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ORIGINAL PAPER

Experimental Investigations on Microstructure, Mechanical Behavior and Tribological analysis of AA5154/SiC Composites by Stir Casting

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Abstract

Aluminum metal matrix composites (MMCs) exhibit promising mechanical properties that are potential materials for the aeronautical and automotive industries. In this study, aluminum-magnesium base alloy i.e. 5154 based composites reinforced with silicon carbide (SiC) particles were fabricated by the stir casting process. The mechanical properties such as tensile strength, impact strength, and micro-hardness were evaluated. The microstructural analysis was studied using field emission scanning electron microscopy and X-ray diffraction analysis. With uniform dispersion and good interfacial bonding between the aluminum and silicon carbide, the mechanical properties were found to be enhanced significantly. The 15wt% SiC reinforced composites exhibited a maximum enhancement of 37 % in the hardness, 35 % in the tensile strength. The impact strength was found to be reduced by a maximum of 37 % when compared with the base aluminum alloy showing the loss in ductility. Furthermore, the sliding wear behavior of the SiC reinforced composites was also studied. The wear rate during the test was found to be decreased with sliding distance whereas an increase in the applied load resulted in a higher wear rate. At 2000 m of sliding distance, the wear rate of 15wt% SiC composite was reduced by 51 % as compared to base alloy at an applied load 10 N whereas, at 30 N of applied load, the wear rate was reduced by 66 %. A reduction in the volumetric wear loss of the composites was observed as compared to the base alloy indicating an enhancement in the wear resistance of the composites.

Keywords Silicon carbide · Aluminum 5154 · Wear · Mechanical · Stir casting

1 Introduction

In recent years, there is more interest among researchers in the development of new composite materials for structural applications due to their better performance than monolithic metals and alloys. Aluminum-based metal matrix composite (MMC) materials are primarily used in many engineering applications like aviation, automotive, defense sectors for their combination of properties like high specific strength, stiffness, excellent wear and corrosion properties, lower density, etc. [1, 2]. The nature of the reinforcement has an important role in deciding the overall properties of the composites. The addition of hard ceramic particles in aluminum alloys can enhance the wear resistance of the composites. Moreover, the enhancement in the mechanical behavior depends on homogenous dispersion and interfacial strength between the reinforcement and aluminum matrix. Different types of ceramic particulate such as Al_2O_3, TiC, TiB_2, SiC, B_4C, etc. are used as reinforcement in aluminum MMCs which exhibit superior mechanical and tribological characteristics [3-7]. When compared to the fibers and whiskers, the particulate reinforcement composite gives better performance owing to dispersion and dislocation strengthening mechanisms [8].

In the development of aluminum MMCs, the selection of processing methods is crucial as the expected properties greatly depend on the process attributes. From previous studies, the major shortcomings in choosing composite processing methods are overall fabrication cost, non-uniform distribution, and poor wettability. Considering these issues, stir casting is considered to be the most promising method as it is cost-effective, simple in processing, and is desirable for mass production [9, 10]. In the stir casting method, the aluminum alloy was completely melted to which the reinforcement particles are introduced. Aluminum hybrid composites were fabricated

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with SiC and WC using stir casting process where the mechanical and tribological properties were enhanced as a result of uniform dispersion of the reinforcement particles [11]. Silicon reinforced with Al-Si alloy composites were manufactured by stir casting process where the mechanical and wear properties were found to be enhanced [12]. Similarly, the stir casting process led to an increase in the wear resistance of aluminum composites as a result of homogenous distribution [13]. Moreover, nanoparticles of SiC reinforced aluminum composites were also successfully casted using the stir casting method where it was reported that the nanoparticles were also could be uniformly distributed using the liquid metallurgy route [14].

Aluminum composites with different reinforcements can achieve superior properties which therefore prove to be a potential material for industrial applications. In-situ synthesized SiC reinforced Al-Si alloy composites were fabricated using a multi-step casting method where the tensile strength and wear resistance were enhanced [15]. The improvement in the mechanical and tribological properties of the Al/SiC composite made it suitable for high-temperature applications. Zheng et al. [16] had fabricated the aluminum composite brake material with ceramic waste SiC which exhibited a higher coefficient of friction and a substantially reduced wear rate due to the formation of mechanical mixing layer which protected the plastic flow of the matrix. Aluminum composites considering Al 6061 and A356 alloy reinforced with boron carbide were fabricated using high-speed vortex stir casting [17]. With effective heat dissipation, the aluminum composites were proposed to be a potential material for nuclear waste fuel storage. Wang et al. [18] studied the tribological characteristics of Al/SiC composites where the composites exhibited good chemical bonding and self-lubricating effect, thus enhanced their wear resistance. The effect of SiC particle size and content on the mechanical properties was instigated where the tensile strength was seen to be enhanced with higher SiC content at the loss in ductility, which was due to localized crack initiation [19]. With a larger particle size, the ultimate tensile strength was found to be higher. This was due to the fact that the smaller particles caused agglomerations and larger particles led to more uniform dispersion. Similarly, Smirnov et al. [20] fabricated the Al-Mg alloy composites reinforced with SiC particles where the effect of SiC was found to be significant in deciding the plastic and mechanical behavior under different tensile and compression tests. Singh et al. [21] reported the wear and mechanical study for hypereutectic Al-Si alloy composites reinforced with silicon carbide particles by the stir casting method. The ultimate strength was enhanced by 38 % when compared to the base alloy as a result of uniform dispersion in the aluminum melt. The wear rate was found to be increased with the applied load whereas it remained constant with the variation of the sliding distances. Moreover, Adopting a combination squeeze casting and stir casting process, Zhu et al. [6] fabricated Al 6082 MMCs with considering nano SiC particles. With the homogenous distribution of nanoparticles and subsequent grain refinement, the mechanical strength was found to be improved. Khan and Dixit [22] produced LM13/SiC composites by stir casting route where the addition of SiC particulates led to an improvement in the hardness and wear resistance of the MMCs. Furthermore, the oxidation resistance was seen to be increased both in mining and marine environment.

The focus of this work is to fabricate aluminum MMCs by stir casting route considering AA 5154 alloy matrix with silicon carbide (SiC) as reinforcement particle, which has not yet been studied so far. The microstructural observation is carried out along with the evaluation of the mechanical properties of the composites. The effect of SiC on aluminum composites is thoroughly studied in the context of its mechanical strength comprising of hardness, impact strength, and tensile strength. Apart from the mechanical behavior, the pin-on-disc sliding wear behavior of the aluminum composites with respect to the addition of SiC particles was also investigated in this study. Moreover, an attempt is made to fabricate a light-weight aluminum composite that can be utilized in automotive applications considering its improved tribological properties and mechanical strength.

