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EFFECT OF ADDITION OF SIC AND AL_2O_3 ON WEAR BEHAVIOR OF HYBRID ALUMINUM METAL MATRIX COMPOSITES

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Abstract: In the present investigations, wear test is conducted on pin on disc device at room temperature for both the age hardening and without age hardening conditions. Al7075 has chosen as the matrix material. HMMCs are produced utilizing stir casting route for enhancing the wear behavior and hardness number. The reinforcement used is silicon carbide with 5%, 10% and 15% weight percentage and Al_2O_3 as the reinforcement in 5%, 10% and 15% weight percentage. In the aluminum matrix Microstructural characterization reveals the homogeneous mixing of reinforcements. This investigation shows the enhanced in wear resistance is due to the increment weight fraction of reinforcement. By raising the sliding speeds there is a reduction in the rate of wear and it reduces with increment in sliding distance. As an increase in weight fraction there is decrement in rate of wear of composites. In general tribological property enhances because of the addition of the two reinforcements.
Keywords: Al7075/SiC–Al_2O_3, Dry sliding wear, wear rare, HAMMCs

INTRODUCTION

MMCs comprise of an alloy or a metal as the matrix and a reinforcement such as the particles, short fibre or whisker and/or long fibre. MMCs were a group of material with perspective for a broad collection of applications in structural management. Their properties such as light in weight, superior strength and resistance to wear are the requirement for the aviation and automobile industries.

Discontinuously reinforced MMCs are much less expensive to fabricate than continuously reinforced composites. Consequently, performance enhancement of the matrix comes at lower additional costs with discontinuous reinforcements compared with aligned reinforcements. Particulate reinforced MMCs are not expensive to manufacture than reinforced composites. Accordingly, performance improvement of the matrix comes at lesser expenses with particulate reinforcements compared with fiber aligned reinforcements. In addition, particulate reinforced composites exhibit the isotropic properties [1], whereas the properties of composites with fiber aligned reinforcements are highly anisotropic.

Hybrid aluminum metal matrix composite (HAMMC) materials are an excellent substitute to conventional materials, because of the enhanced hardness, specific strength and creep resistance properties. Based on the literature survey made, one can consider the Al7075–SiC/alumina particulate MMC for automobile applications such as: pistons, cam shafts, brake components, Bearing surfaces, cylinder liners, etc., and aerospace applications such as wing and fuselage (main body) of aircraft structure, internal aerospace engine components, exhaust systems.

A surface phenomenon referred as wear will occurs by relocation & separation of material. It generally suggests a progressive loss of material and change of measurements over some undefined time frame.

The principle tribological considerations that manage the wear and friction properties of discontinuously reinforced aluminium (DRA) composite can be categorized into two types (i) Mechanical and physical properties: such as loads, speeds, surface finish, sliding distance, orientation of reinforcement, temperature and environment etc. (ii) Material factors: for instance the type, size, and size distribution, shape, reinforcement's weight fraction, and the matrix microstructure [2].

The important parameter which influences the wear of materials is the microstructure. According to research reports, microstructure and mechanical properties have a correlation. On the other hand, to relate the wear techniques with microstructural characteristics only limited reports were used. The wear surface exhibits microstructural heterogeneity which influences wear procedure since constituent, for example, incorporations, intermetallics, and scattered phases have properties not quite the same as those of the matrix. The most imperative part of the microstructure is the distribution of second phase particles [3].

AMCs are majorly impacted by the characters of the matirx and reinforcement material. The worn surface of the material, in dry sliding wear, is subjected to considerable work hardening. The layer, mechanically mixed layer (MML) is produced during wear of aluminum alloys, sliding against ferrous alloy. Due to the shift and combination of materials, under definite load and velocity range, MML is formed. The generated MML consists of materials from both contact surfaces. It was also reported that the hardness of the generated MML is greater than the bulk hardness of the composite. The generated MML is majorly responsible for the decrement of wear rate and holding–up of transition to severe wear.

The literature survey gives the survey of the published material accessible on the influence of different types of reinforcements, volume/weight fractions, aging behaviour and size with aluminium based MMCs are a blend of two phases: one is referred as matrix, and the other as the reinforcement. Singla et al [4] developed aluminium alloy/ SiC_p composites of varying weight fractions of silicon carbide (5–30%) by stir casting techniques using a two step–mixing method. Results showed that impact strength and hardness increased with an increment in weight percentage of silicon carbide. Rajesh A M et al [5–7] conducted experimentations like hardness, wear behavior at as–cast and age hardened conditions etc on aluminum hybrid metal matrix composites. The matrix material considered is Al7075, and reinforcement material is SiC and alumina. From the results it is clear that the HAMMCs have better properties as compared to unreinforced aluminum alloy.

M K Surappa et al [8] studied the Al–Si composite for their tribological behavior. For the study, they considered the automobile brake in pin on disc tribometer. Aluminum metal matrix composites were utilized as a disc whereas brake pad material forms the pin. Form the outcomes it is observed that the coefficient of wear and the fraction is varied with the load. Also as the coefficient of fraction decreases wear rate increases. R. L. Deuis et al [9] surveyed the wear behaviour of the materials and the development of fine equiaxed wear debris is related with a stable tribo–layer on the worn surfaces. The critical parameters for adhesive wear are applied load, sliding velocity, the surface hardness of worn surface and morphology in relative to the theories of wear encuontered by the materials.

Radhika et al. [10,11] has conducted the experiments to evaluate the wear characteristics of $Al/Gr/Al_2O_3$ hybrid MMC and suggested that the graphite reinforcement has boost up the resistance to wear. This increment is due to the forming a protective layer between the counterface & pin. Addition of the reinforcement Al_2O_3 has considerable influence in reducing rate of wear of the composite. Saleemsab Doddamani et al [12] conducted experimentation on wear behaviour of Aluminum–graphite MMC. From the results it is found that the adding of particles of graphite has increased the resistance to wear of the MMC. Also it is reported that addition of particles of graphite in aluminum reduces the friction then that of the base alloy.

Heat treated material demonstrate the resistance to wear [13]. Because of the higher ductility and strength of the aluminum matrix, the effectual stress connected on material surface along with the wear progression is less on account of the heat–treated alloys. This occurrence caused a reduction in the cracking propensity of the material surface when contrasted with the as–cast alloy [14]. The heat treatment didn't drastically modify the morphology, but rather the matrix hardening by age hardening occurred, which prompted greater strength & hardness [15]. The yield strength and higher hardness of the material after this heat treatment condition may have the benefit of keeping generation of aluminium debris & reduction in its exchange to the steel surface [16]. Amro M. Al–Qutub et al [17] investigated the properties of Al6061 matrix reinforced with 10% volume fraction of Al_20_3. Cui Y Geng et.al [18] observed that, an aluminum matrix composite was viably gotten using the self proliferating high temperature silicon carbide particles. The composite was seen to be better in mechanical exhibitions to those of the composite with the normal status evaluation silicon carbide particles. From the outcome it is reported that between aluminum–SiC their exist a high strength interfacial bond.

It is noticed from the literature that more research conducted on the wear characteristics of Al–SiCp, Al–Li/SiC MMCs. In this background, the research gaps indicate that there is a lot of scope for current researchers for investigation with the use of a combination of silicon carbide and aluminium oxide as reinforcement. Therefore this research work will focus on wear behaviour of aluminum hybrid metal matrix reinforced MMCs. Main aim of the proposed research work is to develop the hybrid MMC in–order to improve the strength and wear resistance characteristics of the material that generate Mechanically mixed layer.

