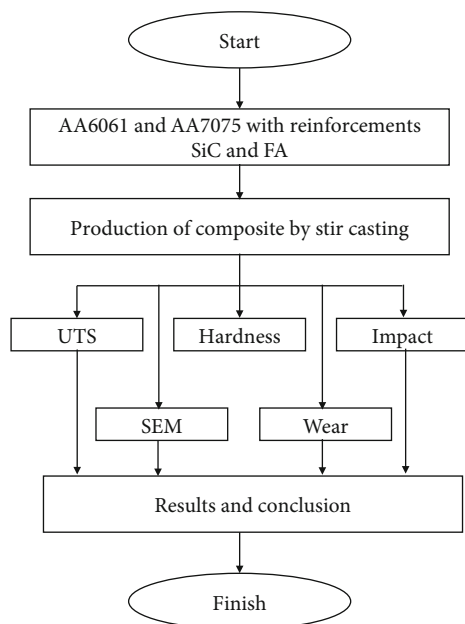


FIGURE 1: Proposed work flowchart.

performance of AA8011 matrix composites for braking applications. The stir casting process was used in the production of the AA8011 matrix composite. In [22], authors considered the different compositions include AA8011, AA8011 with a weight percentage of 4 weight percent Al₂O₃, AA8011 with a weight percentage of 8 weight percent Al₂O₃, and AA8011 with a weight percentage of 12 weight percent Al₂O₃ for effective stir casting process. Here, SEM was used in order to investigate the Al₂O₃ particle dispersion inside the AA8011 matrix. In [23], authors focused mechanical characteristics improvement of stir casting process, which were shown to be greater on AA8011 composites that included 8 weight percent Al₂O₃. Hence a wear test was performed on an AA8011–8 weight percent Al₂O₃ composite with varying values for the process parameters load, disc velocity, and distance. However, this method resulted in poor process parameters. In [24], authors performed the experiments using a L9 orthogonal array as a demonstration. The outcomes were improved with the use of Grey Relational Analysis (GRA). Through GRA, the optimal process parameters that would lead to the lowest possible WR and COF were determined. Here, load was the factor that had the greatest impact on both the COF and the wear resistance. In [25], authors adopted powder metallurgy, which is used to create an AMCs with reinforcement consisting of a ten percent by weight percentage of SiC in this article. It is important to take into account the process parameters, which include the compaction pressure (100-130 MPa), sintering temperature (300-600°C), and sintering duration (120-300 minutes). However, this method consumes the more processing time. In [26], authors used the principal component analysis method, which is applied in order to determine the important and optimal factors that contribute to the composite's preferred qualities in AMCs stir casting process. In [27], authors analyzed the composite's micro-

TABLE 1: Composition of AA6061 and AA7075 by weight percentage.

Alloy	AA6061	AA7075
Elements	% of weight	% of weight
Copper	0.4	0.2
Silicon	0.8	0.4
Aluminium	96.35	90
Manganese	0.15	0.3
Magnesium	1.2	2.4
Titanium	0.15	0.2
Zinc	0.25	6
Iron	0.7	0.5

TABLE 2: Properties of SiC.

Parameter	SiC (in Wt%)
Melting point (°C)	2200
Density (g/cm ³)	3.2
UTS (MPa)	240
Hardness (Moh's scale)	9-9.5
CS (MPa)	1395
Fracture toughness (MPa-m ^{1/2})	4.6

TABLE 3: Properties of FA.

Parameters	FA
Moisture content	2%
Density	2.17 g/cm ³
Specific gravity	1.66-2.55
Color	Grey
Bulk density	1.26 g/cm ³
pH	6.0-10.0
Particle shape	Spherical/irregular



FIGURE 2: Stir casting setup.

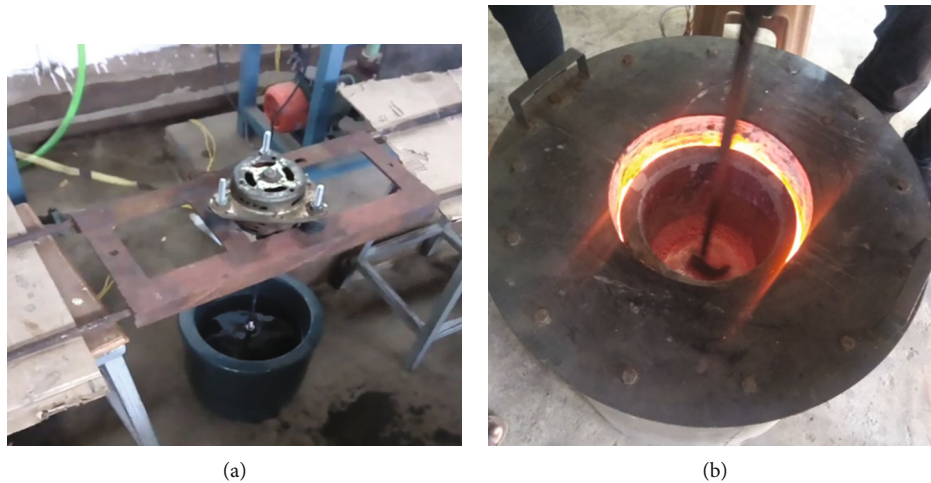


FIGURE 3: Stir casting process. (a) Setup of stirrer. (b) Mixing.

structure, in order to provide an explanation for the development of the mechanical properties. Based on the findings, it was determined that the composite that included 10 percent FA exhibited the highest level of increased qualities when compared to the other composites.