2 Materials and Methods

In this study, aluminum alloy 5154 was selected as the matrix, which was procured from Nextgen Steel and Alloys, Mumbai, India. The chemical composition of the AA 5154 alloy is illustrated in Table 1. AA 5154 is a non-heat treatable alloy that exhibits high wear and corrosion resistance. With its high corrosion and wear resistance, it is best suited for marine application and friction material in automotive components. Tables 2 and 3 gives the physical and mechanical properties of AA5154 alloy. SiC with 99.9 % purity and average particle size of 20 μm is used as reinforcement material, was procured from Parshwamani Metals, Mumbai, India. The SEM and EDX micrograph of SiC particles is shown in Fig. 1. SiC is an extremely hard ceramic material in which the silicon and carbon atoms are covalently bonded with each other. SiC is a non-oxide engineering material that finds application that involves high wear resistance, long durability, ballistic protection, etc. SiC is also favorable for applications at elevated temperatures as it retains its elastic resistance up to a temperature of 1600°C. The above favorable characteristics of SiC inspire to use it as reinforcement material for composite materials in this study.

The liquid metallurgy process i.e. stir casting was employed to fabricate the AA5154/SiC composites. Initially, 500 g of aluminum alloy block was kept in the graphite crucible and was allowed to melt in the induction furnace. The different weight percentages of SiC i.e. 5 %, 10 %, and 15 % are considered as reinforcement quantity for the composites.

Table 1 Chemical composition of AA5154

Element	Mg	Si	Cr	Fe	Zr	Mn	Ti	Al
Wt.%	3.2	0.86	0.11	0.15	0.02	0.09	0.77	Remainder

The aluminum alloy was heated up to 750°C after which the reinforcement particles of appropriate stoichiometric quantity were added to the molten aluminum. The schematic diagram of the stir casting adopted for this study is presented in Fig. 2. After the addition of the preheated SiC particles, the stirring started with a constant speed of 300 rpm for 15 min. The SiC reinforcement particles are preheated at 400°C in a separate furnace to remove any residues, volatile contents, moisture in it. Meanwhile, the argon gas was supplied to the furnace chamber to avoid any oxide formation with the atmospheric air. A small amount of C_2Cl_6 was also added to remove any dissolved hydrogen gas from the molten melt. For better fluidity and wettability among the molten Al and SiC, 1 % of pure magnesium was added which enhances the bonding by reducing surface energy. After ensuring the SiC particles were properly mixed, the aluminum melt was then transferred into the preheated iron mold for final casting. The iron mold was preheated at a temperature of 300°C to reduce the chilling effect at the time of pouring. Different specimens were machined from the casted product according to their respective dimension. Metallographic specimen were also taken from the casted product to study the microstructure of the MMCs, where the standard procedure was followed for the preparation of the samples. Grit papers of different sizes i.e. 400, 600, 800, 1000, 1200, and 1500 were used for polishing the composites specimen followed by velvet cloth polishing with alumina suspension. The Keller's reagent (2.5 % HNO_3 + 1.5 % HCl + 1 % HF + 95 % of distilled water) was used as etchant for the microstructure study. The etched specimen were examined by field emission scanning electron microscope for further metallographic study.

The microhardness of Al/SiC MMCs was evaluated by OMNITECH Vickers hardness tester (semi-automatic) with a load of 500 g and a dwell time of 10 s [23]. To avoid any irregularity surface and agglomerations on the test zone on the composites, we have considered five different locations for hardness testing on each specimen from which the average value was considered as the final hardness value for different weight % of the composites. To determine the impact strength of the MMCs, the specimens were prepared according to ASTM E23 standard (55 mm × 10 mm × 10 mm) with a center V-notch of 45°, and are subjected to Charpy Impact tester (Tinius Olsen Model 104). Moreover, Universal testing machine (TUE-C-200) was employed to study the tensile properties of the MMCs. The tensile specimens were prepared according to ASTM E8M standard with a gauge length of 25 mm and width of 6 mm under ambient temperature. Three numbers of samples were taken for each weight % of SiC for the tensile test and the average value was considered as the final value. Similarly, the DUCOM TR-201 pin on disk tribometer was used to study the wear behavior of the composites. An illustration of the pin on disc tribometer is shown in Fig. 3. For this, rectangular specimens were machined from the casted product as per ASTM G99-04 standard having a dimension of 30 mm × 6 mm × 6 mm. To avoid any undesirable element on the surface, the pins were cleansed with acetone and polished before the wear testing. The counter disc is made of EN31 hardened steel which is properly cleaned before beginning the experiments. The height loss of the specimen due to the sliding wear is continuously displayed on the tribometer. By multiplying the height loss during the sliding with the cross-sectional area of the specimen, we can calculate the volumetric wear loss. The ratio of the volumetric wear loss to the sliding distance provides the wear rate for the study. Similarly, the frictional force generated during the sliding action is recorded continuously by the tribometer. The coefficient of friction can be calculated by the ratio of the tangential friction force to the normal applied load to the composite specimen.

Table 2 Physical and mechanical properties of AA5154 alloy

Properties	Value
Density	2.66 g/cm^3
Tensile (yield) strength	240 MPa
Elastic modulus	70–80 GPa
Hardness	85 HV
Thermal conductivity	127 W/m.K
Thermal expansion	23.9×10^{-6}/°C
Melting temperature	607–649°C

Table 3 Physical properties of SiC

Properties	Value
Density	3.20 g/cm^3
Elastic modulus	410 GPa
Hardness	2800 kg/mm^2
Thermal conductivity	120 W/m.K
Thermal expansion	4×10^{-6}/°C
Structure	Hexagonal
Melting temperature	2200–2700°C

3 Results and Discussion

3.1 Morphological Analysis

The SEM micrographs of the casted Al/SiC composites specimen are shown in Fig. 4 for different weight percentages of