MATERIALS AND PROCESSING

— Materials

Al–7xxx alloys, for instance, 7075 are commonly used as a part of applications including transport, automobile, marine and also in aerospace, because of their high strength and low weight. The main constituents in the Al7075 are Si=0.4%, Zn = 6.1%, Mg=2.9%. The properties of the Al7075 are density = 2.85g/cc, ultimate strength = 480MPa, elastic modulus = 75GPa, Poissons' ratio = 0.33, melting point = 650^{0}C.

Silicon carbide is a ceramic material also known as carborundum, denoted as SiC. It is a blend of silicon and carbon. It is an outstanding abrasive material utilized to prepare grinding wheel and other abrasive parts. Now a day, the SiC material is formed into a technical grade better quality ceramic with excellent mechanical/physical properties. Some of the key properties of silicon carbide utilized here are Density –3.1 g/cc, melting point –2730^{0}c, molecular mass – 40.10 g/mol, grit size –16–100grit, Appearance –Black in color.

Aluminum oxide, commonly known as alumina (Al_2O_3) is corundum in its crystalline form is widely used in industry. The alumina (Al_2O_3) as a reinforcement is steadier with aluminium and withstand higher temperatures. Some of the key properties of aluminum oxide utilized here are density=3.69g/cc, melting point –2072^{0}C, mesh size=100–200 mesh, appearance – White in color.

— Processing

Al7075–SiC/Al_2O_3 samples are formed at varied weight fractions of SiC/Al_2O_3 (5%, 10% and 15%) utilizing stir casting technique. The aluminum slabs were melted in the furnace. In the wake of liquefying, liquid aluminum was superheated to 750^{0}C temperature [5,6]. The required measures of SiC/Al_2O_3 particles were added to the liquid aluminum while mixing with a stirrer at 600rpm speed. The liquid Al7075–SiC/Al_2O_3 was filled a permanent mold and it was permitted to set. The Al7075–SiC/Al_2O_3 composite bars were taken out from the mold. The samples were set up from as–cast combinations for investigation of required properties. Shearing temperature (620^{0}C) and shearing speed (600 rpm) were the two process parameters which affect the composites. To examine the effect of processing parameters tests were conducted. The different process parameters were chosen to exert a hydrodynamic force on the molten material and to retain best possible fluidity for the casting.

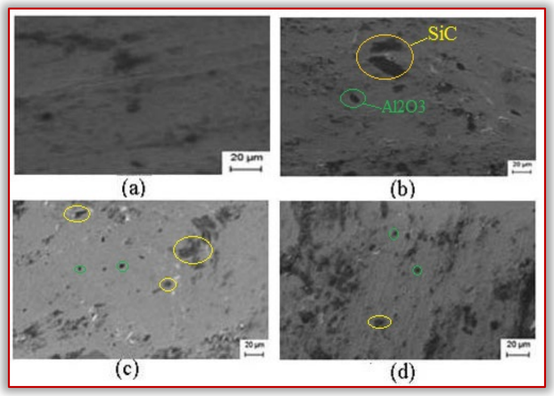


Figure 1. Scanning Electron Micrograph shows a uniform distribution of particles of SiC/Al_2O_3 (a) As cast Al7075 (b) 5% SiC/Al_2O_3 (c) 10% SiC/Al_2O_3 (d) 15% SiC/Al_2O_3

In the microstructure, shown in Figure 1, of the Al7075–SiC/Al_2O_3 particulate composite confirms uniform distribution of the reinforcement. In the process of the mixing, a whirling of molten material is formed from the rotation of the stirrer through which the SiC/Al_2O_3 particles are drained into the melt. The force gave by mixing the molten material with a mechanical stirrer beats the surface vitality hindrance because of poor wettability of SiC/Al_2O_3 by Al composite. Once the SiC/Al_2O_3 particles are moved into the molten aluminium, the dissemination is firmly influenced by certain flow transitions. From the momentum transfer and the outspread flow of melt, lifting of SiC/Al_2O_3 particles will take place and also causes prevention of particle settling in the matrix. Meanwhile, local hydrodynamic forces are induced on the particle grouping of SiC/Al_2O_3 particulates. These forces induced are capable of separating the clustering of SiC/Al_2O_3 particles which in turn leads to homogeneous microstructure all through the cast segment.

A strong homogeneous microstructure between the reinforcement and matrix helps in the load exchange from the reinforcement to the matrix. Thus, the break happens in the composite via the reinforcement and not along the interface. Despite the fact that the SiC/Al_2O_3 is a non–load bearing ingredient, a solid particle/matrix interface helps the SiC/Al_2O_3 particles install themselves into the matrix legitimately, enhancing the crack resistance. It has been reported that during solidification, an enhancement in the interfacial relationship between the aluminum matrix and SiC/Al_2O_3. By reason of the uniform distribution and good bonding of SiC/Al_2O_3 particles in the aluminium matrix, Al7075–SiC/Al_2O_3 particulate composites have greater tribological properties such as the good machinability, low wear rate, high damping capacity, and their outstanding properties.

— Age Hardening

The as–cast composite specimens were heat treated at a temperature of 465^{0}C for 02 hrs taken after by quickly quenched in cool water. After quenching the specimens, these are subjected to an age (precipitation hardening) by heat–treatment the specimens to 120^{0}C, maintaining this temperature for 05 hrs and after that taken after cooling in air to room temperature.

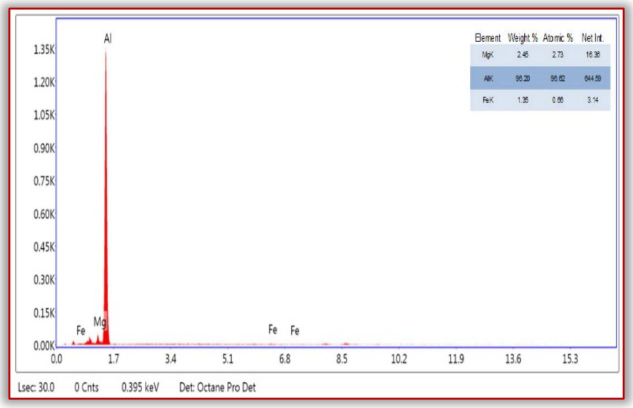
EDX ANALYSES

To determine the chemical composition of the Al7075–SiC, alumina composites, EDX measurements are carried out in the SEM on individual specimens. The EDX analysis indicates the foremost composition of Al7075–SiC, alumina composites silicon, magnesium, Fe, carbon and aluminum. Small amount of oxygen are also observed. The signals of oxygen may arise from the contamination of the aluminum oxide. Table in the Figure 2 describes the atom percentage of Si, magnesium, carbon, and aluminum. These outcomes specified that the chemical compositions of the Al7075–SiC, alumina is consistent. The atomic percentage of carbon is high than compared to silicon and magnesium. The presence of carbon indicates the adding up of SiC, alumina reinforcement with the Al7075 matrix. The content of Silicon (0.63 to 0.91) and Magnesium (0.6 to 2.54) indicates that the presence of Si and Mg in the Al7075 alloy.

