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Paper Authors
Mahesh Dangeti

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Properties Investigation Of Aluminium Matrix Based Composite With Different Reinforced Materials- A Review

Mahesh Dangeti
mahesh.mech304@gmail.com
Asst.professor, Department of Mechanical Engineering, Kakinada institute of Engineering and technology, Korangi, Andrapradesh

Abstract:
Aluminum metal grid composites are fundamentally significant in the different requesting fields of medication and designing like aviation, protection, autos, dental and purchaser products. The modern need of good materials with light weight, fantastic properties and minimal expense requested the researchers to explore on composite materials. Among the MMCs, aluminum framework composites (AMMCs) looked for over other customary materials due to their high solidarity to weight proportion, high wear opposition and low monetary. These AMMCs offer a huge assortment of mechanical properties relying upon the compound sythesis of the Al-grid. The support in AMMCs could be as nonstop/spasmodic filaments, hair and particulate as second stage contingent upon their applications and property prerequisites. Expansion of different fortifications, for example, fly debris, TiC, SiC, Al2O3, TiO2, B4C and so on, to aluminum lattice will upgrade the mechanical and tribological properties. This paper endeavors to survey the various mixes of the utilization of supported materials as a building up specialist in various Aluminum lattice compounds in the handling of aluminum metal network composites alongside its properties.
Keywords: Aluminium, fly ash, TiC, SiC, TiO2, B4C.

1. Introduction

Many applications in the electronic and manufacturing industries necessitate components with high electrical and thermal conductivity, as well as excellent corrosion and oxidation resistance and outstanding mechanical qualities. In addition, microstructural stability and high temperature resistance must be maintained. The reason for composite materials' rapid adoption and popularity in engineering and material sciences is that they offer a highly appealing mix of stiffness, toughness, light weight, and corrosion resistant qualities. A composite substance is defined by its name, which implies that it is made up of different materials. When two or more constituent materials with significantly different physical or chemical properties are mixed, they produce a substance with distinctive features that are distinct from the others.

There are twoprincipal classifications, namely casting alloys and wrought alloys, both of them are further subdivided into the categories heat-treatable and non – heat treatable alloys. Thus as has been described above, the alloys from 1xxx to 8xxx series could be classified as non heat treatable or heat treatable.

Classification	Alloys
Non – Heat Treatable	1xxx, 3xxx, 4xxx, 5xxxx, 8xxx series alloys
Heat Treatable	2xxx, 6xxx, 7xxx series alloys

Table 1. Heat Treatable and Non- Heat Treatable Alloys

Aluminum alloys are classified as heat treatable or non - heat treatable, depending on whether or not they respond to precipitation hardening. Heat treatable alloys are also produced by the addition of alloying elements to the pure aluminium. These elements include copper (2xxx series), magnesium and silicon, which is able to form the compound magnesium silicide (6xxx series), and zinc (7xxx series). The heat treatable alloys contain elements that decrease in dissolubility with decreasing temperature and in concentrations that exceed their balance solid dissolubility at room and fractionally higher temperatures. A normal heat treatment cycle includes a solutionizing soak at high temperature to maximize dissolubility, followed by quick cooling or quenching to a low temperature to obtain a solid solution supersaturated with both solute elements and vacancies. 1xxx – 3xxx and 5xxx series alloys are designated to the major non–heat – treatable aluminium. These alloys consist of the pure aluminum alloys (1xxx series), manganese alloys (3xxx series), silicon alloys (4xxx series) and magnesium alloys (5xxx series). Differently from the heat treatable alloys, which welded strength from precipitation hardening, the non-heat-treatable

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alloys are strengthened by elements in solid solution and dislocation structures introduced by cold rolling.