In [28], authors performed the experimental investigation using Al–Mg–Si–T6 with 5 percent FA, which was used for stir cast to include boron carbide particles in three distinct fractions: 2.5 percent, 5 percent, and 7.5 percent, respectively. These percentages were used because each fraction was used to strengthen the FA in a different way. In [29] authors developed the AMCs, which is manufactured using an advanced technology known as bottom pouring stir casting (BPSC) [30]. It is a vacuum-sealed bottom pouring technique and it has been discovered that the sintering temperature, which may range from 300 to 600 degrees Celsius. Further, it is a critical parameter that influences the characteristics of AMCs.

2.1. Gaps Found from Literature. In the course of doing the research for the current study, an exhaustive literature analysis was carried out. This review revealed that a great deal of effort has been documented to improve the characteristics of AMCs by using stir casting or any other procedure. The many kinds of research that have been carried out by various researchers may be grouped together into the following general categories:

(i) It has been claimed that only a very little amount of study has been done to elucidate the variables that impact the mechanical characteristics of AMCs like UTS and IS

(ii) There has been a very limited amount of research done on the combined influence of FA and silicon on the characteristics of AMCs

2.2. Methodology. Figure 1 shows the flowchart of proposed workflow. Here, workpiece is fabricated by considering AA6061 and AA7075 as major alloys with SiC and FA as reinforced materials. In addition, two combinations of materials are formed using AA6061 and AA7075 composites with

stir casting process to perform the production of composites. The stir casting technique is rapidly becoming one of the most popular and cost-effective methods for manufacturing MMCs. In general, casting allows the manufacturer to get the required attribute in their product (composites can be prepared). Because the molten metal is agitated so thoroughly, the cast product will have an excellent surface finish because the gas bubbles will be eliminated. After machining the workpieces, multiple tests such as tensile, hardness, impact, and wear are performed to identify the mechanical and tribological properties of prepared workpiece. Further, SEM also performed to know the SiC and FA particles propagation in AA. The results show that the fabricated workpiece resulted in superior processing parameters as compared to conventional AMC combinations.

3. Materials and Methods

In this section, the components (of the composites that are going to be manufactured) are broken down in terms of their features, qualities, concentration range, and other relevant information that will be utilized in the proposed task.

3.1. Matrix Material (AA6061 and AA7075). AA6061 is a heat-treatable alloy that has a strength greater than that of 6005A. It ranges from medium to high strength. Zinc is the principal ingredient used in the production of the AA7075, which is an aluminium alloy. It has a strength that is equivalent to that of many steels, as well as excellent fatigue strength and an average ability to be machined. Table 1 presents the composition of AA6061 and AA7075 by weight percentage for different elements. Both aluminium alloys are fabricated by using Copper, Silicon, Aluminium, Manganese, Magnesium, Titanium, Zinc, and Iron elements with diverse weight percentages.

3.2. Reinforcement (SiC and FA). The only other chemical substance that contains both carbon and silicon is called as SiC. Silicon and carbon were first reacted electrochemically



FIGURE 4: Work pieces. (a) Casting work pieces. (b) Process of machining. (c) Final specimens of different composition.

at a high temperature in order to make it in the beginning. In addition, FA is being utilized in the building of highways and embankments, although with a few design modifications.

Additionally, the IS property is employed as a raw material in a variety of different development initiatives, including agricultural and waste land. Thus, impact test is better to perform to identify the reinforcement quality of SiC and FA. Thus, the performance of percentage of weight levels is purely depending on their properties. Table 2 presents different properties such as melting point ($^{\circ}\text{C}$), density (g/cm^3), UTS (MPa), hardness (Moh's scale), compressive strength (CS) (MPa), fracture toughness ($\text{MPa}\cdot\text{m}^{1/2}$) of SiC. Similarly, Table 3 presents the moisture content, density, specific gravity, color, bulk density, pH, and particle shape properties of FA.

3.2.1. Significance of FA. FA is recognized as an environmentally friendly material, and it has lower embodied energy. In addition, it requires less water and is easier to use in cold weather as well. Other significant profits of FA include the following:

- (i) Reduces crack problems, permeability, and bleeding
- (ii) Reduces heat of hydration



FIGURE 5: Setup for computing UTS.

TABLE 4: UTS results of AA7075 reinforced with SiC and FA.