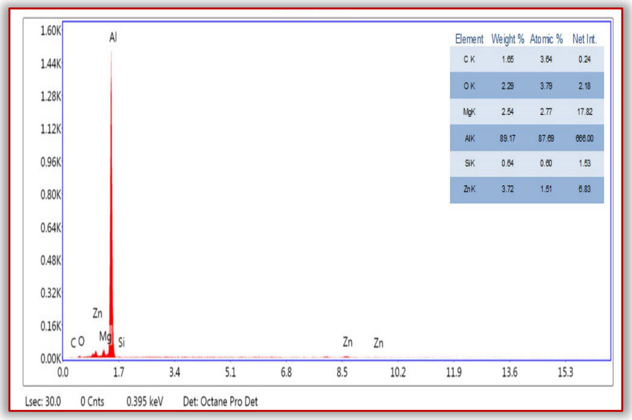
From the EDX analysis (Figure 2), it is found that Al7075– SiC, alumina MMCs are rich in both Si and Mg. The existence of $MgAl_2O_4$ at interfaces was confirmed in a detailed study on the interfaces in discontinuously reinforced metal–matrix composites. In all the compositions of Al7075– SiC, alumina, oxygen (O) content has been obtained. The content of O is due to the formation of Al_2O_3 on the top of the pits as the main compound on the surface. The analysis of mechanically mixed layer was carried out by utilizing EDX to study the degree of exchange of material from the disc to pin. O–mapping, in addition, is performed to know if any sample of oxidation tested at Along with Fe, O was likewise in age hardened Al7075 reinforced with Sic and alumina specimens. The O presents in an O_2, though, no clarity though it is a FeO_2 or Alumina.

WEAR ANALYSIS

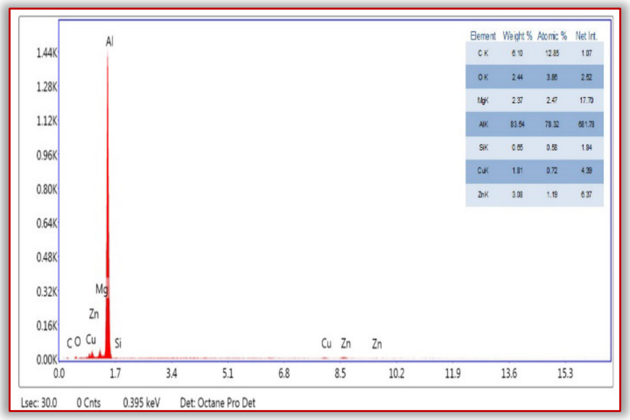
The dry sliding wear behaviour of Al7075/SiC–Al_2O_3 HAMMCs and heat treated (T6) Al7075/SiC–Al_2O_3 HAMMCs conducted according to ASTM G–99 standard testing procedure. Dry sliding wear experiments were conducted using a computerized Pin–On–Disc (POD) wear apparatus (Model: Wear & Friction Monitor TR–20) supplied by DUCOM. The dry sliding wear tests are conducted by weight loss measurement technique and data obtained from the experimentation for different loads, speeds and different compositions for as–casted and age hardened conditions.



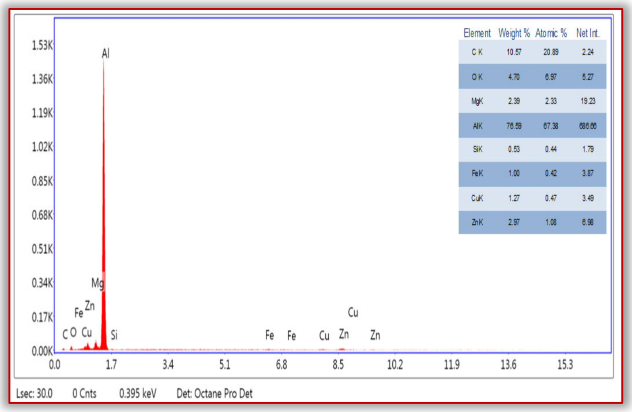
(a) 0% reinforcement



(b) 5% reinforcement



(c) 10% reinforcement



(d) 15% reinforcement

Figure 2. EDX profile analysis for the surfaces

SEM was carried out to understand the changes in worn surfaces with the addition of SiC and Al_2O_3 reinforcements. The dry sliding wear behavior of Al7075 base Alloy–Sic– Al_2O_3, HAMMCs and heat treated (T6) Al7075 base Alloy–SiC– Al_2O_3 HAMMCs conducted according to ASTM G–99 standard testing procedure. Dry sliding wear experiments were conducted using a computerized Pin–On–Disc (POD) wear apparatus(Model: Wear & Friction Monitor TR–20) supplied by DUCOM The machine comprises of high carbon EN–31steel disc and a wear track diameter of 90 mm. The cylindrical specimen of 10 mm diameter and 30 mm height were utilized for wear tests. Wear tests conducted for 3 different normal loads i.e. 2kg, 4kg, 6kg, at a fixed sliding velocity of 0.942m/s, 1.8849m/s, 2.82m/s for 200, 400, 600rpm respectively for about 5minutes.During the wear test, height loss of the specimen was recorded and the corresponding volume loss, wear rate, were calculated. Before and after the test, both disc and specimen were cleaned.

After the sliding wear test the volumetric wear loss was calculated over a Sliding distance of 282.47m, 565.48m, and 848.23m for 200, 400, 600rpm respectively for about 5minutes at a load of 2kg (19.62N), 4kg (39.24N), 6kg (58.86N). It was observed that the volumetric wear loss increased linearly with the increase in sliding distance in all the investigating composites. The volumetric wear loss reduced with increment in content of SiC and Al_2O_3 reinforcements in MMCs when compared with base alloy. It shows the increased wear resistance of the composites. In HAMMCs the reduced wear loss was observed when compared with as–cast 7075 because of the existence of Sic and alumina, which act as solid lubricant [19]. At higher in sliding distances the temperature of the sliding surfaces increases, which consequences in soften of the pin surface which is in contact with the disc, leading to heavy deformation and results in advanced volumetric wear loss of the pin.

From the analysis minimum wear loss was observed in Al7075–10wt%SiC–10wt% Al_2O_3 HAMMCs. Dry sliding wear tests on hybrid aluminum matrix composites, reinforced with silicon carbide and graphite particle and show that graphite particles were useful agents in rising resistance of dry sliding wear of Al2219–SiCp composites [20]. Graphite particles effect on distribution on wear behavior of aluminum composites with a weight percentage of graphite content. They found that the existence of graphite particulate could enhance the wear resistance in composites. When compared with base matrix alloy lower wear loss was observed in composites. Increased loads resulted in delamination leading to high volumetric wear of both the matrix alloy.

— Impact of sliding distance on the volumetric wear rate

The volumetric wear rate varies with the sliding distance as shown in Figure 3(a–c) as–cast and Figure 4(a–c) with age hardening, by incrementing the sliding distances rate of wear reduces. The high temperature effect led to deformation instead of wear in softer material. This outcome is seen in each composites which reduces the rate of wear.