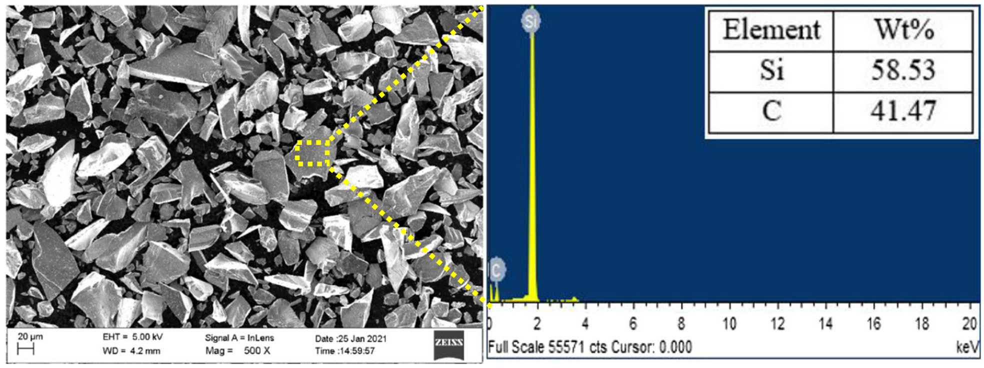


Fig. 1 SEM and EDX micrographs of SiC particles

SiC. It is evident from the SEM images that the SiC particles are homogeneously distributed throughout the matrix in the composites. The uniform distribution of SiC was mainly attributed to optimum mechanical stirring in the melt. It is crucial for the uniform dispersion of reinforcement particles towards the enhancement of mechanical and tribological properties of the composites [24]. Moreover, the composites were free from any casting defects which also established good bonding between the matrix and reinforcement interface. Furthermore, it is confirmed from the SEM spectra in Fig. 4a, b, c that there is no evidence of cluster or accumulation of SiC particles in the composites even with the higher SiC content, which proved an efficient and successful casting process. The absence of particle agglomeration means there was observed strong particle interface bonding between aluminum and SiC that would enhance the performance evaluation. Figure 5 shows the good interfacial bonding between aluminum and SiC at higher magnification. The presence of SiC and the alloying elements of the AA5154 was also confirmed from the EDX analysis of Al/SiC composites as shown in Fig. 6. The peaks of Si and C which are detected in the EDX spectrum confirmed the elemental presence of SiC particles in the composites. Furthermore, the elemental mapping of the Al/SiC composites is presented in Fig. 7 where the uniform distribution of the reinforcement elements along with the alloying element was clearly illustrated.

XRD patterns of AA5154 composites for different weight percentages of SiC are shown in Fig. 8. Silicon carbide peaks are present in the XRD spectrum confirms the existence of SiC in the composites. It was also observed that the intensity of SiC peaks is found to be gradually increased with the rise in weight % of SiC content. On the other hand, the aluminum peaks were found to be reduced and shifted marginally towards the higher two theta angle. There are not any signs of the formation of any secondary elements which proved the successful casting of the composites. It can only be attained through proper control of casting process parameters reaction temperature, reaction time or holding time, and stirring time of the melt.

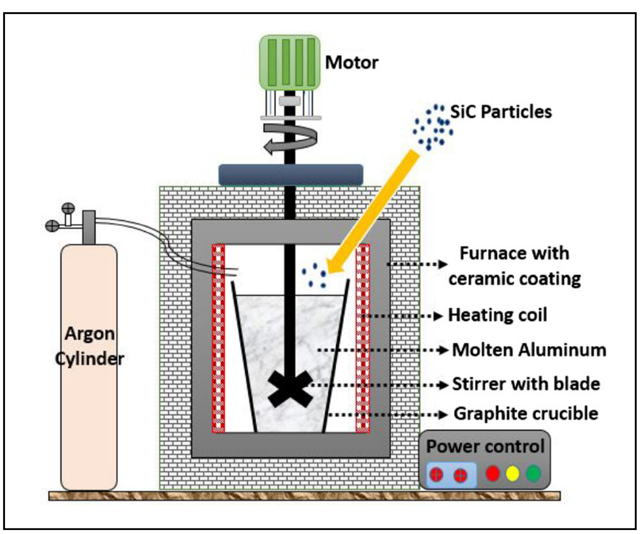


Fig. 2 Schematic diagram of stir casting set up

3.2 Mechanical Behavior

3.2.1 Micro-hardness

Graph showing the variation of microhardness with weight % of SiC in the composites is shown in Fig. 9. From the graph, it was observed that the hardness was seen to be increased with the increase in the weight % of SiC. Compared to the base alloy, the 15 wt% SiC reinforced composites witnessed a 37 % increase in the microhardness as shown in Fig. 9. The

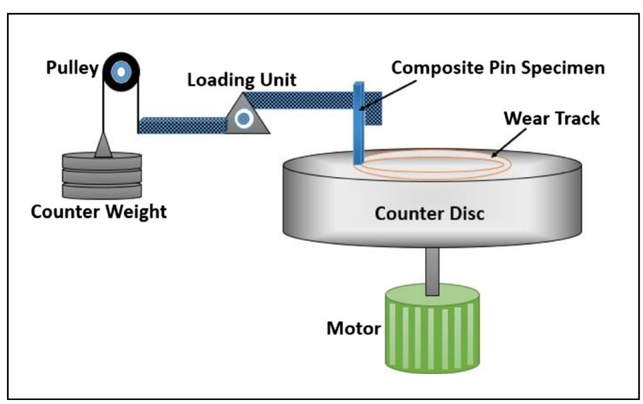


Fig. 3 Illustration of the pin on disc tribometer

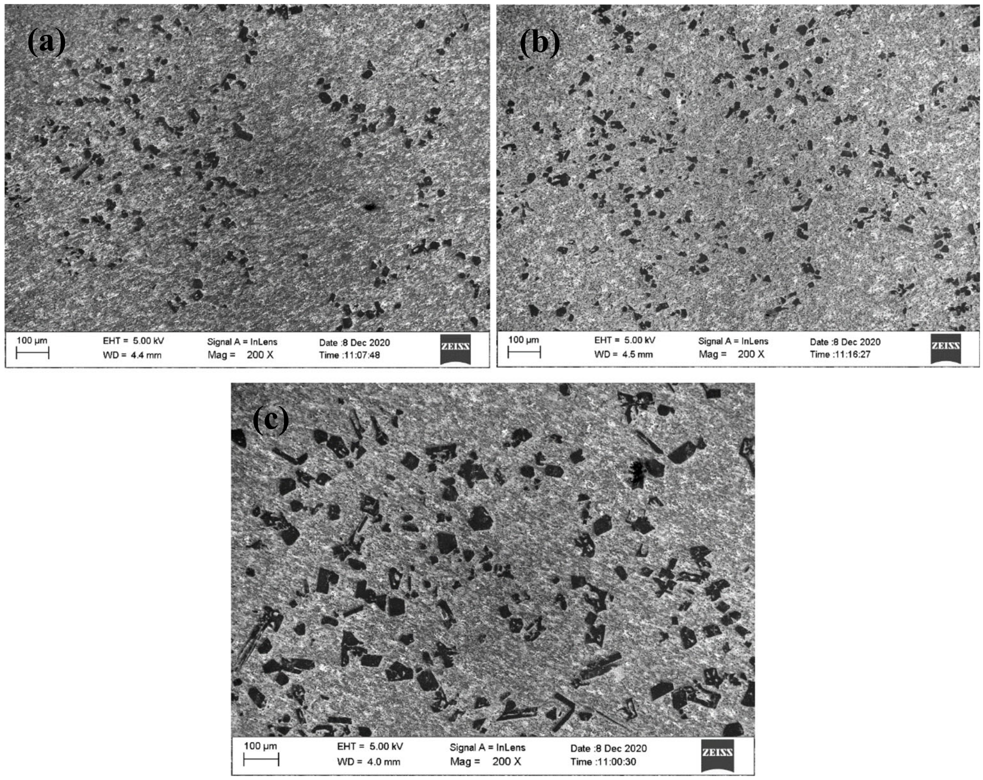


Fig. 4 SEM micrographs of Al/SiC composites (a) 5 % SiC, (b) 10 % SiC, and (c) 15 % SiC