S. no.	Samples	SiC			FA		
		YS(N/mm ²)	UTS(N/mm ²)	Elongation (%)	YS (N/mm ²)	UTS(N/mm ²)	Elongation (%)
1	AA7075	80.88	170	8	50.88	160	9
2	AA7075 + 5%	90.02	255	6.3	60	212	7.5
3	AA7075 + 10%	126.42	276	4.9	80	250	5.5
4	AA7075 + 15%	150.09	320	2.9	100	275	3.8

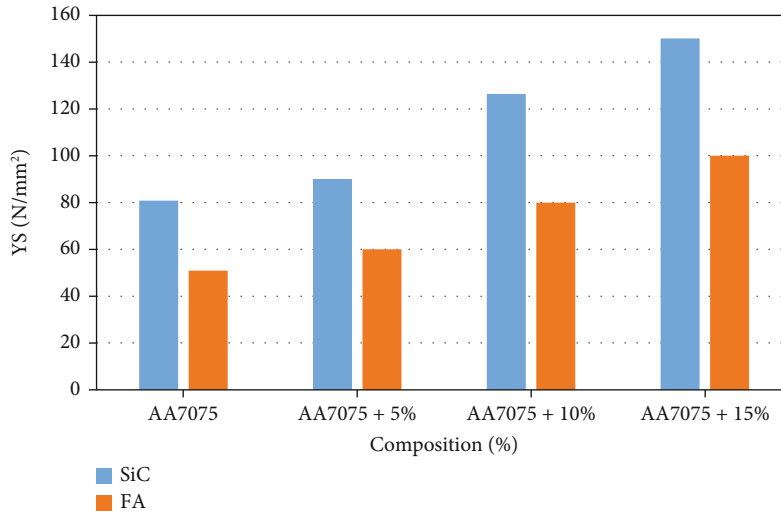


FIGURE 6: YS comparison for AA60661 wt. % variation with SiC and FA composition.

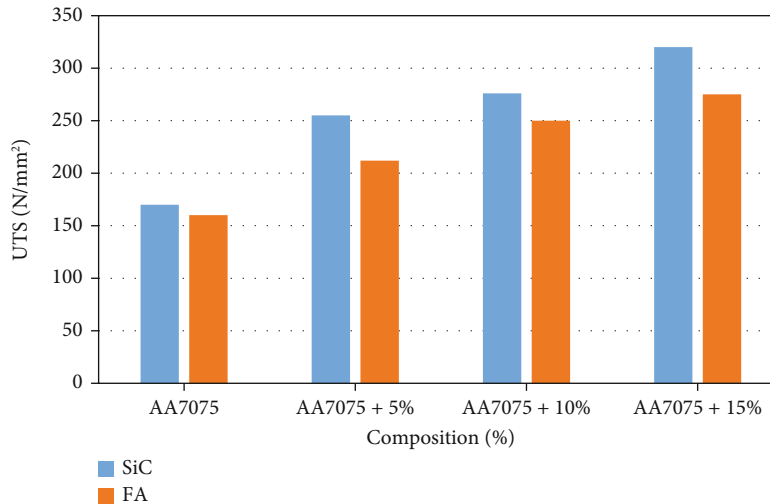


FIGURE 7: UTS comparison for AA60661 wt. % variation with SiC and FA composition.

- (iii) Reduces CO₂ emissions
- (iv) High strength gains, depending on use
- (v) Considered a non-shrink material
- (vi) Great workability

3.3. *Composite Fabrication.* The particle size and shape of the FA and the SiC are clearly visible, and it can be seen that

the FA flakes and the SiC are almost identical in size. Furthermore, the FA and the SiC both have quasi-cubic and polyhedral sizes, both of which have been found to improve the properties of the composite materials that are synthesized through the process of stir casting. Because of the shape of the particles, it is possible to achieve a uniform dispersion of the reinforcement particles, which contributes to

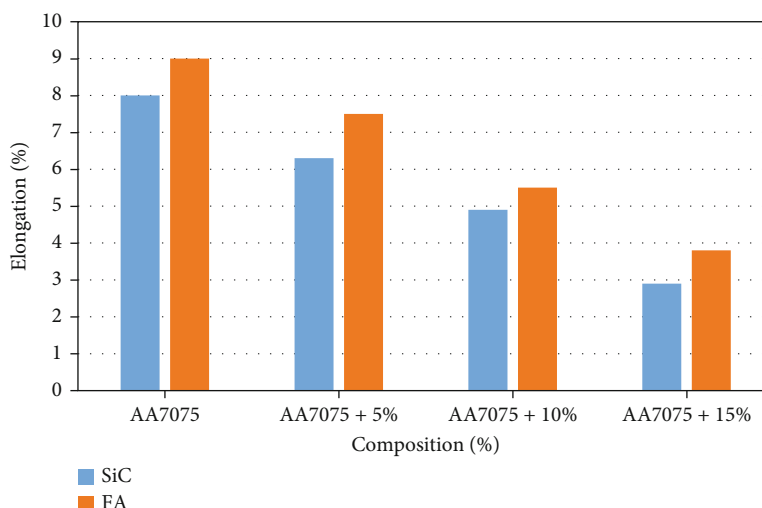


FIGURE 8: Performance comparison of elongation with AA60661 wt. % variation with SiC and FA composition.