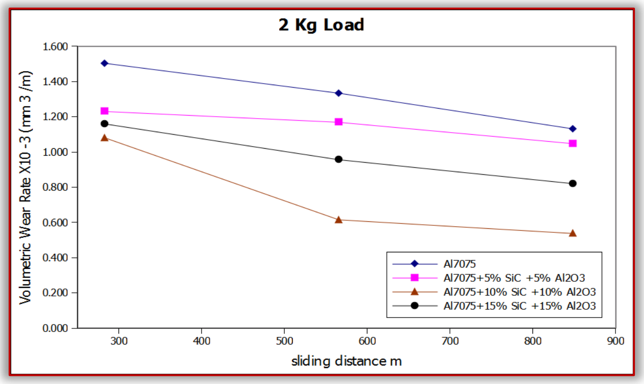


Figure 3a. Volumetric wear rate vs sliding distance Al7075 HAMMCs at load of 2kg [as–cast]

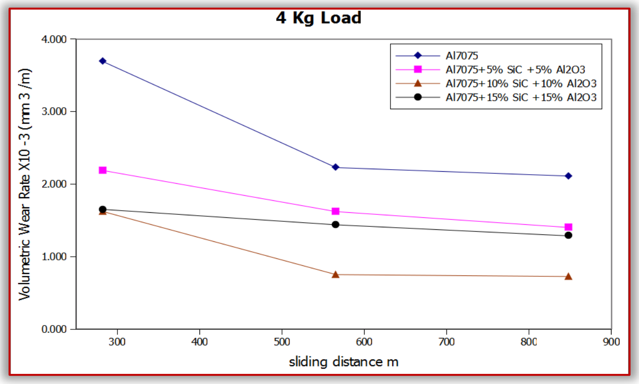


Figure 3b. Volumetric wear rate vs sliding distance Al7075 HAMMCs at a load of 4kg [as–cast]

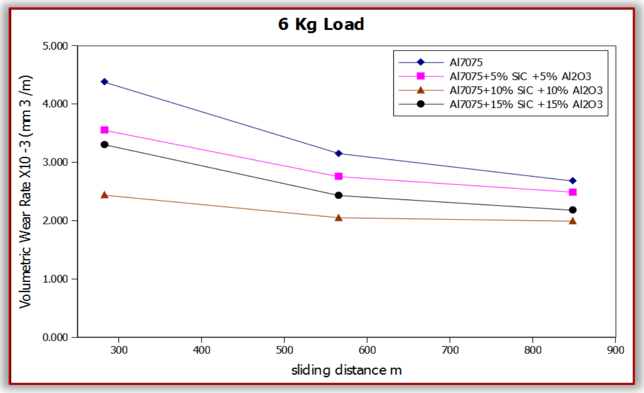


Figure 3c. Volumetric wear rate vs sliding distance Al7075 HAMMCs at a load of 6kg [as–cast]

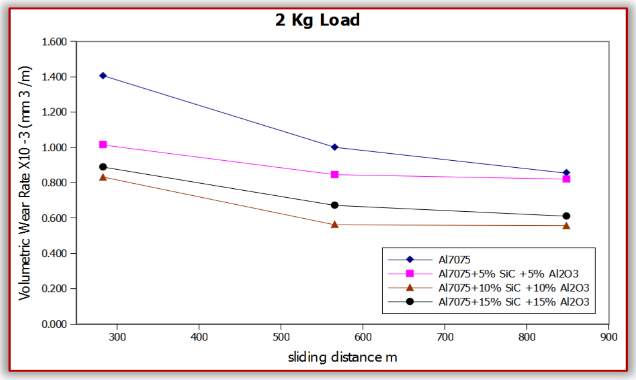


Figure 4a. Volumetric wear rate vs sliding distance Al7075 HAMMCs at a load of 2kg [age hardening]

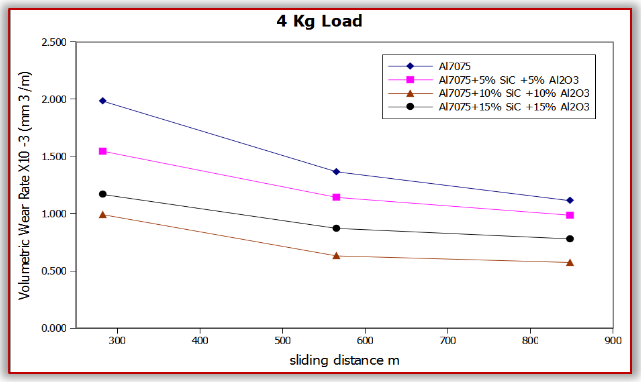


Figure 4b. Volumetric wear rate versus sliding distance Al7075 HAMMCs at 4kg load [age hardening]

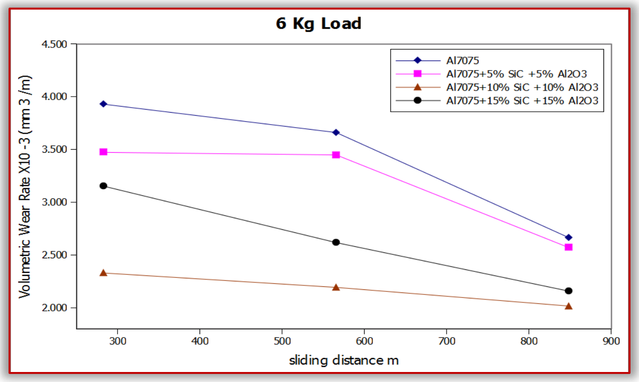


Figure 4c. Volumetric wear rate versus sliding distance Al7075 HAMMCs at 6kg load [age hardening]

From Figure 3 to 4 it was observed that the volumetric wear loss decreased in heat treated 7075 HAMMCs increased Sic and Al_2O_3 reinforcement (10%). When compared with the 7075 HAMMCs.

In aged HAMMCs the volumetric wear loss was further reduced when compared with 7075 HAMMCs. Remarkably the lowest volumetric wear loss was observed in heat treated Al7075–10%SiC + 10%Al_2O_3– with ageing when compared to 7075 HAMMCs. Wear behavior of AA6092–SiC composite which is heat treated, highlighted the improvement in hardness due to T6 heat treatment, which lead to the improved wear resistance of MMCs.

— Outcome of functional load on the volumetric wear rate

The wear properties of 7075 HAMMCs and heat treated 7075 HAMMCs were discussed on the basis of volumetric wear rate with applied load. From Figure 5 to Figure 6 it was observed that, with an increase in load from 2 kg (19.62N), 4 kg (39.24N) and 6 kg (58.86N) the volumetric wear rate increased in 7075 HAMMCs and heat treated 7075 HAMMCs proportionately. In heat treated 7075 HAMMCs, the volumetric wear rate was less when compared with the 7075 HAMMCs Also the lowest volumetric wear rate was observed at Al7075–10%SiC + 10%Al_2O_3, at a load of 2 kg(19.62 N). The cumulative volume loss increases with increasing applied normal load [96]. The parameters like time 5minutes, track diameter 90mm is considered for all the wear specimens without heat treatment and age hardening.

From Figure 5a, for sliding velocity 0.9424m/s, the volumetric wear rate will increases as there is increase in applied load. Also the lowest volumetric wear rate was seen at Al7075+10%Sic + 10%Al_2O_3, from Figure 5b, sliding velocity is 1.884 m/s the Volumetric wear rate will be less for 10% reinforcement at a speed of 400 RPM is applied. From Figure 5c, for sliding velocity2.827 m/s, the volumetric wear rate will decreases for 15% reinforcement when load is applied and it is less for 10% reinforcements.