enhancement in the hardness is ascribed to the fact that the high hardness property of SiC and its incorporation in the composites. Moreover, the high hardness value of the composites represents the hard and stiff ceramic in the composites enhanced the greater resistance to indentations [25]. Since we have considered five different regions on each hardness specimen, it indicates the uniform distribution of reinforcement all over the composites encouraging the dispersion strengthening. The hardness of the composites contributes to the overall bonding of reinforcement with the matrix material and the ability to withstand deformation and load [26].

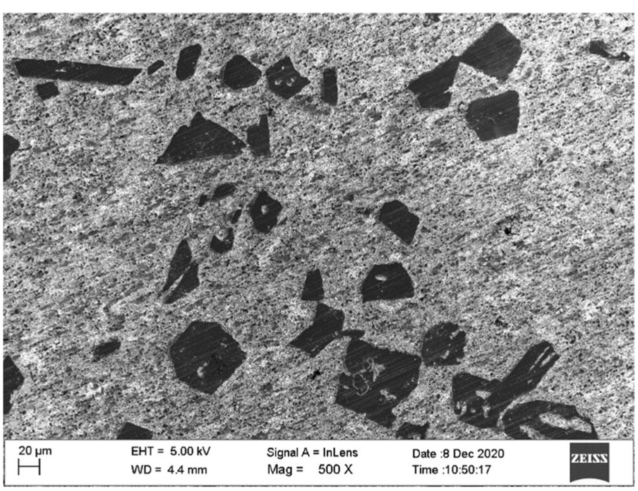
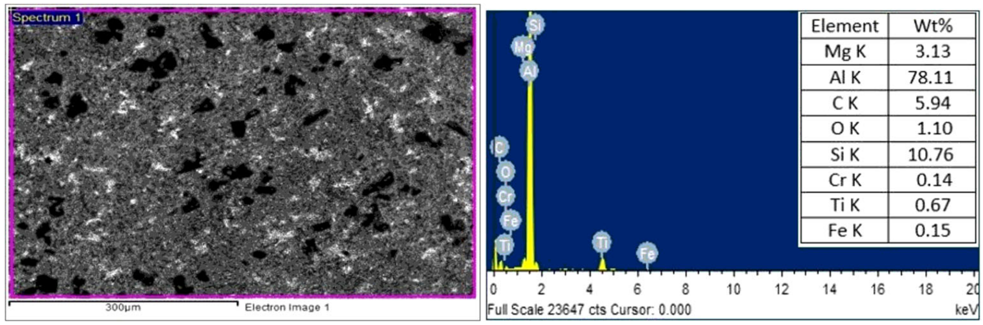


Fig. 5 Al-15 % SiC composites showing good interface bonding at higher magnification

3.2.2 Impact Strength

Graph showing the variation of impact strength with the weight % of SiC in the composites is shown in Fig. 10. With the increase in the SiC wt % resulted in a decrease in the impact strength of the composites. A maximum reduction of 37 % in the impact strength of the 15 wt% SiC was observed when compared to that of the base alloy (refer to Fig. 10). The reduction in the impact strength can be attributed to the brittle nature of the MMCs with the addition of SiC particles. With the increase in the hardness, the composites lose their ductility, and the stress concentration areas are increased. These stress concentration areas at the interface of the matrix and reinforcement caused debonding and subsequently, a reduction in the impact strength of the MMCs. The energy consumed under the application of a high-speed load defines the impact strength of the material. In the case of the composites, the energy concentration for debonding increases. Therefore, the plastic deformation energy was decreased as compared to the aluminum alloy, resulting reduction in the impact strength of the composites [27]. Moreover, the formation of high dislocation density at the interface due to the thermal mismatch between Al and SiC also resulted in the decrease in the impact strength of the composites [28].

Tensile Strength and Elongation The variation of the ultimate tensile strength and yield strength of AA5154/SiC composites are shown in Fig. 11. With the addition of SiC particles into



Element	Wt%
Mg K	3.13
Al K	78.11
C K	5.94
O K	1.10
Si K	10.76
Cr K	0.14
Ti K	0.67
Fe K	0.15

Fig. 6 EDX spectrum of Al/SiC composites

the aluminum alloy, the tensile strength was seen to be significantly enhanced. When compared to the base alloy, the 15 % SiC reinforced composites exhibited an increase of 35 % in ultimate tensile strength. Similarly, with the addition of SiC into the AA5154 alloy, the yield strength was seen to be decreased in line with the ultimate tensile strength. The curve between the tensile stress and tensile strain is shown in Fig. 12. The tensile strain is mentioned in terms of percentage elongation of the gauge length of the specimen. The percentage elongation was seen to be decreased with a higher content of SiC particles shows that the ductility of the composites is reduced. A maximum decrease of 38 % in the percentage elongation was observed in the case of the 15 % SiC composites as compared with the base 5154 alloy. The inclusion of the hard SiC particles increases the brittleness of the composites thus causing a reduction in ductility. The increase in the ultimate tensile strength was attributed to the uniform dispersion of SiC particles throughout the composite with the help of optimum stirring. This improvement was resulted from the strengthening effect due to the good interfacial bonding between the matrix and reinforcement. The interfacial bonding is directly related to the better transfer of load between the

