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Research Paper

Aluminum metal matrix composites a review of reinforcement; mechanical and tribological behavior.

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Abstract

This review aims to explore the fundamental mechanical and tribological behavior Aluminum matrix composites (AMCs) reinforced with different reinforcements. Aluminum matrix composites are considered to be the new emerging class of materials which are having the tailored properties for specific applications. AMCs are the advanced engineering materials having superior properties as comparison to other conventional aluminum alloys. AMCs exhibits attractive properties such as high hardness, better yield strength, strength to weight ratio, high thermal conductivity, low coefficient of thermal expansion, superior wear and corrosion resistance. In recent times, because of these properties they have repealed keen interest for various potential applications in aerospace, automotive and various other structural applications.. Extensive research and development has been made in the Al-based MMCs with every possible alloy and different reinforcements so as to get the material of desired properties. By suitable use of different reinforcements in the Al metal matrix a wide range of properties combination can be obtained. The fundamental mechanical and tribological behavior of different reinforcements under dry and wet lubricated sliding conditions is recently being studied. It is reported that various reinforcement were successfully employed to decrease friction and wear in various applications. A comprehensive review is provided with the aim to analyze such properties of different reinforcements.

Keywords: Metal Matrix Composites (MMCS); Aluminum Matrix Composites (AMCS); Reinforcement; Wear; Coefficient of Friction (COF).

1. Introduction

A composite material can be characterized as a combination of at least two materials that outcomes as preferable properties over those of the individual segments used alone. Rather than metallic alloys, every material holds its different chemical, physical, and mechanical properties. The fundamental advantage of composite materials is their high quality and solidness, consolidated with low density, when contrasted with mass materials, allowing for a weight reduction in the completed part [1]. The composite materials have received an extraordinary consideration in a couple of years, because of having unordinary properties, sometimes interesting, which could lead to various applications in innovation domain. Their properties rely upon the particle size and accordingly the dispersion level of composite particles is a factor that influencing the composite properties. A factor that impacts the properties of the composite materials is the communication surface between the host matrix and particles. The composite material is made of a base material called matrix which has low properties, yet ease cost price, reinforced with different materials in the form of continuous fibres, short fibres or particles with mechanical physical or chemical properties [2]. From the nature and morphology of the composites, their behaviour and properties can be anticipated, and the factors such as inborn properties, basic course of action and the connection between the constituents are of much importance. The inborn properties of constituents decide the general request of properties that the composite will display. The interactions of constituents bring about another set of properties. The shape and size of the individual constituents, their structural arrangements and distribution and the relative measure of each contribute to the general performance of the composite. The factors that decide properties of composites are volume part, microstructure, homogeneity and isotropy of the system and these are strongly affected by extents and properties of the matrix and the reinforcement. The properties such as Young's modulus, shear modulus, Poisson's proportion, the coefficient of friction and co efficient of thermal expansion are anticipated regarding the properties and focus.