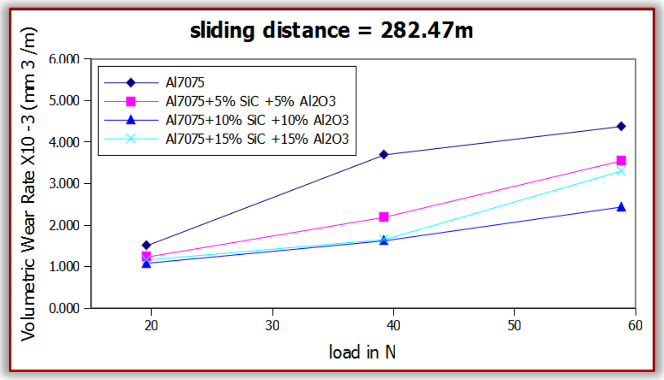


Figure 5a: Volumetric wear rate at an applied of speed 200 RPM in Al7075 HAMMCs [as–cast]

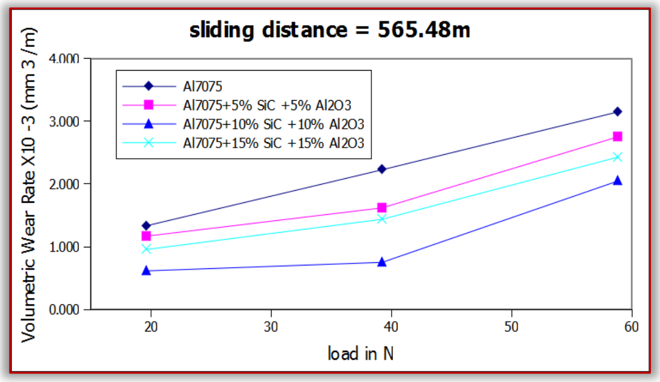


Figure 5b: Volumetric wear rate at an applied of speed 400 RPM in Al7075 HAMMCs [as–cast]

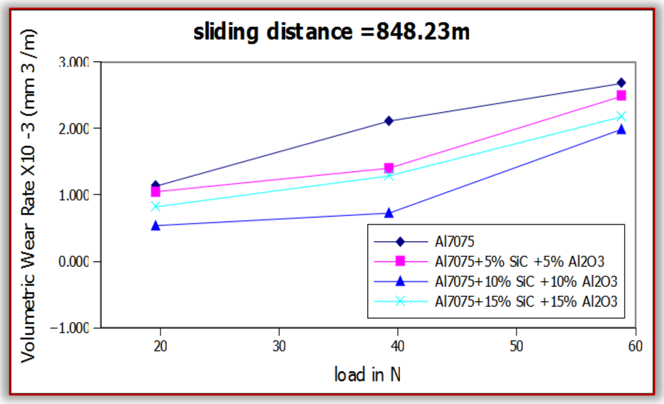


Figure 5c: Volumetric wear rate at an applied of speed 600 RPM in Al7075 HAMMCs [as–cast]

The inclusion of ceramic materials in an aluminium alloys incremented the load bearing capacity. The investigation of wear behaviour of Aluminum Matrix Composites against friction materials is receiving particular attention because of the possibility of using these materials for disc brakes in automotive application [89]. The addition of reinforcement in an aluminium matrix increases the load bearing capacity and higher wear resistance. The role of silicon carbide and alumina are responsible for improving the wear resistance of the hybrid composites. Because of increase in load rate of wear incremented as material contacting pressure is more. Pressure raise influenced the wear depth this is seen from the Figure 5 to 6.

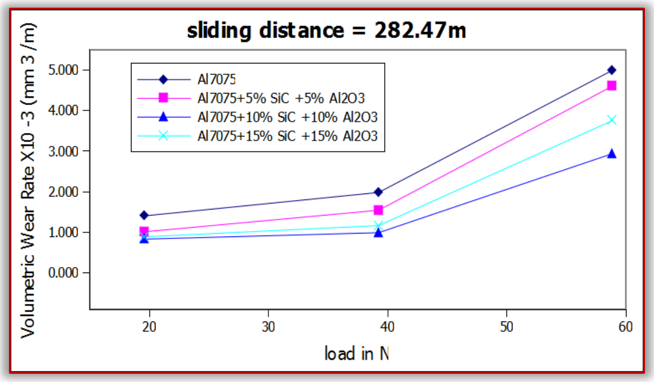


Figure 6a: Volumetric wear rate at an applied of speed 200 RPM in Al7075 HAMMCs [age hardening]

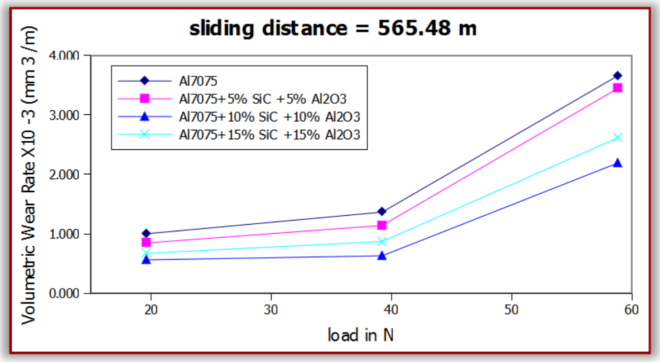


Figure 6b: Volumetric wear rate at an applied of speed 400 RPM in Al7075 HAMMCs [age hardening]

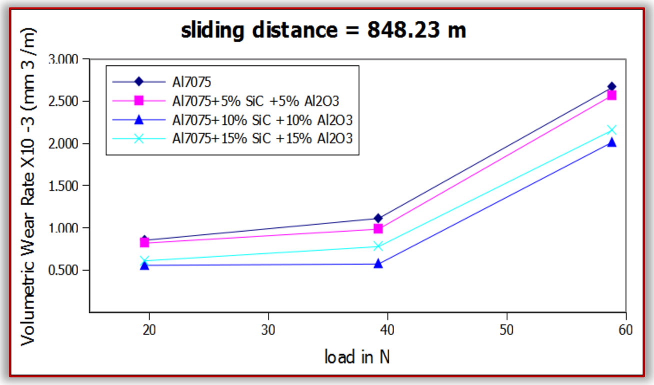


Figure 6c: Volumetric wear rate at an applied of speed 600RPM in Al7075 HAMMCs [age hardening]

From Figure 6a,sliding velocity 0.9424m/s the Volumetric wear rate will increases as the load increases to 4kg and again increases as the load increases to 6kg and it is observed From Figure 6b, sliding velocity 1.884 m/s, the Volumetric wear rate will be less for 5% reinforcement when a load of 6kg is applied. From Figure 6c, for sliding velocity 2.827m/s, the volumetric wear rate will decreases for 5% reinforcement when 4kg load is applied and it is less for 15% reinforcement when 6kg load is applied. Silicon carbide reinforced aluminum alloy composite observed that the useful effect of particle reinforcement is reduced with load increment. The effect of each reinforcement particle is able to carry a bigger portion of load.

— Result of sliding distance (sliding speed) on wear rate

In the Metal Matrix Composites (MMCs) increase wt% of SiC and Al_2O_3 reinforcement improves the hardness. At larger sliding distances, the rise of the sliding surface temperature is unavoidable. Addition of hard particulate reinforcement in the composites restricts the composites from getting soft which results in the reduction in wear rate. A Similar trend was observed in case of Al7075–Sic–Al_2O_3HAMMCs as shown in Figure 7 to Figure 8.