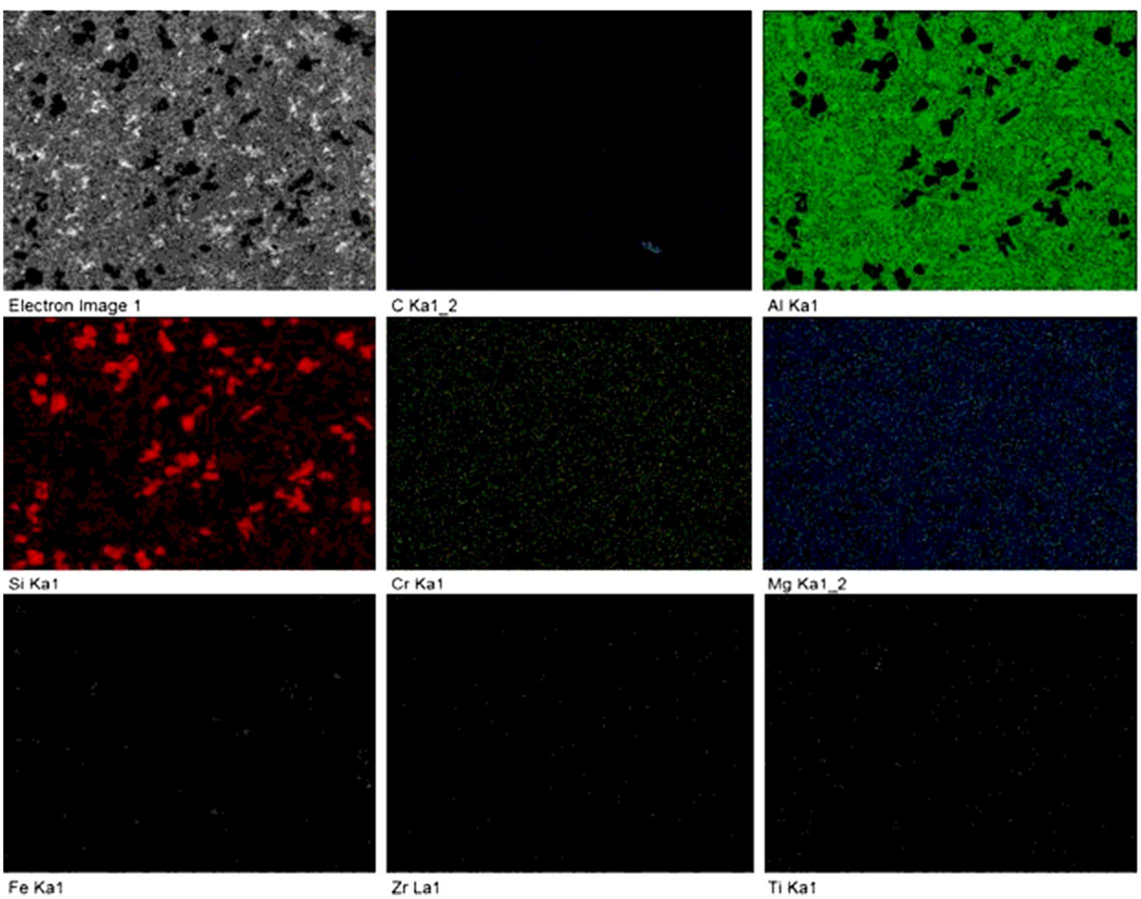


Fig. 7 Elemental mapping of Al/SiC composites

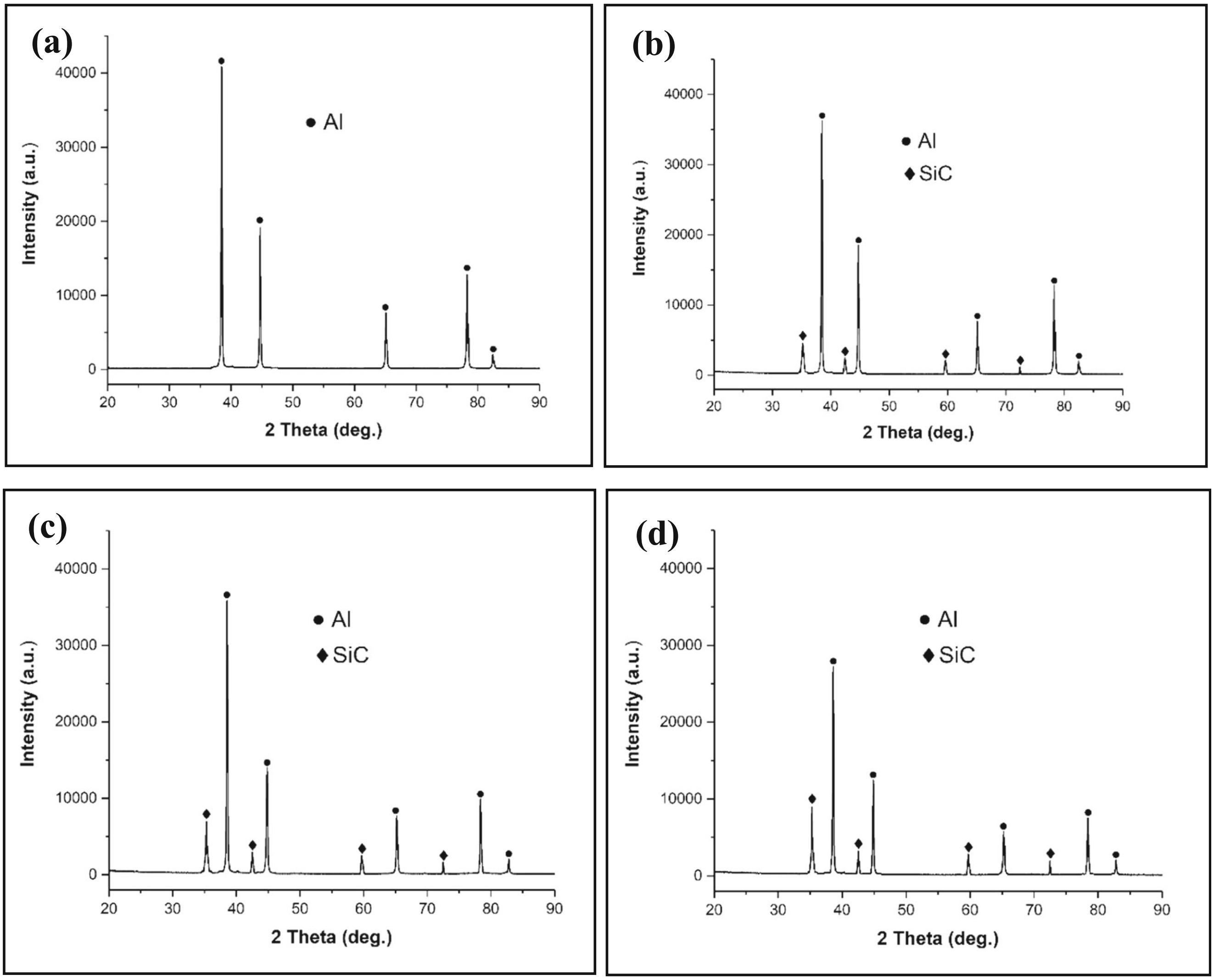


Fig. 8 XRD pattern of Al composite **a** base alloy, **b** 5 % SiC, **c** 10 % SiC, and **d** 15 % SiC