2. Mechanical behavior of composites

2.1. Hardness

Hardness of the composite depends on the particulate reinforcements with low aspect ratio. The hardness of the MMCs is measured on the polished sample using Zick/Roll Micro hardness tester. The tests were carried out by applying an indentation load with the Vickers indenter. Many researchers contributed a lot regarding the effect of particulate reinforcement on the hardness of the AMCs and HAMCs which have been summarized. Rajmohan et al., [3] investigated the hardness value of the Al-composites reinforced with fixed amount (10%) of SiC particles and different mass fraction of mica particles. The results showed that the maximum hardness value is achieved with 3% mica particles after that the hardness value of the composites goes on decreasing. He also suggested that the low hardness and strength of a composite is favourable for good machining characteristics. Suresha and Sridhara[4] in their research observed that the hardness value of the hybrid aluminium based composite reinforced with SiC and Graphite particles increased up to 2.5 wt% reinforcement content for both reinforcing materials and then decreased. The increase in hardness may be due to the presence of hard ceramic particles and decrease in the hardness may be due to the soft graphite reinforcement particles. It was also found that the addition of the graphite in the matrix material lead to increase in the porosity of the composite. Boopathi et al., [5] worked on the Al/SiC/Flyash hybrid composite and found that the hardness valve increased as there was an increase in the weight fraction of the reinforcements. They observed that the composite having the composition of Al/10wt% SiC/10wt% FlyAsh exhibit maximum hardness value. This shows that the inclusion of FlyAsh as a reinforcement significantly improved the hardness value of the Al-matrix. Prasad and Shoba[6] reported that the hardness of the pure A356.2 alloy was less than that of hybrid composite (A356.2/x%RHA/x%SiC). They reported that the hardness value of the alloy increased due to addition of the reinforcement. It was also reported that the addition of the reinforcing particles up to 8 wt% increased the hardness value by more than 50%. The increase in hardness may be due to the presence of relatively hard ceramic particles. Prasad et al., [7] in their research measured the BHN of (Al/x%RHA/x%SiC) where x = 0-8 wt% in order to characterize the age hardening behaviour at a temperature of 155˚C. The Al composite was subjected to aging at a load of 500 N. A 30 mm diameter steel ball indenter was used for a time period of 30 s. It was found that the hardness value of the composite increased after age hardening treatment. These investigations and results suggested that the presence of the ceramic particles is beneficial in order to improve the hardness value and resistance of the composites toward dislocations.

2.2. Fracture toughness

Fracture toughness of a composite material is a property which describes the ability of a material containing a crack to resist fracture, and is one of the most important properties of any material for many design applications. Particle cracking, particle debonding or interfacial cracking are some of the primary reasons which may lead to the fracture in the material. Ceramics particles are generally hard and brittle because of this they have fewer tendencies to resist rapid crack propagation. Generally the metallic composites reinforced with hard conventional ceramics possess poor fracture toughness. By investigating and analyzing the results by the different researches it is found that the fracture toughness of most of the engineering materials varies inversely with the yield strength. It has been reported from various researches that the presence of the Bamboo leaf ash (BLA) and Rice husk ash (RHA) in the AMCs and HAMCs increase the fracture toughness properties of the composites; it might be due to the presence of silica (SiO_2) particles in these compounds. Silica is a soft material as compared to the other ceramic reinforcements such as SiC etc. Alaneme et al., [8] in their research on hybrid aluminum based composites observed that the fracture toughness can be enhanced by increasing the content of BLA in the Al/SiC/BLA hybrid Composite. Alaneme et al., [9-10] made another research in order to determine the fracture toughness value of HAMCs. They used load extension plot to determine the fracture toughness of the composite. Ravesh and Garg[11] in their research reported that there is an increase in the fracture toughness of the Al/SiC/Flyash composite with the increase in the weight percentage of reinforcements. They observed that the maximum value for toughness was obtained for the composite containing 10 wt% SiC and 5 wt% Flyash content.

2.3. Tensile strength

AMCs have two types of strengthening mechanism i.e. direct strengthening and indirect strengthening. Chawla and Shen[12] reported that the direct strengthening can be achieved by the addition of hard and stiff reinforcement in the soft matrix. Due to this hard reinforcement in the matrix the applied load is transferred from the matrix to the reinforcement, this increased the resistance of composite to plastically deform during external loading. The reason for the indirect strengthening was high thermal mis-match between the matrix having higher coefficient of thermal expansion (CTE) and the reinforcing particles having lower CTE during the cooling and solidification. As the temperature changes, it generates the thermal stresses in the composite that lead to the formation of dislocations at the matrix/reinforcement interface. This increase in the dislocation density leads to the improvement in the strength of the composite. It is also observed that the increase in the reinforcement or the decrease in the particle size of the reinforcing material leads to increase in the dislocation density hence strength increases. Boopathi et al., [5] in their investigation reported that the strength of the HAMCs reinforced with SiC and FlyAsh increased by addition of the reinforcements. The tensile strength of the composite is more than that of unreinforced alloy. Results shows that the tensile strength of unreinforced alloy is 236 N/mm2 and this value increases to 263 N/mm2 for the Al/10% FlyAsh composite, 265 N/mm2 for Al/10% SiC composite and further increases to 293 N/mm2 for Al/10% FlyAsh/10% SiC composite. Rajmohan et al., [3] in their research found that the tensile strength of the Al-composite reinforced with SiC (10 wt% fixed) and mica (0,3 and 6 wt%) increased with an increase in the mica mass fraction up to 3 wt% after this limit exceeds, there was a dip in the tensile strength at 6 wt% of mica. Prasad et al., [7] observed and reported that the yield strength (YS) and ultimate tensile strength (UTS) for (Al/ x%RHA/ x%SiC) where x = 0-8 wt% hybrid composite increased with the increase in the weight fraction of the reinforcements and there was a decrease in the elongation percentage of the composite. This may be due to the presence of hard ceramic phase in the composite, which increases brittleness and decreases elongation in composite.. From these studies, it has been reported that the strengthening of composites was due to the increase in the reinforcement percentage or due to the difference in CTE which led to the increase in the dislocation density and hence improved the strength of the composite.