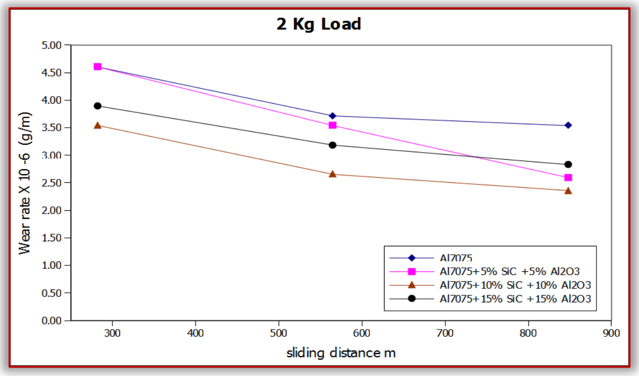


Figure 7a: Wear rate vs sliding distance for HAMMCs at a load of 2kg, after a sliding–distances of 848.23 m [as–cast]

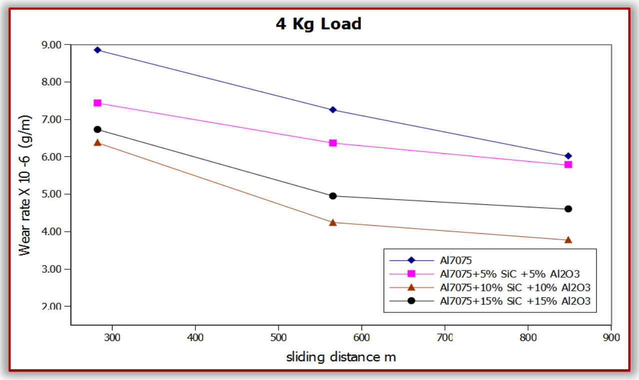


Figure 7b: Wear rate vs sliding distance for HAMMCs at a load of 4kg, after a sliding– distance of 848.23 m [as–cast]

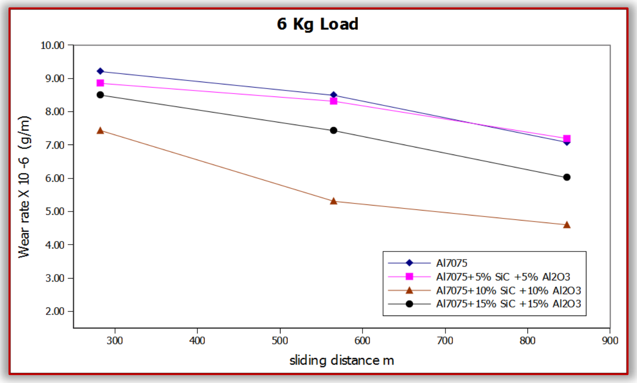


Figure 7c: Wear rate vs sliding distance for HAMMCs at applied load of 6kg, after a sliding distance of 848.23 m [as–cast]

In Al7075–10%Sic–10%Al_2O_3 HAMMCs reported the least wear rate at 58.86 N load. From Figure 7a to Figure 7c it was seen that the wear rate reduced drastically with sliding distance from 282.47m, 565.48m, and 848.23m for 200, 400, 600rpm in base alloy Al7075 HAMMCs and heat treated Al7075 HAMMCs Further increase in sliding distance, the wear rate reduces gradually, beyond sliding distance of around 848.23 m, the wear rate remains almost unchanged. This clearly reflects that the wear stabilization called critical point and the corresponding sliding distance and wear rate are considered to be critical, beyond which the wear stabilization was observed.

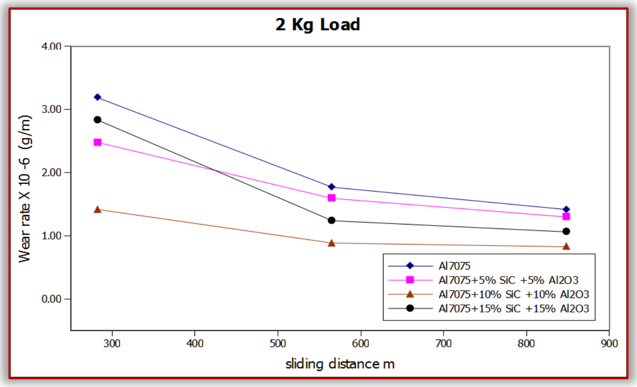


Figure 8a: Wear rate vs sliding distance for HAMMCs at a load of 2kg, after a sliding distance of 848.23 m [age hardening]

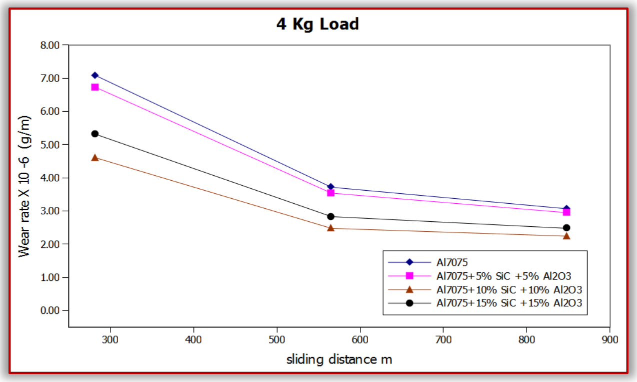


Figure 8b: Wear rate vs sliding distance for HAMMCs at a load of 4kg, after a sliding– distances of 848.23m [age hardening]

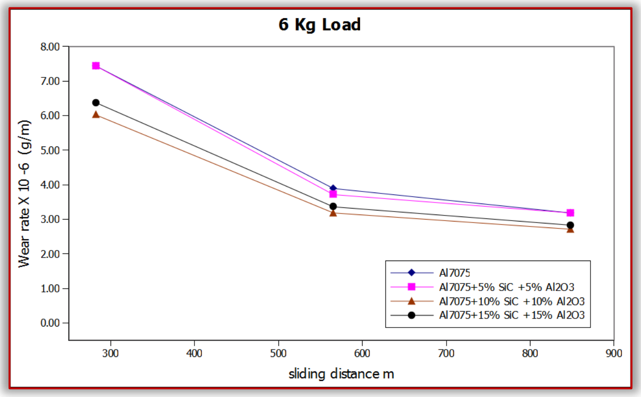


Figure 8c: Wear rate vs sliding distance for HAMMCs a load of 6kg, after a sliding distance of 848.23 m [age hardening]

The reduced wear rate was observed in heat treated HAMMCs with increment in SiC and Al_2O_3 reinforcements as shown in

Figure 8(a–c). The improvement in hardness number of the composite represents the reduced rate of wear as noticed by researcher. The minimum wear rate was observed for all loading conditions in Al7075–10%SiC–10%Al_2O_3 HAMMCs with T6 heat treatment also observed the least wear rate at 58.86N.Minimum wear rate was observed that in Heat treated HAMMCs at 58.86 N loads.

At higher loads the temperature of the sliding surfaces increases which leads to higher wear rates. But due to hard particulate reinforcement in the composites, it restricts the composites from getting soft. Further increased sliding distance reduces the wear rate and after a particular sliding distance.

The wear rate remains almost unchanged as shown in Figure 7 to Figure 8. This clearly reflects that the wear stabilization occurs at a critical point and such corresponding sliding distance and the wear rate are considered as critical, beyond which the wear stabilization occurs.

— Effect of applied load on wear rate

The applied load is the most dominating factor which controls the wear behavior. Figure 9 to Figure 10 shows the effect of applied on the wear rate of 7075 HAMMCs and heat treated 7075 HAMMCs. The wear rate varies with the normal load. It was seen that at high loads the wear rate was increased in both 7075 HAMMCs and heat treated 7075 HAMMCs with the increase in load the wear rate was increased. The decrease in wear rate was observed with the increase in the percentage of SiC and Al_2O_3 reinforcement up to 10 wt%.