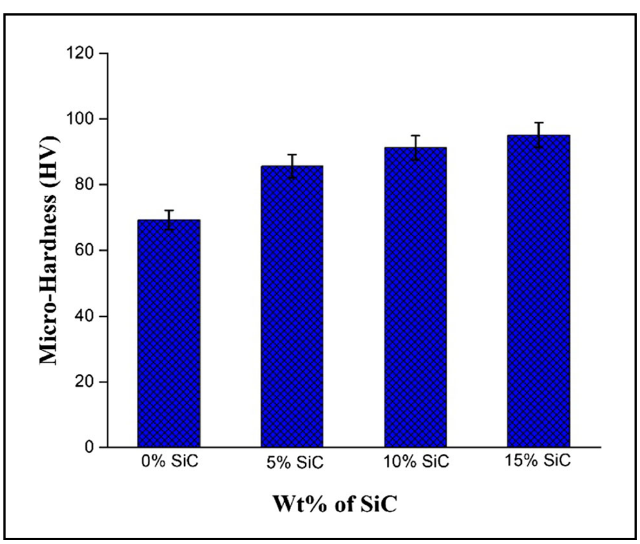


Fig. 9 Variation of microhardness with weight % of SiC

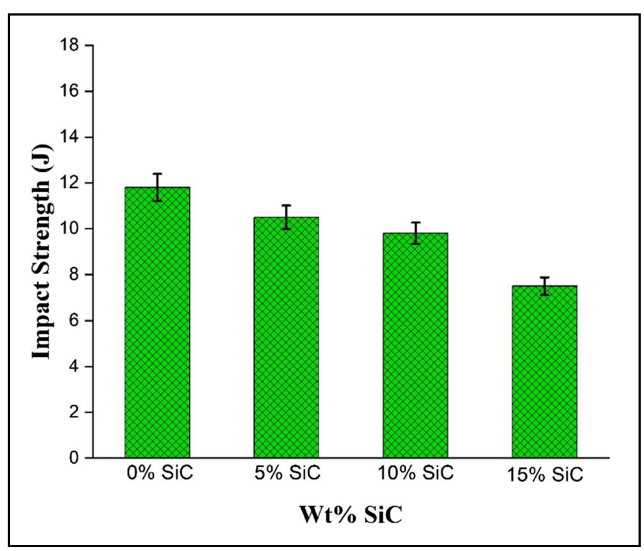


Fig. 10 Variation of impact strength with weight % of SiC

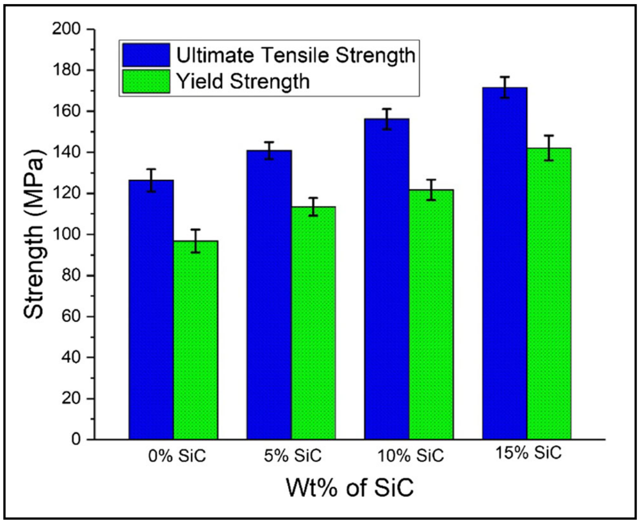


Fig. 11 Variation of ultimate tensile strength and yield strength with wt% of SiC

matrix and the dispersed reinforcement particles. The effect of reinforcement particulates on the strength of composites is described by the Orowan mechanism. The uniformly distributed SiC particles offer resistance to the dislocation movement as a result the tensile strength of the composites was enhanced which works according to the Orowan strengthening criteria [29]. The excellent bonding and clear interface postpone the detachment of SiC particles, thus contributing to the enhancement of the tensile strength of the composites. Similar results of enhancement in the tensile strength were reported after reinforcing SiC in the aluminum matrix, where the ultimate tensile strength was increased by approximately 32 % for 9wt% SiC composites as compared with the base matrix due to excellent interfacial bonding [30]. The yield strength and

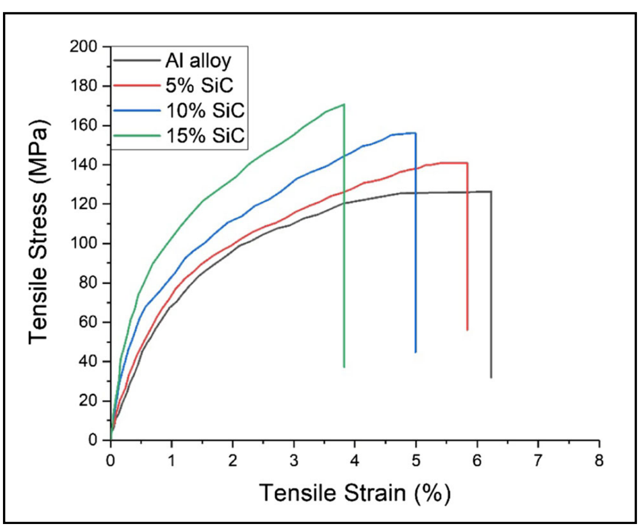


Fig. 12 Tensile stress vs. tensile strain curve for the composites

ultimate tensile strength of the composites was enhanced by 30 and 38 %, respectively as compared to the aluminum alloy whereas the elongation was reduced up to 86 % while reinforced with silicon carbide and tungsten carbide as reported the article [11]. Moreover, the thermal mismatch between matrix and reinforcement occurs during the solidification from processing temperature to ambient temperature. This mismatch causes large stress intensity which is greater at the matrix-particle interface and smaller at positions far from interface. The large difference of coefficient of thermal expansion between matrix and reinforcement resulted in a volumetric strain which forms a geometrically necessary dislocation (GND) loops around the particles. This phenomenon enhanced the strength of the composites [31]. Furthermore, the interaction of dislocation with the SiC particles delays the crack propagation during the tensile loading, as a result of which the tensile strength of the composites improved [32]. With the increase in the weight % of SiC particles, the dislocation motions and resistance to crack propagation also increased, which leads to the improvement in the mechanical properties.