3. Tribological behavior

The gradual removal of material from solids surface is termed as wear. The separated material become loose wears debris. Wear is a continuous loss of material due to rubbing action between the two contacting surfaces. Wear may be due to micro-cracks or by localized plastic deformation. Wear may be due to many physical, mechanical or chemical phenomenon. Abrasive, adhesion, corrosion, oxidation, fretting, fatigue and erosion are the different kind of wear that leads to material removal [14]. It is difficult to completely nullify the effect of wear, but we can reduce the friction and wear by means of lubrication, by formation of smooth surface, by modification of components material rubbing against each other and by correct assembly of fitted components parts. Aluminum alloy have two basic wear mechanisms i.e. oxidation mild wear and metallic severe wear [15-16]. The beginning of the severe wear is taken as the start of the seizure and the point is designated as point of seizure. Many studies are conducted in order to investigate the effect of applied load, sliding velocity and alloys composition on seizure resistance. Applied load and sliding velocity influence the point at which seizure start but has no effect on the mechanism of seizure [17]. Addition of silicon in the aluminum alloys results in improving the wear resistance of the composite material. Many researchers contributed a lot to investigate the tribological properties of AMCs and HAMCs out of which few have been summarized. Moustafa and Soliman[18] investigated the wear loss of Al-Cu material. It was reported that the wear rate of the Al-Cu material is 2×10-3 mm3/m. Wear loss reduced to 0.5×10-3 mm3/m when reinforced with 30% of Al_2O_3 reinforcement particles. The test was performed under dry test conditions at 10 N load, 3.6 m/s sliding speed. Prasad et al., (2014) investigated that the wear loss for the Al-Cu material was 7×10-12 mm3/m and

4 mm3/m for 10% SiC reinforced Al/Cu material. The test were performs under dry sliding conditions with speed of 1 m/s over a sliding distance of 500 m. Yalcin and Akbulut[19] observed a wear loss of 18 mm3/m for A356 Aluminum alloy which was reduced to 12 mm3/m for the Al composite reinforced with 5% SiC particles. The wear tests were performed under dry sliding conditions at 5 N load 0.4 m/s speed for 1000 m sliding distance. Gurler et al., [20] in their investigation reported that the wear strength increase with an increase in the particle reinforcement. The obtained wear resistance was reduced by 50-400% by particle reinforcement. It was observed that the wear loss was 35 mg for the AlMgSi material which further improved by the addition of 3 to 5 % of SiCpas reinforcement. The wear loss reduced to 25 mg and 20 mg for 3 and 5 % of SiCp respectively. The wear test were performed on the pin on disc apparatus under dry test conditions with speed 2.64 m/s and sliding distance of 3200 m. Reihani et al., [21] studied the wear behavior of Al6061 with or without reinforcement. SiC is used as the reinforcing particles. It was reported that the wear loss was 3 mg for the Al6061 base alloy which was reduced to 1.2 mg for the composite material when reinforced with 30% SiC particles. The wear tests were performed under abrasive wear test conditions at 150 N load and at 2000 rpm. Lim et al., [22] studied the wear behavior of Al-Cu/SiC composite material with 13% of SiC as reinforcement. The wear tests were performed at speed of 1m/s sliding distance of 1000 m with varying load under dry testing conditions. It was reported that the wear loss was 3 mg at 30 N load, 4 mg at 50 N load and 5 mg at 70 N load, so it was concluded by the author that the wear rate increased with the increase in the applied normal load. Hosking et al., [14] in their study, continuously increased the transition load with the increasing silicon content. It was observed that oxidation wear appeared to be independent on both silicon content and the size of silicon particles in the composite.N.Natarajan et al., [23] in their study presents, the friction and the wear behaviour of Al MMC, grey cast iron and the semi-metallic brake shoe lining at different sliding velocities, loads and sliding distances. The worn surfaces and sub-surface regions of MMC, the cast iron and the lining have been analyzed using optical micrographs. The investigation shows that the MMCs have considerable higher wear resistance than conventional grey cast iron while sliding against automobile friction material under identical conditions.