2. Strength properties

BalarajuAnkam et al investigated the mechanical properties of AA7068 reinforced with TiC and Gr hybrid composites and found that it has higher ultimate tensile strength than unreinforced aluminium alloy. The highest content of graphite added specimen AA7068-7.5 percent Gr-2.5 % TiC gave high tensile strength, and the hardness of the reinforced composite gave good results when compared to unreinforced metal. Hardness increases are clearly visible in hybrid composite metals. The composite with the highest TiC content, AA7068-2.5 % Gr-7.5 % TiC, had the highest hardness of all the composites. In addition, AA7068 alloy reinforced with a high TiC content and a low Gr content outperformed all other reinforced and unreinforced metals in terms of wear resistance. Because TiC has a higher hardness, the wear resistance of AA7068-2.5 % Gr-7.5 % TiC has increased.AkhileshSoni et al. discovered that the mechanical properties of the hybrid composite vary with the weight percentage of reinforcement. When incubated with 1 wt. % TiB2 and 2 wt. % fly ash, the hardness, tensile, and compressive strength improve by 50.22 %, 94.5 %, and 6%, respectively.Ravindra Sagar et al. tested the hardness of aluminium LM13 alloy and aluminium LM13/MgO particulate composite before and after heat treatment. When compared to aluminium LM13 alloy, aluminium LM13/MgO particle composites had a considerable increase in hardness. Warmth treatment greatly impacts Brinell hardness of Aluminum LM13 alloy and its composites, and it has been successfully generated with genuinely uniform scattering of MgO particles using the vortex technique. The highest hardness of matrix alloy and its composites was achieved by ice extinguishing followed by simulated ripening for 6 hours.Mohammed Naveed et al. aims at developing aluminium based hybrid metal matrix composites containing both silicon carbide and graphite and characterize their mechanical properties by subjecting it to heat treatment. Results indicate that increase of graphite content increases wear resistance of hybrid composites reinforced with constant SiC reinforcement. Further heat treatment has a profound influence on the wear resistance of the matrix alloy as well as its hybrid composites. For all the heat treatment processes studied ice quenching with ageing duration of 6hrs resulted in improved wear resistance of both the unreinforced matrix alloy and its hybrid composites.Manjunatha et al. examined the mechanical characterisation of Aluminum 6061 alloy composites supplemented with Mg, and varied weight % of TiB2 particles were successfully produced utilising halide salts in an in-situ reaction procedure. The inclusion of TiB2 particles increases the load carrying capacity of 3, 6, 9, and 12 wt. % TiB2 when compared to the base alloy, according to the results. The uniform distribution of TiB2 particles and fine size of TiB2 particles generated during the in situ procedure improve load carrying ability. The composite's tensile strength was substantially higher than that of the matrix alloy. Composites, on the other hand, were less ductile than the matrix alloy.Rama Rao et.al. studied the fabrication and mechanical properties of aluminium-boron carbide composites. The aluminum alloy-boron carbide composites were fabricated by liquid metallurgy techniques with different particulate weight fractions (2.5, 5 and 7.5%).The authors observed that Uniform distribution of the boron carbide particles in the matrix phase, hardness of the composites increased and density was decreased with increasing the amount of the boron carbide in the matrix phase.Mahendraboopathi.M et al. investigated the mechanical characteristics of aluminium alloy 2024 hybrid metal matrix composites augmented with silicon carbide and fly ash. A two-step stir casting procedure was used to successfully manufacture Al-SiC, Al-fly ash, and Al-SiC-fly ash composites. Optical micrographs revealed that both SiC and fly ash particles were distributed equally in the aluminium matrix, according to the author. They found that increasing the areafraction of reinforcement in the matrix increased the tensile strength, yield strength, and hardness of the hybrid composite. They also discovered that increasing the percentage of SiC and fly ash in the hybrid MMCs reduces the rate of elongation substantially.Dora Siva Prasad et al. examined the mechanical characteristics of aluminium hybrid composites. They used a double stir casting process to make aluminium hybrid composites reinforced with varied volume percentages of Rice hush ash (RHA) and SiC particles in similar amounts (2, 4, 6, and 8wt %). They discovered that they could easily synthesise up to 8% rice husk ash and SiC particles. The density of hybrid composites decreases as the percentage of reinforcement increases, whereas porosity and hardness increase, and yield strength and ultimate tensile strength increase as the percentage of reinforcement increases.Viswanathan