Tensile Fracture Spectroscopy The SEM micrographs of the fracture surfaces of tensile specimens are given in Fig. 13. It was observed that the combination of the ductile and brittle mode of fracture has materialized. The tensile strength is related to the initial crack propagation and its subsequent growth during loading. From Fig. 13a, there were many equiaxed dimples present in the fracture surface of the base alloy sample indicating the ductile mode of fracture. As aluminum is ductile in nature, therefore, the specimen without any SiC content shows the fracture mode as ductile. Further, the pores and crack initiation were found to be major factors in the fracture specimen of Al/5 % SiC as shown in Fig. 13b. The nucleation of voids and their coalescence was also identified from the fracture analysis. With the addition of the SiC particles in the composites, the dimples are largely diminished which indicates the nature of the fracture was changed to brittle mode. Moreover, the small-sized cleavage facets were observed in the 10 % SiC composites which shows the brittle mode of fracture as shown in Fig. 13c. The crack initiation from the voids and its subsequent propagation leads to the tensile fracture as shown from the fractography. As the crack propagation starts, it confines the reinforcement by restricting the precipitation of the grain boundary. Subsequently, by applying the tensile load, the cleavage facets are formed contributing towards the failure of the specimens [33]. The fracture mode changed to brittle mode can be summarized as the composites exhibited a loss in ductility which also can be confirmed from the tensile stress-strain graph.

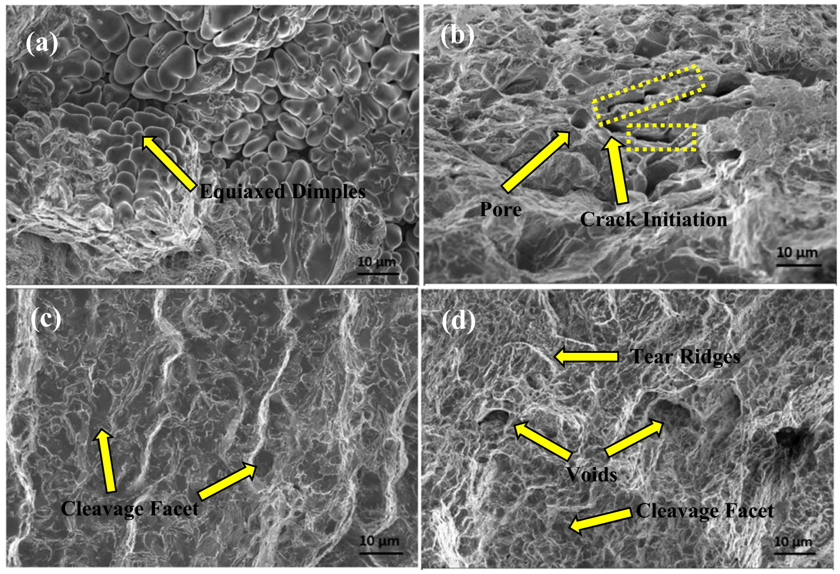


Fig. 13 SEM micrographs of the fracture surface of tensile specimens

3.3 Wear Characterization

The variation of wear rate with sliding distance for each weight % of composites is shown in Fig. 14. The wear experiments were conducted at a constant sliding speed of 1.5 m/s for different loading conditions i.e. 10 N, 20 N, and 30 N. The wear rate was found to be decreasing with respect to the sliding distance irrespective of SiC content. It can be observed from the results that the volumetric wear loss of the base alloy is higher than the reinforced composites. With higher sliding distances, volumetric wear loss was seen to be higher irrespective of the reinforcement content. However, with a higher content of SiC particles, less wear loss was observed that leads to a decrease in the wear rate. The reduction in the wear rate was ascribed to the addition of hard ceramic and thermally stable SiC particulates into the soft Al alloy. As a result, the SiC particles act as a load-bearing phase and protect the surface of the composites against sliding, thus improving the wear resistance of the composites [34]. Moreover, the reinforced SiC particles resist the plastic deformation of the matrix and help to absorb the continuous frictional heating during sliding. The reinforcement particles largely supported the wear resistance in the matrix region. Since the particle removal did not take place during the sliding action, it further clarified excellent interfacial bonding between matrix and reinforcement. Moreover, the sliding wear rate was found to be increased with the applied load along with sliding distance. The variation of average coefficient of friction with sliding distance for the base alloy as well as the composites are shown in Fig. 15. The coefficient of friction of the base alloy is comparatively higher than that of the composites. The adhesive frictional force generates due to the adhesive action between the contacting friction parts whereas the plastic deformation is due to the ploughing action. With the increase in the hardness of the composites, the surface contact between the counter disc and composite specimen was happened to be less. Therefore, the ploughing components appear to be low, thus exhibiting less coefficient of friction. On contrary, the base alloy involves a large amount of plastic deformation which eventually increases the ploughing action with the high value of the coefficient of friction [35]. Moreover, the adherence of the transfer layer on the composites specimen leads to a reduction in the direct metal to metal interaction. The transfer layer formed due to thermal and mechanical effects during the sliding action thus enables a lubricating medium between the contact surfaces which caused a decrease of coefficient of friction for the composites [36]. In our future work, we are going to investigate an in-depth study of the different wear mechanisms and wear surfaces that involve with the tribological behavior of the AA5154/SiC composites.

4 Conclusions

Aluminum alloy 5154/SiC metal matrix composites were successfully fabricated and the following conclusions were made:

- The stir casting process was found to be very useful to fabricate the SiC reinforced composites.
- The microstructural study revealed a uniform distribution of SiC particles due to a controlled stirring parameter. Moreover, the uniform dispersion resulted in better interfacial bonding between the aluminum and SiC. Furthermore, XRD analysis also confirmed the presence of SiC particles in the composites.
- Significant improvement in the ultimate tensile strength and hardness was observed due to the addition of SiC