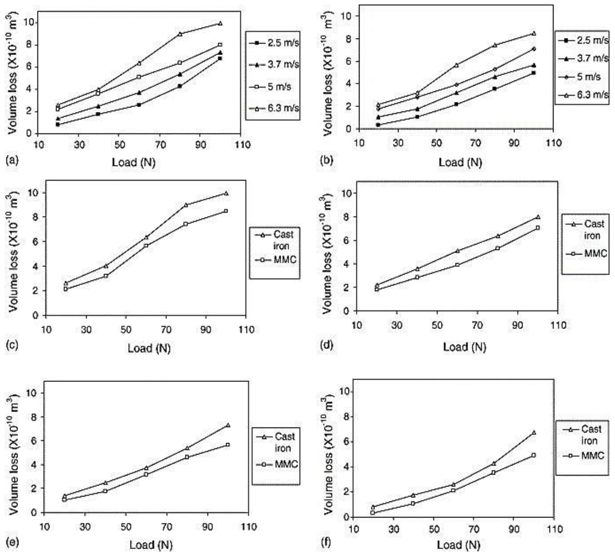

Fig. 1: Variation of Wear in Cast Iron and MMC with Applied Load. (A) Cast Iron, (B) MMC, (C) Wear at 6.3 M/S, (D) Wear at 5 M/S, (E) Wear at 3.7 M/S, (F) Wear at 2.5 M/S. [23]

4. Reinforcements in Amcs and Hamcs

Different reinforcing materials are used in the development of the MMCs. Reinforcements can be produced in the form of particles, whiskers, short fiber and continuous fiber. Particles or discontinuous are the important reinforcement phases that uniformly distribute in the matrix material because they have relative good isentropic properties compared to other types of reinforcements. Particles-reinforced MMCs are used mostly in the piston, cylinder liners and breaks materials in the automotive sector because of their attractive friction and wear properties. AMCs and HAMCs are manufactured by blending ceramic, synthetic,industrial waste and agro waste reinforcement's particles in micro and nanoscale within the matrix material. Addition of hard reinforcement in the matrix improves four to ten times wear resistance in comparison to unreinforced composites [17], [25].