the formation of strong bonds. Because of their capacity to produce high-performance composites, AA6061 and AA7075-SiC-FA composites were fabricated by the process of stir casting. The furnace was loaded with the measured quantity of cut pieces of aluminium AA6061 and AA7075, and then the temperature was increased to 770 degrees Celsius. After being warmed to 350 degrees Celsius for two and a half hours, the ash flakes made of FA and SiC were then introduced to the molten metal and stirred using a ceramic coated AISI 316L stirrer for ten minutes at a speed of 600 revolutions per minute. Tablets containing hexachloroethane, also known as C_2Cl_6 , were submerged in the molten metal in order to dislodge the trapped air. After that, the temperature of the molten metal was maintained at 750 degrees Celsius, and then there was a second round of stirring that went on nonstop for a period of ten minutes before the melt was poured into the die that had been prepared. The stir cast composites with varied weight percent of SiC and FA were heated to the following temperatures: 40 degrees Celsius, 80 degrees Celsius, 120 degrees Celsius, 160 degrees Celsius, and 200 degrees Celsius. Figure 2 shows the images that were taken throughout the stir casting process, as well as the images of the pouring of molten metal into the die-set and the cast specimens. The 'T6-grade' heat treatment cycle included two stages: the solution treatment, which was performed at 530°C for a duration of 2 hours; water quenching and ageing at a temperature of 150°C for a duration of 6 hours; and the thermal treatment, which was performed at temperatures of 40°C, 80°C, 120°C, 160°C, and 200°C in an oven made by HeatTek, with time and temperature controls available at university, the dissolution of intermetallic phases are facilitated by this process, which involves solutionizing, ageing, and heat exposure.

4. Experimental Investigation

The metal is melted in a separate furnace, and then a conventional ladle that can hold one kilogram of molten aluminium is used to transport it to the stir casting furnace.

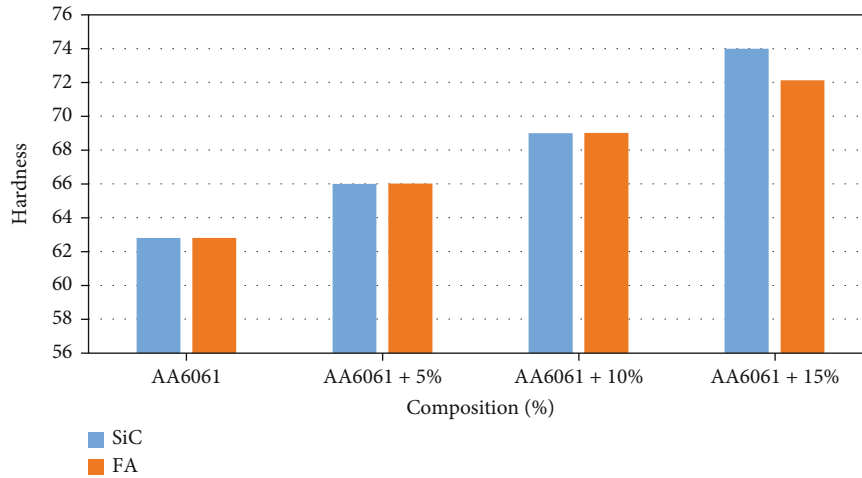


FIGURE 9: Setup for computing hardness test.

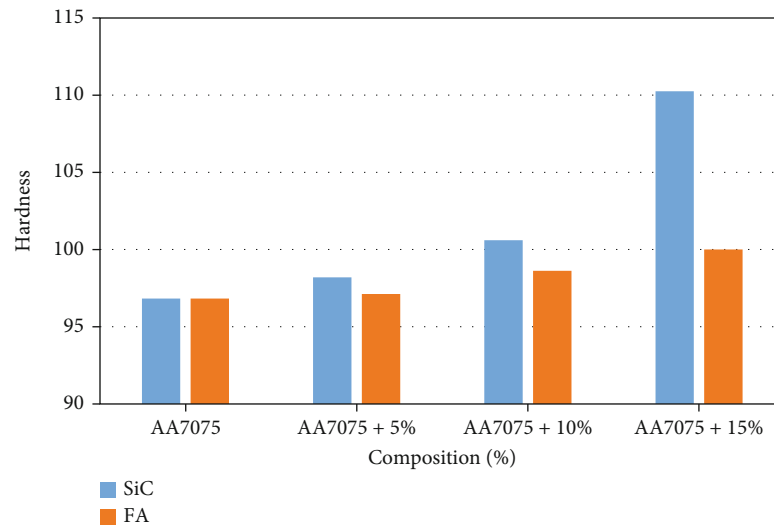
Within the stir casting furnace, the temperature of the metal is kept at 700 degrees Celsius. The aluminium in its molten state is first loaded into the stir casting furnace. SiC at a concentration of 5 percent by weight is weighed and measured independently before being concurrently warmed in separate containers mounted directly on the furnace. After the temperatures within the furnace have stabilized at about

TABLE 5: Hardness test results of AA6061 and AA7075.