The wear rate was significantly lower in heat treated 7075 HAMMCs when compared with the 7075 HAMMCs, from Figure 9a, for sliding velocity 0.9424 m/s. Wear rate decreases as the % of reinforcement increases up to 10%. From Figure 9b, for sliding velocity of 1.884 m/s. Wear rate will be less for 10% reinforcement of silicon carbide and aluminium oxide. From Figure 9c, for sliding velocity 2.827 m/s, wear rate will be less for 15% reinforcement. But when 6kg load is applied the wear rate will decreases for 10% reinforcement sic and alumina. According to several authors with an increase in load, increase in wear rate was observed. At higher loads the contact surface temperature increases.

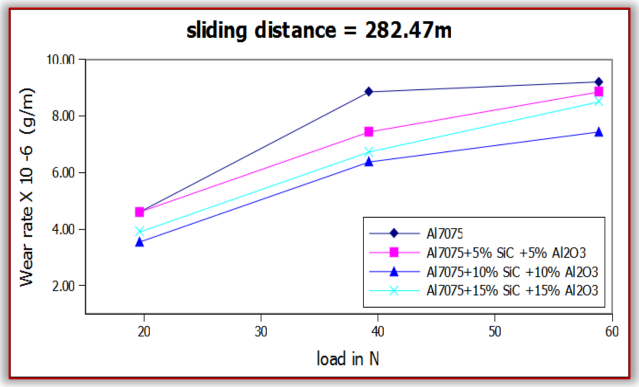


Figure 9a. Effect of load on rate of wear of HAMMCs for a speed of 200 RPM [as–cast]

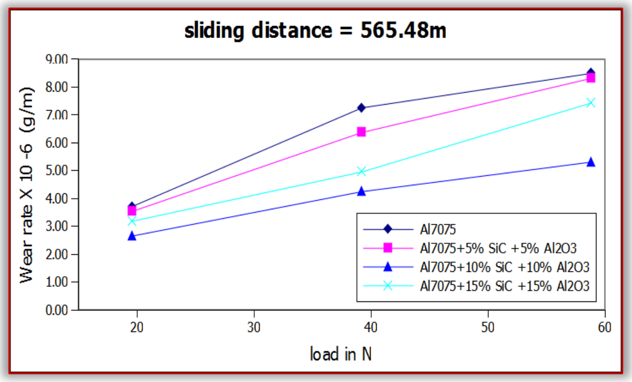


Figure 9b. Effect of load on the rate of wear of HAMMCs for a speed of 400 RPM [as–cast]

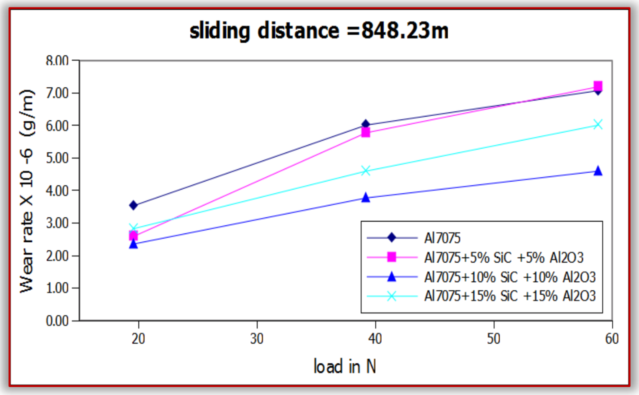


Figure 9c. Effect of load on the rate of wear of HAMMCs for a speed of 600 RPM [as–cast]

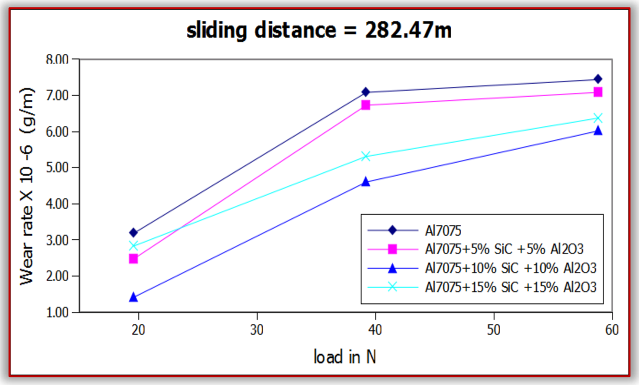


Figure 10a. Result of load on the rate of wear of HAMMCs for a speed of 200 RPM [age hardening]

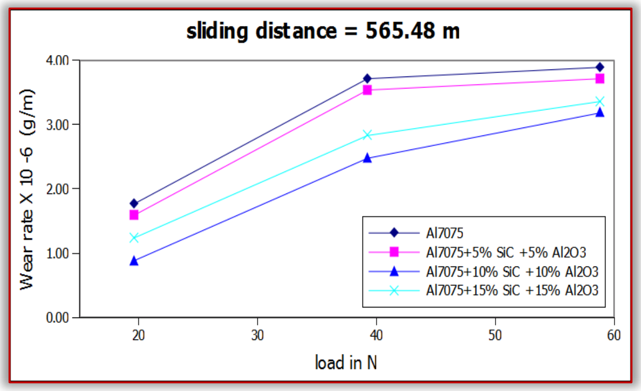


Figure 10b. Cause of load on the rate of wear of HAMMCs for a speed of 400 RPM [age hardening]

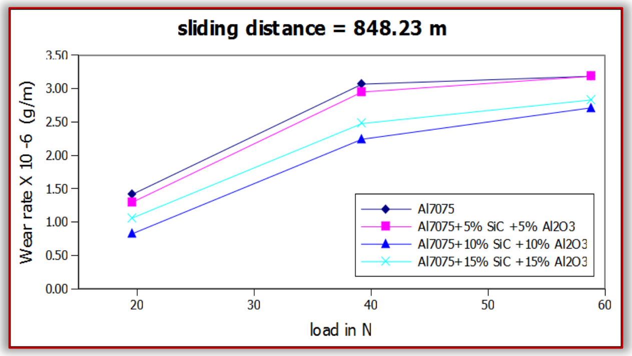


Figure 10c. Cause of load on the wear rate of HAMMCs for a speed of 600 RPM [age hardening]

From Figure 10a, for, sliding velocity 0.9424m/s, wear rate decreases as the % of reinforcement increases up to 10%.From Figure 10b, for, sliding velocity 1.884 m/s Wear rate will be less for 10% reinforcement of silicon carbide and aluminium oxide. From Figure 10c, for, sliding velocity 2.827 m/s wear rate will be less for 5% reinforcement at 4kg of load. But when 6kg load is applied the wear rate will decreases for 10% reinforcement. In the present investigation similar trend was observed. The enhancement of hardness of the composites in improvement of wear and seizure resistance.