AMCs and HAMCs made with the SiC reinforcement particles have low density as well as weight; they have high strength at elevated temperature, high hardness and stiffness and also have improved wear resistance. Hosking et al., [14] reported that at low load the wear resistance effectiveness of the SiC particles was much better than that of Al2O3 particles. G.B. Veeresh Kumar et al., [26] in their investigation on Al6061/SiC and Al7075/Al2O3 composites observed that the composites show better wear resistance as compared to alloy. It was also reported that the addition of SiC particles showed better wear resistance in comparison to the Al2O3 particles. Sahin et al., [27] worked on the abrasive wear performance of Al/SiCp composite. It was observed that the wear rate increased linearly with the applied load and sliding distance for SiC emery paper but decreased for Al2O3 emery paper. S. Mahdavi et al., [28] investigated the wear properties of aluminum alloys based on the size of the reinforced particles (19, 93, 145 µm). They also investigated the wear behavior of Al6061/10vol% SiC and Al6061/10vol% SiC/5vol% graphite. It is also observed that the wear rate of the composite material was less in comparison to the alloy material. It was found that the adhesion is the main reason for the wear of the unreinforced alloy material. In case of the composite and hybrid composite material abrasive and delaminating wear are the main reason for the wear phenomenon. It is due to the fact that the hard ceramic particles present in the composite changes the wear mechanism from adhesion to abrasive wear. Mahdavi and Akhlagi[29] studied the effect of SiC particle (0-40 vol%) of size 19 µm along with 9 vol% graphite on Al6061 alloy by using powder metallurgy and stir casting fabrication route. It was concluded that the wear resistance and higher hardness value can be achieved for the HAMCs as compared to unreinforced aluminum alloy. It was reported that there was an increase in the volume loss and wear rate by 76% with the increase in the SiC volume fraction by 20-40 vol% where as the COF reduced by increasing the SiC particles up to 30 vol%. Ma et al., [24] investigated the wear properties of A390 aluminum alloy reinforced with SiC particles ranging (20-50 vol %). It was reported that the composite with 50 vol% of SiC particles exhibit lower wear rate compared to 20 vol% SiC reinforced particles. Ravindran et al., [30] studied the microstructure and mechanical properties of hybrid aluminum based nano-composite. The composite contained 5% of SiC and graphite (Gr) varied from 5-10 vol%. It was reported that the increase in the reinforcement percentage increased the mechanical properties of the composite. Composite with composition Al/5% SiC/10% Gr has the best hardness value, wear resistance and highest strength. They reported that the loss in the material and COF were mainly influenced by the applied load and the sliding distance.

D Garbies et al., [23] studied the behavior of Al/Al2O3 composite material fabricated by using spark plasma sintering technique. The reinforcement content varied from [5] vol% to 20 vol%. It was reported that the increase in the reinforcement enhanced the mechanical and wear properties of the composite material. It was due to the presence of hard ceramic particles in the aluminum. The study showed that the maximum hardness (1355 MPa) and compressive strength (246 MPa) value was achieved with 20 vol% of the Al2O3 content in the composite. Devaraju et al., [31] investigated the effect SiC/Gr and SiC/Al2O3 on the Al6061-T6 alloy. It has been reported that there was proper distribution of the reinforced particles in this hybrid composite. Friction stir processing technique was used to fabricate the samples. The hardness of the

Al6061-T6 / SiC/Al2O3 was better than the other hybrid composite but it has less wear resistance as compared to the composite which contained graphite because graphite acted as a solid lubricant. Umanath et al., [32] studied the dry sliding wear of aluminum alloy reinforced with SiC and Al2O3 particles. It was reported that this hybrid composite showed a significant improvement in the wear resistance of the composite. It was observed that the increased in the composite led to increase in the mechanical properties and the wear behavior of the composite. Ramnath et al., [33] studied the mechanical properties of the HAMCs reinforced with Al2O3 and B4C. The HAMCs exhibited higher impact strength and superior hardness then the unreinforced composite but slightly less tensile strength and flexural properties. It was reported that the poor stirring and uneven distribution of the reinforcement was the reason behind these results. Ramachandra et al., [34] in their investigation studied the hardness and wear resistance of aluminum matrix composite reinforced with nano zirconium dioxide (n-ZrO2). It was reported that there was an increase in both the mechanical and tribological properties of the composite as compared to the unreinforced aluminum metal. Lakshmanampoovazhagan et al., [47] in their investigation fabricated the test sample of Al/ nano B4C MMNCs by using ultrasonic assisted casting process. This fabrication route was adopted to enhance the uniformity of the reinforcement particles in order to get the better mechanical properties. It was reported that there was a significant reduction in the grain size of Al6061/2% B4C and reduction in the grain size increased the ability of the material. C. Antony Vasantha Kumar et al., [35] studied the role of rutile (TiO2) in the enrichment of micro hardness and tribological properties of aluminum based composite. Al was reinforced with different reinforcement content (0, 4, 8, 12 % mass fraction). Wear test were performed under dry sliding conditions. TiO2 offer promising wear and micro hardness properties. Increase in the (TiO2) content decreased the porosity of the composite hence higher micro hardness is achieved. The composite reinforced with 12% TiO2 shows good wear resistance. Delaminating wear and adhesion wear, the two prominent type of wear occur in this composite material. It was also reported that there was the presence of oxide phase on the worn surface and wear debris. Minimum oxide phase was present in 12% TiO2 reinforced composite which designate good thermal stability of the composite. Y. Zhu et al., [36] in his study on the wear analysis of Al/ TiO2 concluded by saying that TiO2 film formed on the worn surface decreased the coefficient of friction as well as the wear rate. They also recommended this material for the aerospace, automotive and structural applications because of its superior tribological properties. Amal e. Nassar et al., [37] studied the behavior of pure nano aluminum reinforced with nano titanium dioxide (n-TiO2) as reinforcement on the mechanical and tribological properties of the composite. It was reported that there was an increase in the porosity, tensile strength and hardness of the composite with an increase in the volume fraction of the nano-reinforcement but the ductility of the composite decreased. Maximum hardness value is observed at 4.5 vol% of reinforcement. It was also observed that the wear resistance of the composite also increased due to nano-reinforcement.