S. no.	Wt.%	AA6061		AA7075	
		SiC	FA	SiC	FA
1	0	62.8	62.8	96.83	96.83
2	5%	66	66.02	98.20	97.12
3	10%	69	69.02	100.60	98.62
4	15%	74	72.12	110.25	100



(a)



(b)

FIGURE 10: Hardness test results graphical representation of aluminium alloy wt. % variation with SiC and FA composition. (a) AA6061, (b) AA7075.

700 degrees Celsius, the metal is treated by adding coverall to the molten metal, which eliminates oxides and other impurities from the metal. This process is carried out after the temperatures have reached their maximum. After some time has passed, a stirrer is dropped into the crucible before being let free to revolve and produce a whirlpool. In order to get the proper vortex, the speed of the stirrer may be adjusted using a potentiometer. After the proper speed has

been maintained in the crucible, reinforcements are added gradually to the vortex. Once all of the reinforcements have been introduced, the stirrer is allowed to continue rotating for another ten minutes so that the particulates are distributed evenly. After the metal has been stirred, it is poured using a ladle from the crucible into the hollow of the die, where it is then left to cool and harden for approximately two minutes before being withdrawn from the die. The

residual pieces of metal in the crucible are used in the sample collection process as well. The same technique is performed in order to produce samples of TiB_2 at 5%, 10%, and 15% concentrations, as well as FA at 5%, 10%, and 15% concentrations. All of the samples were organized into groups and labelled according to the types of reinforcements, and then they were sent to the machining process. Figure 3 shows the images of stirrer setup and mixing process during stir casting. It impacts strength possible for the distribution of SiC particles in an Al-SiC composite to have a significant impact on the mechanical properties of the Al-SiC composite. In order to achieve a uniform distribution of SiC particles in stir-casting Al-SiC composite, within this equipment, there are three blades that are uniformly distributed, and each blade has a horizontal tilt angle of 25 degrees. These blades are designed to mechanically raise the SiC particles by creating an upward movement of slurry while electromagnetic stirring. The obtained work pieces from stir casting process is depicted in Figure 4(a). Figure 4(b) shows the machining process. Figure 4(c) shows the final specimens of different composition.

5. Results and Discussion

5.1. Tensile Test Results. In order to evaluate the composites and matrix alloy's response to mechanical stress, tensile tests were carried out. Both the composite and the matrix alloy were machined into tensile specimens, with the length of the former measuring 13.5 mm and the latter measuring 30 mm. Figure 5 illustrate the setup of UTS computation along with YS, and elongation. Table 4 shows the UTS output performance of AA7075 reinforced with SiC and FA. The UTS is the maximum stress that a material can withstand while being stretched or pulled before necking. Necking is the point at which the specimen's cross-section begins to significantly contract.

Figure 6 shows the graphical representation of YS for various AA6061 wt. % reinforced with SiC and FA. Here, the YS should rise as the reinforcement weight percent increases. This may be the result of the dispersion of silica carbide and FA, both of which act as a barrier to the motion of dislocation. So, IS is necessary to apply a greater stress in order to shift this flaw, which involves plastically deforming or yielding the material. Further, the AA6061 with 15% of composition holds better YS as compared to other wt.% compositions. Figure 7 shows the graphical representation of UTS for various AA6061 wt. % reinforced with SiC and FA.

The findings suggest that the reinforcement wt.% of UTS will likewise grow as the reinforcement amount increases. This phenomenon may be caused by the dispersion of SiC and FA, both of which act as a barrier to the mobility of dislocations. In addition, the AA6061 with 15% of composition holds better UTS as compared to other wt.% compositions. Figure 8 shows the elongation performance comparison for various AA6061 wt.% reinforced with SiC and FA. The findings indicate that elongation is decreased as the weight percent of SiC and FA rises. This is because of an increase in UTS, which leads to a loss in elongation.



FIGURE 11: Machinery used for Impact test.