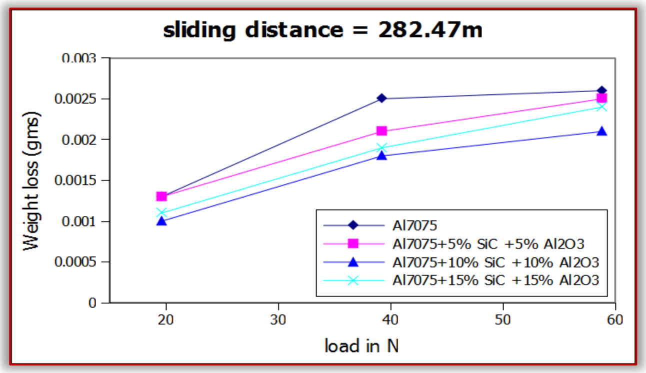


Figure 11a. Result of load on weight–loss of HAMMCs for a speed of 200 RPM [as–cast]

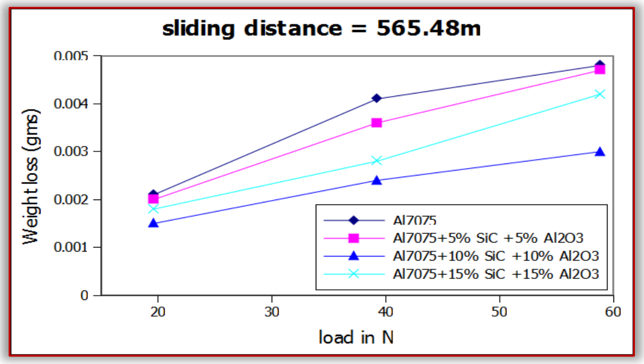


Figure 11b. Outcome of load on weight– loss of HAMMCs for a speed of 400 RPM [as–cast]

From Figure 11a, for sliding velocity 0.9424m/s, the weight loss will be less for 10% reinforcement when speed of 200 RPM is applied. From Figure 11b, for sliding velocity 1.884 m/s, the weight loss will be less for 10% reinforcement compared to other percentages of reinforcement when 6kg load is applied. From Figure 11c, for sliding velocity=2.827m/s. The weight loss will be less for 15% reinforcement when 4kg of load is applied but when the load is increased to 6kg the weight loss is reduced for 10% reinforcement.

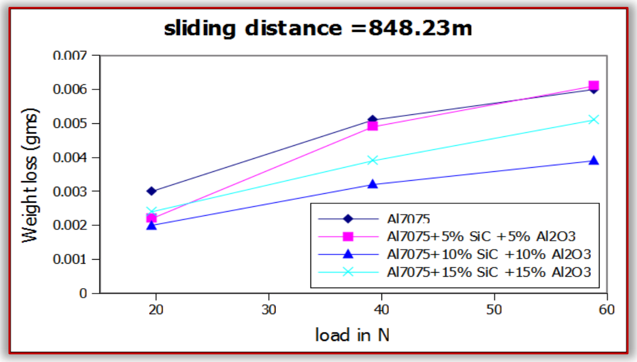


Figure 11c. Outcome of load on weight loss of HAMMCs for a speed of 600 RPM [as–cast]

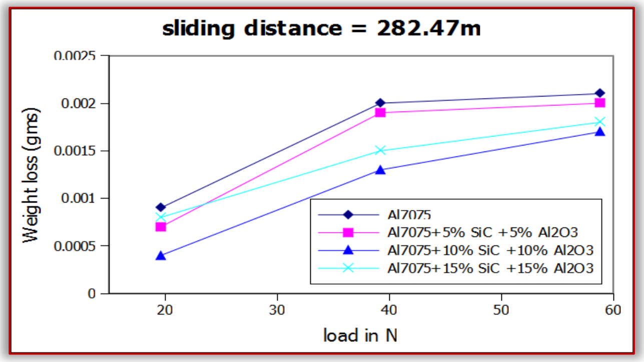


Figure 12a. Outcome of load on weight loss of HAMMCs for a speed of 200 RPM [age hardening]

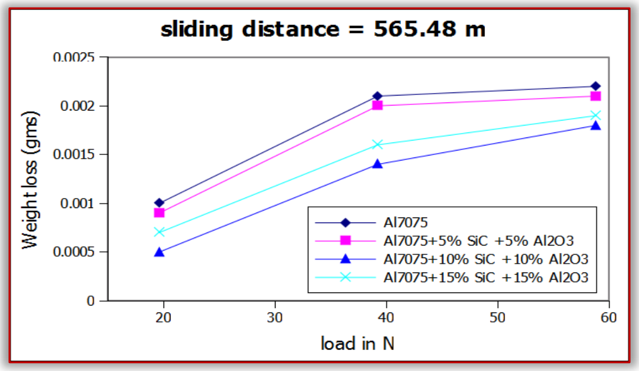


Figure 12b. Outcome of load on weight–loss of HAMMCs for a speed of 400 RPM [age hardening]

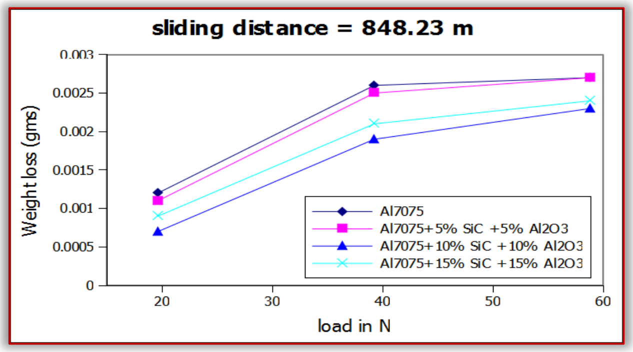


Figure 12c. Outcome of load on weight –loss of HAMMCs for a speed of 600 RPM [age hardening]

Friction coefficient reduced with an increment in percentage volume of Sic particles, wear and friction in Copper reinforced Al_2O_3 composites and reported the decreased coefficient of friction with increase in alumina content. From Figure 12a, for sliding velocity 0.9424m/s. The weight loss will be less for 10% reinforcement when 4kg of load is applied. From Figure 12b, for sliding velocity of 1.884 m/s, the weight loss will be less for 5% reinforcement compared to other percentages of reinforcement when 6kg load is applied. From Figure 12c, for sliding velocity 2.827m/s, the weight loss will be less for 5% reinforcement when 4kg of load is applied but when the load is increased to 6kg the weight loss is reduced for 10% reinforcement.

CONCLUSIONS

From the investigation the following conclusions were drawn on the mechanical and wear performance of as–cast and T6 aging of HAMMCs–Al7075–SiC–Al_2O_3. Wear resistance of Al7075/Al_2O_3+SiC composites incremented with weight percentage. The reduction in rate of wear with sliding distances, composition. It enhances with loads for age hardening & without age hardening. The age hardened Al–7075/Sic+Al_2O_3 Composite shows excellent resistance to wear while compare to Al7075/ Al_2O_3+SiC it has the distinctive property as addition of Silicon–carbide and Aluminium–oxide. The microstructural characterization discovered that the homogeneous circulation of the particle in the matrix system with minimal amount of porosity. The micro–structural study of SEM and EDX techniques shows the homogeneous distribution of the particulates in the hybrid composites.

In T6 heat treated (age hardening) Al7075–10wt%SiC+10wt% Al_2O_3 HAMMCs, improved the wear resistance was observed when compare with base alloy. Highest resistance to wear was observed in Al7075–10wt%SiC+10wt% Al_2O_3 due to the presence of reinforcements. Further decrement in wear rate with increment in weight percent of reinforcement for the desired sliding distances. From the investigation, it was concluded that, composites containing 10% weight of silicon carbide and 10% weight of aluminium oxide reinforcements with ageing exhibited superior mechanical and tribological properties.

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