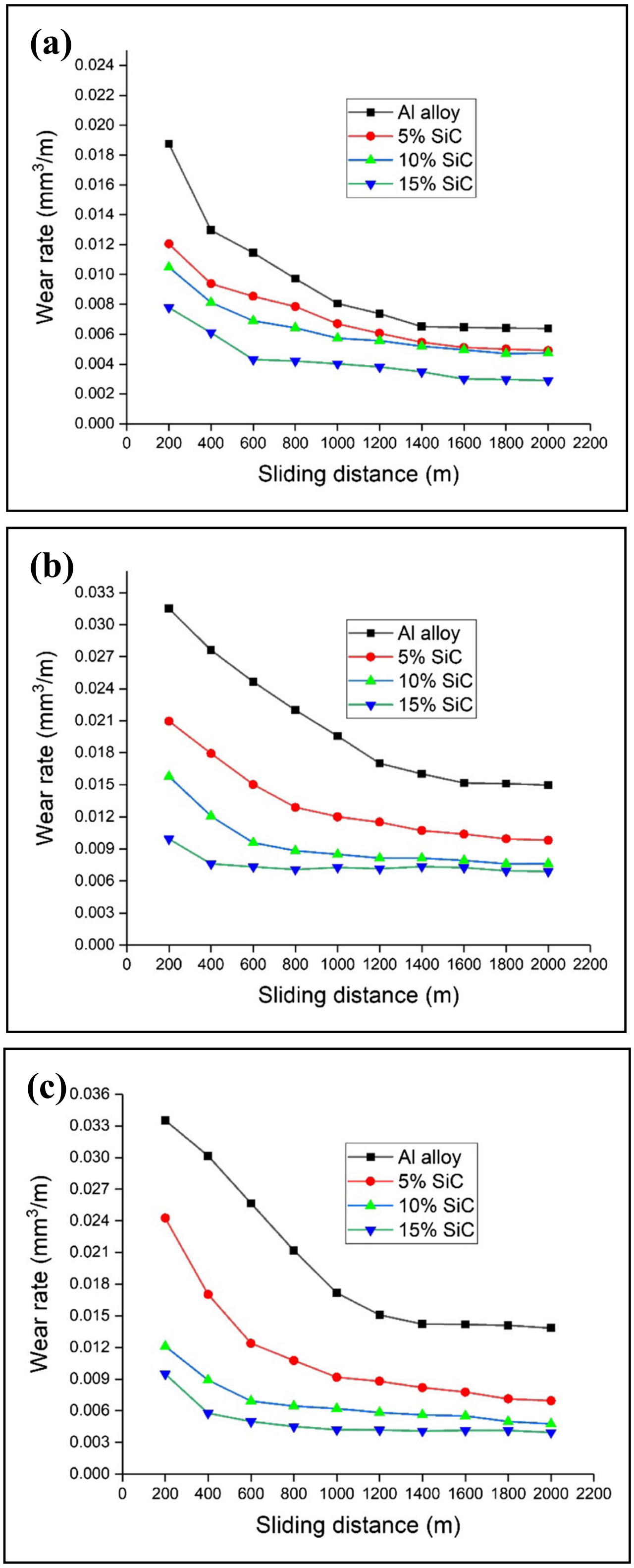


Fig. 14 Variation of wear rate with sliding distance under load **a** 10 N, **b** 20 N, and **c** 30 N

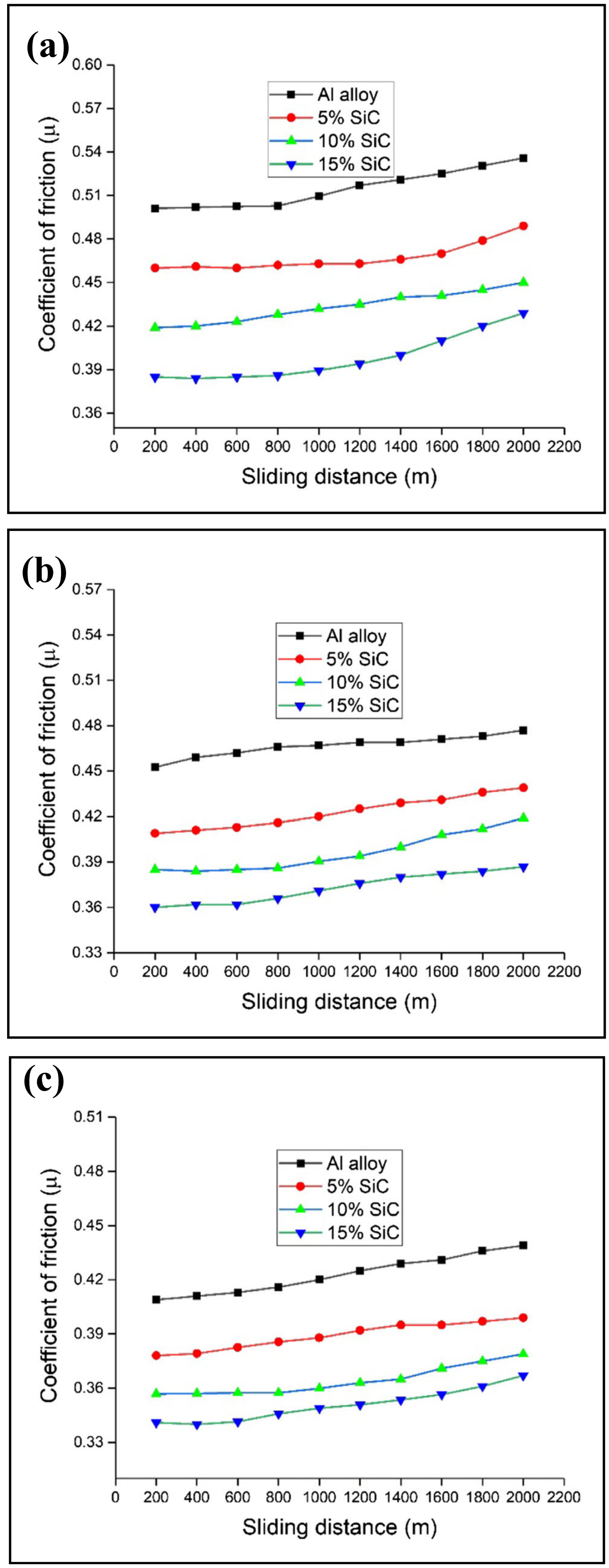


Fig. 15 Variation of coefficient of friction with sliding distance under load **a** 10 N, **b** 20 N, and **c** 30 N

particles. With increased hardness, the ductility was seen to be reduced for the composites when compared with the base alloy. With the loss in ductility, a decrease in the impact strength was also observed with higher content in the composites.

- The wear resistance of the composites was found to be enhanced as a result of the inclusion of SiC reinforcements as there was observed a gradual drop in the wear rate along with a higher sliding distance.
- With the enhanced tribological and mechanical properties, the Al/SiC composites are suggested for potential application for automotive components that deal with friction and wear.

Author Contributions Priyaranjan Samal: Conceptualization and Experimentation, Result & Analysis.

Dr. B. Surekha: Experimentation and Analysis.

Dr. Pandu R. Vundavilli: Supervision and final draft of the manuscript.

Data Availability All data generated and analyzed in this study are included in the article.

Declarations

The research was carried out in accordance with all ethical standards.

Consent to Participate The authors give full consent to participate in this research work.

Consent for Publication The authors give full consent for the publication of this research work.

Conflict of Interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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