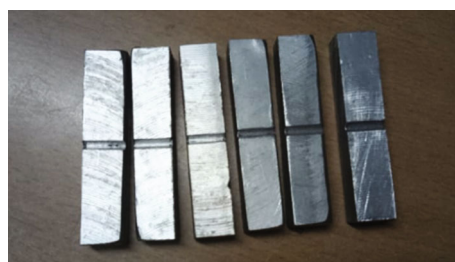
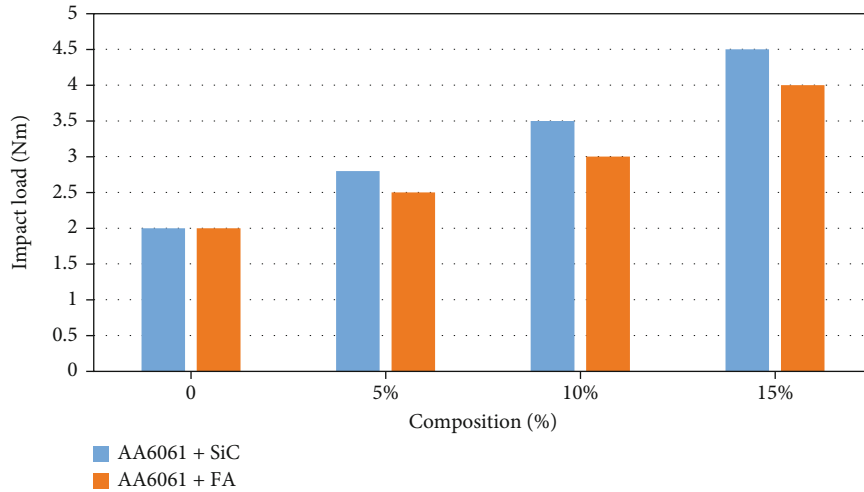


FIGURE 12: Specimens after impact test.

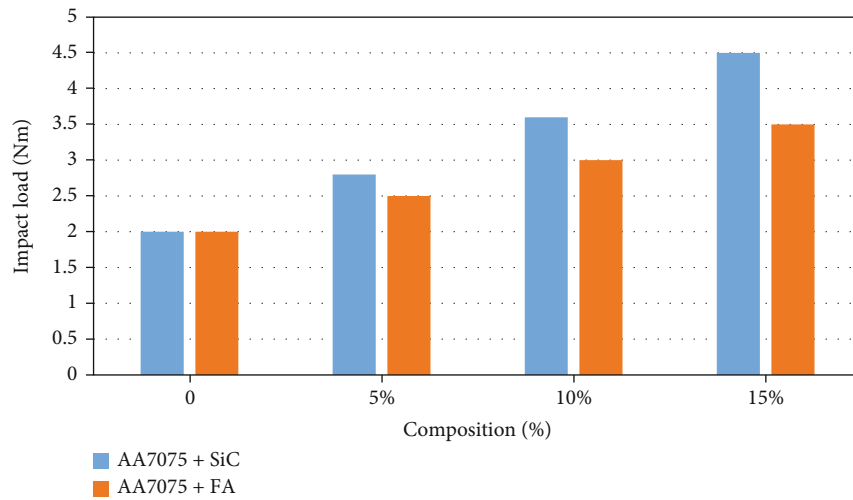
TABLE 6: IS results of AA6061 and AA7075 reinforced with SiC, FA.

S. no.	Wt.%	AA6061		AA7075	
		SiC	FA	SiC	FA
1	0	2	2	2	2
2	5%	2.8	2.5	2.8	2.5
3	10%	3.5	3	3.6	3
4	15%	4.5	4	4.5	3.5

5.2. Hardness Test Results. A Rockwell hardness tester machine that measures IS (shown in Figure 9), which is used for the purpose of carrying out the measurement of the hardness. Emery paper with grit sizes of 100, 220, 400, 600, and 1000 was used in order to provide the metallographic finish that was necessary for the surface that was being evaluated. The load that was employed on the Rockwell hardness testing was 200g, and the dwell duration for each sample was 20 seconds. Table 5 displays the results of Rockwell's hardness test on a AA6061, AA7075 without any reinforcement (Sample No. 1) as well as the wt.% variation of many alternative reinforcements, including SiC/FA and Al alloy LM6 (Sample Nos. 2-4).



(a)



(b)

FIGURE 13: Impact load test results graphical representation of aluminium alloy wt. % variation with SiC and FA composition. (a) AA6061, (b) AA7075.

Figure 10 represents the graphical representation of Table 5. Here, the AA6061 and AA7075 have seen an improvement in their resistance to deformation because to the addition of SiC and FA as reinforcement. The AA6061, AA7075 with 15% of FA and SiC composition resulted in better performance as compared to other reinforcement combinations.

5.3. Impact Test Results. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test that assesses the amount of energy that is absorbed by a material during the process of fracture. Figure 11 disclose the machinery used for IS test and the specimens after the impact test are demonstrated in Figure 12, where Charpy V-notch is clearly visible. This amount of energy is used as a measurement of toughness of certain material.

Table 6 presents the results of ISofAA6061 and AA7075 reinforced with SiC, FA. Here, without any reinforcement is presented in sample No. 1, as well as the wt.% variation of many alternative reinforcements, including SiC/FA and Al

TABLE 7: WR results of AA7075 reinforced with SiC, FA.