HAMCs and AMCs are now days are also fabricated using synthetic and industrial waste as reinforcements. Low cost and low density with good properties are the most attractive benefits of these reinforcing materials. Flyash and Red Mud are the two typical industrial wastes from the power plant and other industries. These wastes have been suggested as good reinforcement which can be used in aluminum based composites. Flyash is produced due to the combustion of the coal. The principal oxide present in Flyash includes Al2O3, SiO2, and Fe2O3 where as some other oxides such as K2O, NaO, MgO are present in traces. Anilkumar, H.C. et al., [38] studied the effect of flyash particles on the mechanical properties of the Al6061 alloy composite. It was reported that the mechanical properties increased with an increase in the reinforcing content and decreased with the decrease in the particle size of the reinforcement. It was also reported that the ductility of the composite increased with the increase in the particle size of the flyash and decreased with an increase in the vol% of the reinforcement. Prasad and Subramanian [7] investigated the tribological properties of AlSi10Mg/Flyash/Gr hybrid composite. It was found that there was an improvement in the mechanical properties and wear resistance of the composite. The increase in the wear resistance was attributed to the load bearing capacity of the FlyAsh and lubricating effect of Graphite. It was also reported that the further increase in the Flyash content decreased wear resistance of the composites. Moorthy et al., [39] investigated mechanical properties and dry sliding wear behavior of Al/FlyAsh/Gr hybrid composite using Taguchi optimization method and reported that the load was the most important factor that affected the wear rate of the composite followed by sliding speed and flyash content. It was reported that the increase in the FlyAsh content increased the hardness of the composite. FlyAsh content also vanquished interfacial reaction between the matrix and the reinforcement. Uma Shankar et al., (2012) investigated the effect of the glass particles on the mechanical properties of the Al6061 alloy. It was found that there was an increase in the mechanical and microstructure properties of the composite reinforced with glass fiber.

Another new generation AMCs and HAMCs are developing now days using agro based reinforcements which act as a complimentary reinforcement to the synthetic reinforcements. These reinforcements have some advantages which include low cost, low density, reduce environmental pollution and its accessibility. These agro wastes have been processed in to ash and then used as a reinforcing phase material. These reinforcements includes; rice husk ash (RHA), bamboo leaf ash (BLA), bagasse ash (BA), palm kernel shell ash (PKSA), maize stalk ash (MSA), corn cob ash (CCA), bean shell waste ash (BSWA) etc. Alaneme and Adewale [40] studied the mechanical behavior of Al6063 aluminum alloy reinforced with silicon carbide (5, 7.5,10 wt %) and RHA. It was reported that the mechanical properties like tensile strength, specific strength and yield strength of the composite increased with the increase in the wt% of the reinforcing particles but fracture toughness decreased with an increase in the reinforcement. The author reported that the reinforcing particles did not affect the ductility of the material and percentage elongation. It was also observed that increase in the RHA content reduced the yield strength, UTS and specific strength of the composite. Hardness value and the elastic modulus reduced, it might be due to the presence of silica in RHA as silica is less hard than that of Silicon Carbide. Alaneme et al., [41] investigated the effect of the BLA on the corrosion performance of the aluminum based composites. It was reported that BLA improved the corrosion resistance of the composite; it was due to the presence of 50% silica in the BLA which might have the potential of suppressing the Al4C3 phase during the fabrication.