S.no.	Load	Wt.% for AA7075 + SiC			Wt.% for AA7075 + FA		
		5%	10%	15%	5%	10%	15%
1	20	0	0	0	0.5	0.65	0.7
2	40	1	2	3	0.3	0.7	0.8
3	60	0.5	1	1.5	0.2	0.3	0.5
4	80	1	2	3	0.1	0.215	0.315
5	100	3	4	5	0.05	0.105	0.2

alloy LM6 are presented in Sample Nos. 2-4. Further, AA6061, AA7075 with 15% of FA and SiC composition resulted in better IS performance as compared to other reinforcement combinations. This is because SiC and FA were properly dispersed throughout the matrix, or because of the strong interfacial bonding that occurred between the Al alloys 6061 and 7075 and the SiC and FA interfaces.

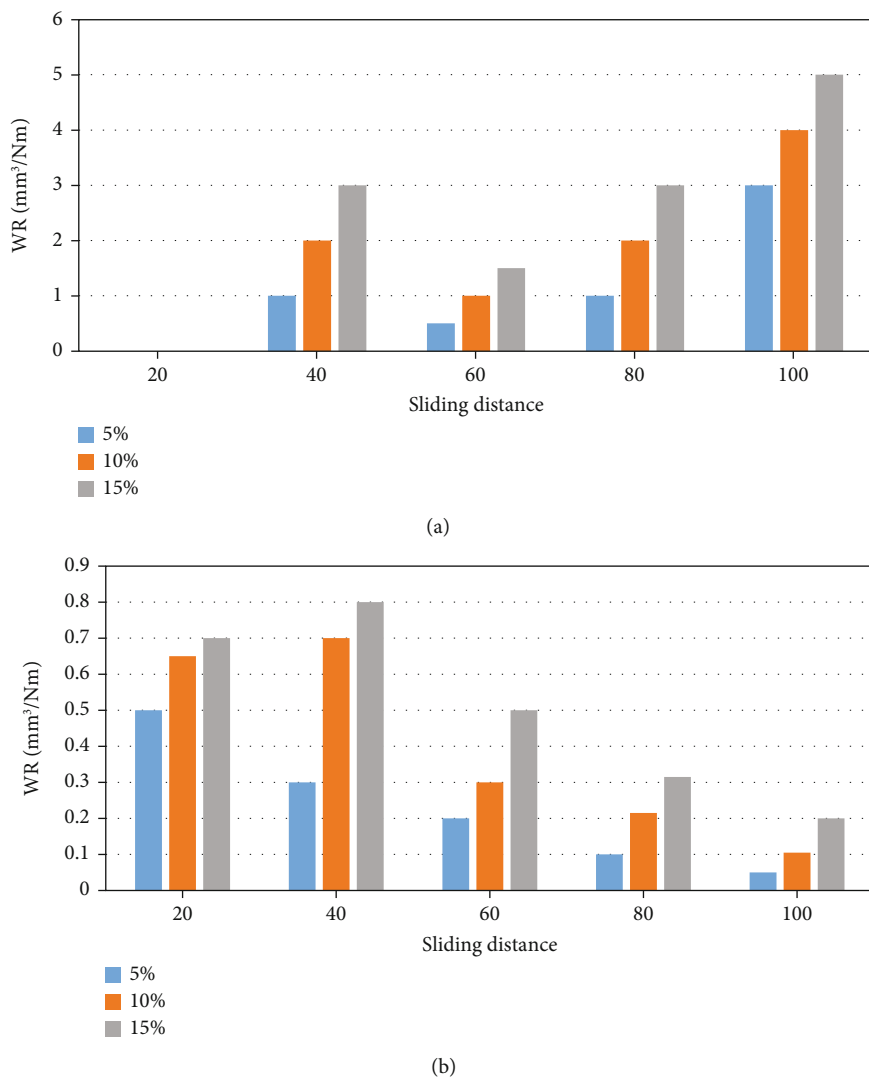


FIGURE 14: WR results graphical representation of AA7075 w.r.t sliding distance (a) SiC reinforcement. (b) FA reinforcement.

Figure 13 presents the graphical representation of table 6 and it is seen that the IS of the composite improves in relation to the base metal as the amount of SiC and FA increases.

5.4. Wear Test Results. Table 7 presents WR results of AA7075 reinforced with SiC, FA for three weight ratios. Here, the WR is decreases for FA reinforcement with an increase in the sliding distance. Additionally, the WR rises for SiC reinforcement in proportion to the increase in sliding distance.

Figure 14(a) shows that the WR varies with sliding distance for three different weight ratios of FA, when the speed is set to 200 rpm. The WR of the composite material is lowering as a result of the addition of red silicon particles. Figure 14(b) shows that the WR varies with sliding distance for three different weight ratios of SiC (5%, 10%, and 15%) when the speed is set to 200 rpm. The WR of the composite is growing as a result of the addition of supplied silicon particles.

5.5. Results of SEM. SEM is a powerful analytical approach for performing an analysis on broad range of materials, at high magnifications, and to produce high resolution images. It depends on the detection of high energy electrons emitted from the workpiece surface after being exposed to a highly focused beam of electrons from an electron gun. This beam of electrons is focused to a small spot on the sample surface, using the SEM objective lens. Variables like the accelerating voltage, aperture size and the distance between the sample and electron gun can be optimized to achieve the best quality images. The microphotographs of Cast AA7075-SiC and FA composites are exhibited in Figure 15.

The distributions of reinforcements in each respective matrix are somewhat consistent with one another for higher reinforcements of composition. In addition, the uniformity of the cast composites is found in SEM images as fractures visible in the microstructure. The higher filler contents in the composites are made abundantly visible by the microphotograph.

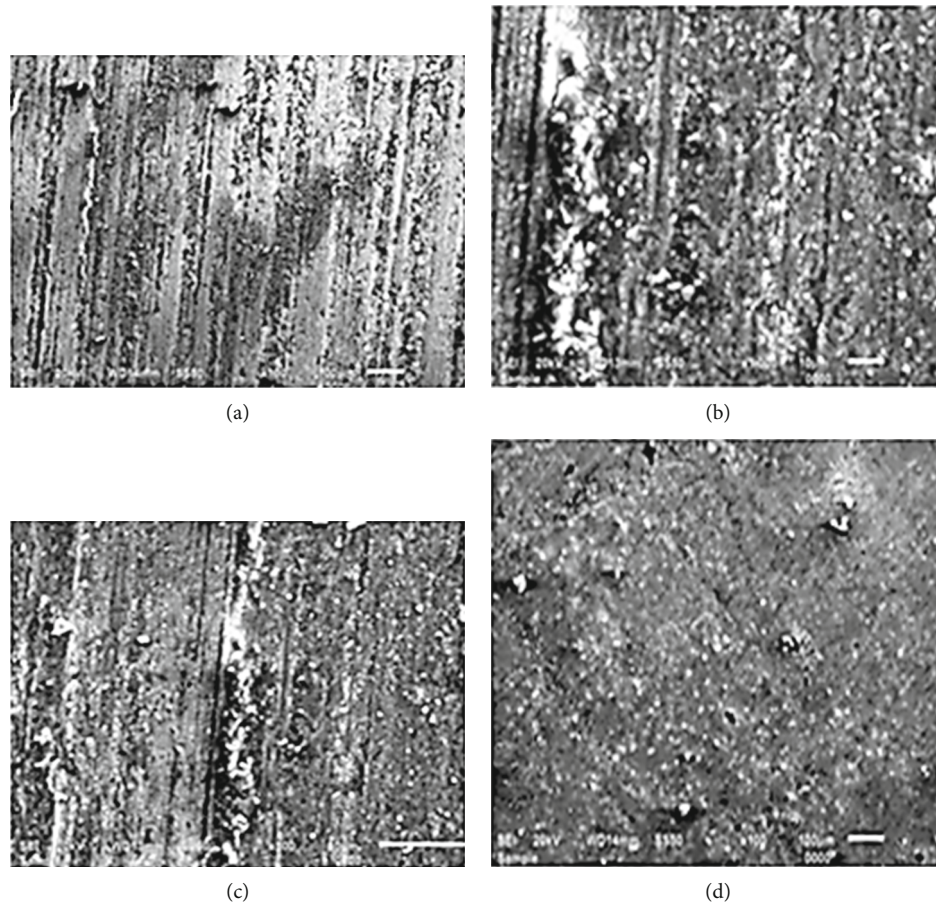


FIGURE 15: SEM Images of AA7075 with SiC different weight ratios, (a) wt. 0%, (b) wt. 5%, (c) wt. 10%, (d) wt. 15%.

6. Conclusions

This article investigated the fabrication and testing of aluminium-based MMNCs with SiC and FA as a reinforcement material with distinct ratios, where AA6061, and AA7075 are considered as base material matrices. Stir casting process is employed for preparing the workpieces and then mechanical properties, tribology properties are computed using YS, WR, hardness, IS, and UTS. Additionally, SEM imaging also produced for examining the distribution of reinforcement material particles in base metal. Finally, several conclusions are drawn from this research work are as follows:

(i) The specimens are successfully manufactured using the process of stir casting with unique propagation of reinforce particles i.e., SiC, and FA

(ii) Obtained outcome proven that the prepared workpiece from AA6061 and AA7075 with SiC, and FA produced enhanced values of output response parameters as equated to base AA

(iii) The hardness of matrix material is enhanced with the propagation of both SiC, and FA particles in AMMCs

(iv) It is observed that values of elongation getting decreased with the increment in the wt. % of particles, which confirms the increment in brittleness with the addition of SiC, and FA

(v) It is noticed that both YS, and UTS are getting increased with the improvement in wt % of SiC, and FA in the matrix while the hardness, and IS are improved after adding the particles of SiC, and FA

(vi) Finally, SEM images are analyzed to find the propagation of SiC, and FA particles in AA6061, and AA7075

Data Availability

The data used to support the findings of this work are included within the article.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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