5. Applications

Metal-Ceramic particles composites have huge potential applications as anti-friction and anti-abrasion material. AMCs and HAMCs have applications in the aerospace, automotive and structural sector. They are primarily developed for aerospace applications but now days find large applications in the automotive industries. In automotive power train, aluminium castings have been utilized for the cylinder, chamber liners, barrel heads, wheels, sections, brake parts, suspension (control arms, supports), steering segments (air bag support, steering shafts, knuckles, housings, wheels) and instrument boards. Their utilization in the automotive sector reduces mass, increase efficiency and satisfies the main requirement of Fuel economy and vehicle emission. Aluminium alloys have additionally discovered extensive application in heat exchangers. Modern superior vehicles have numerous individual heat exchangers, e.g. motor and transmission cooling, charge air coolers (CACs) made up of aluminium alloys. Aluminum alloys such as hypoeutectic, eutectic and hypereutectic Al/Si alloys are found to be ideal low cost material when reinforced with solid lubricant as an application in automotive sector for the manufacturing of cylinder liners. These alloys have attractive mechanical and tribological properties. This alloy when reinforced with solid lubricants shows anti-seizing and anti-galling properties. Al Alloys with dispersed solid lubricants also find applications in the tribo-systems which run at high temperature because there is a possibility of failure of liquid lubricants.

Table 1: Applications of Amcs and Hamcs Reinforced with Different Particles for Use in Various Sectors. (Macke, A. Et Al., 2012)

Reinforcing Material	Application	Property	Benefits
Micro And Nano Amcs And Hamcs Reinforced With Sic, Al_2o_3/ Gr .	Bearing Surface, Cylinder Liner, Piston, Cam, Drive Shaft, Brake Components.	Wear Resistant, Gall Resistant, Reduce Friction, Seizure Resistant.	Reduced Weight Increased Life Reduced Size Increased Power Output Reduced Wear Reduce Reciprocating Mass Higher Running Temperature.
Micro And Nano Amcs And Hamcs Reinforced With Graphite, Hbn,Tib_2, Mos_2 And Other Solid Lubricants.	Bearing Journals, Cylinder Liner, Pistons, Cv Joints, Gear Surface.	Self-Lubricating	
Micro And Nano Amcs And Hamcs Reinforced With High Conductive Carbon, Diamond, Cbn.	Cylinder Liner, Water Passenger, Brake Component, Turbo/Supercharger.	High Thermal Conductivity	
Micro And Nano Amcs And Hamcs Reinforced With Sic, Al_2o_3, Cnt, In-Situ Ceramics.	Connecting Rod, Brahe Clippers, Brake Rotors, Brake Clippers, Piston Ring Groove, Piston Crown.	High Strength, Fatigue And Creep Resistance, Increased Stiffness.	
Amcs And Hamcs Containing Flyash Or Waste Sand As Filler.	Water Pumps, Valve Covers, Oil Pans, Intake Manifolds	Low Cost.	

6. Conclusion

Friction and wear are caused by complicated and multiplex sets of microscopic interactions between surfaces that are in mechanical contact and slide against each other. These cooperation's are the consequence of the materials, the geometrical and topological attributes of the surfaces, and the general conditions under which the surfaces are made to slide against each other, on account of the system idea of tribological parameters, tabulated friction or wear values for these or some other materials are just important if test conditions are carefully reported. Convincingly, because tribological properties are not materials but rather system parameters, tribotesting must be an essential part of both the way toward creating tribo materials and in the determination of materials for applications including friction and wear. This review presents the contribution of reinforcements to develop AMCs and HAMCs. The reinforcement percentage, type, size, multiple reinforcements and types of aluminum matrix are the crucial parameters for enrichment of the mechanical and tribological properties.It was also reported that the tribological testing parameters like applied normal load, sliding velocity, sliding distance, dry/wet conditions, temperature, counter-face also affect the wear performance of the composites.By altering these parameters, better product performance can be achieved in various fields and applications.

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