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et al. investigated the increase in tensile strength of A356/SiC/Gr composites. The increase in tensile strength is attributable to SiC, which functions as a dislocation barrier. As the reinforcement thickness grows, the inter-particulate distance between the reinforcements grows, increasing the resistance to dislocation. During the assessment of Al6061 with fly ash, Kumar et al. noticed an increase in tensile strength. Three different weight fractions of fly ash were used to reinforce the material: 10%, 15%, and 20%. The increase in tensile strength was attributed to the use of filler fly ash, which has a high strength, but the tensile strength was reduced by more than 15% due to poor wettability. The ultimate tensile strength was discovered to be 192.74 MPa. Kumar and Kanagaraj produced the aluminium hybrid composite of Al6061/silicon carbide/graphite/alumina and concluded that addition of 17% weight fraction of alumina increased the tensile strength but graphite showed no significant change. The reason might be the thermal mismatch which tends to be the major driving force for increasing the dislocation density of the base alloy. Another author Muruganandan et al.combined aluminium 7075 with fly ash and titanium carbide and evaluated that the reinforced aluminium alloy had 32% more tensile strength than the pure form of aluminium due to the hardening of the aluminium alloy by fly ash. Dhanalaxmi et al. performed the processing parameters of LM 9 Aluminium alloy (Al-10%Si-0.6%Mg) with silicon carbide of p-bond. The processing parameters that was considered was the stirring speed. The reinforcement of silicon carbide at different speeds was studied. Ultimate Tensile strength and elongation were recorded at different speeds, and uniform distribution was observed at a speed of 500-550 rpm. Due to the less interfacial reaction, the highest tensile strength was achieved at 800oC. In the matter of tensile strength, both silicon carbide and graphite are prominent reinforcements which improve the tensile strength. Alumina also shows good results but not much has been spoken about it. The addition of other reinforcements such as fly ash and red mud increases the strength up to a point and then drastically decreases. Aigbodian developed an Al-Si-Fe/Rice husk composite, and the results showed that the ultimate tensile strength was highest at 15% rice husk addition. Fatile et al.investigated the microstructure of an Al-Mg-Si alloy containing corn cob ash and silicon carbide. Different combinations of silicon carbide and corn cob ash were tested in terms of density and porosity. The findings revealed that tensile strength declines in a step-by-step manner. Corn cob ash is a new substance in the realm of composites preparation. This is an extremely useful material that is both cost-effective and good for composites.Samuel Dayanand et al. evaluated the microstructure and tensile properties of Al-AlB2 composites generated by the liquid metallurgical technique. The unreinforced aluminium alloy was compared to composite materials having 5Wt % AlB2reinforcement phase. The exothermic reaction between Al6061 and accurately measured estimated stochiometrical amounts of KBF4 halide salt was used to create the composite. Scanning electron microscope microstructural characterizations were explored, and tensile tests were performed to determine the mechanical properties of the composites. The 5 wt.% AlB2 composite resulted in a homogeneous dispersion of AlB2 particles throughout the base alloy, with no evidence of clustering or agglomeration.Vinitha and Motgi examined the parameters of Aluminium 7075 with reinforcements such as silicon carbide, fly ash and red mud. The results of Charpy impact test showed that the impact strength increased with increase in the percentage of silicon carbide but decreased with increase in the percentage of fly ash and red mud. When red mud and fly ash were compared, the former showed more impact strength. The composite of aluminium alloy with silicon carbide as the reinforced material showed that as the content of silicon carbide increased, the impact energy decreased and the reason behind this was the brittle nature of the material. Mohan and Manoharan used wrought aluminium alloy and alumina for the fabrication of composite. This combination was specially made for the applications of the turbocharger. Five specimens were prepared to have different combinations of both the matrix and the reinforced material summing up to 100%. The results of Charpy test evaluated that the weight percent of aluminium and alumina in the ratio of 98:2 showed the highest amount of energy absorbed. The increase in weight percent of alumina results in the increase of impact strength due to the efficient amount of bonding between the matrix and reinforcement Singh et al. Meena et al. analyzed the behavior of the Al6063/SiC composite and performed the Izod test in order to find the effects of impact strength. It was inferred that the impact strength was directly proportional to the addition of silicon carbide in terms of proportions but indirectly in terms of particle size. Mathur and Barnawal developed the composite of Aluminium with 4% of copper and 5% of silicon carbide and found in Izod test that the strength increased as the content of silicon carbide was increased

3. Hardness

P.Naresh et al. investigated Aluminium alloy 7068 of metal matrix composites and Titanium Carbide with different weight percentages (2, 4%, 6%, 8%, and 10%) of Tic by using stir casting technique and investigating Wear analysis with the different weight percent of Tic and experiments will be conducted by the design of experiments (DOE). The Wear, Wear Rate, Wear Resistance, and Sp.wear Resistance of Aluminium 7068 & Reinforcement of Tic were discovered in this inquiry (with a different weight proportions).Lawrance C. A. et al. gave an attempt to fabricate in-situ Al6061-TiB2 metal matrix composite by incorporating halide salts such as potassium hexaflurotitanate (K2TiF6) and potassium tetrafluroborate (KBF4) in the aluminium alloy melt at 850ºC. In order to investigate the degree of in-situ reaction during the formation of Al6061-TiB2 metal matrix composite the melt was maintained at 850ºC with different reaction holding times (RHTs). By incorporating halide salts, potassium hexaflurotitanate (K2TiF6) and potassium tetrafluroborate (KBF4) in the Al 6061 alloy at 850ºC Al 6061-TiB2 metal matrix composites were synthesized successfully, and With increase in reaction holding time, there was an increase in tensile strength and hardness of the composite up to 30 minutes' reaction holding time followed by a decrease in both tensile strength and hardness for the next higher level of 15 minutes' reaction holding time.Singh et al. performed trials of aluminium alloy LM 6 with the increase in weight fraction of silicon carbide and alumina and found that increase in weight fraction resulted in increase in the Rockwell hardness number. The reinforcement of fly ash with Al6061resulted in the increase in hardness throughout because of the hard fly ash particles.Rasidhar et al. fabricated an Al-based nano-composite with Ilmenite as reinforced material. High energy ball milling was done prior to the stir casting. The results showed that the maximum hardness was obtained at 5% wt. of nano-composite.Saheb had developed aluminium matrix composites with particulates of silicon carbide and graphite in order to obtain a homogeneous dispersion. The experiments had been conducted with varying weight% of silicon carbide and graphite which resulted in the increase in hardness with the increase in weight%. The best results were obtained at 4% and 25% weight fraction of graphite and silicon carbide respectively.Basavaraju et al. prepared a hybrid metal matrix composite of aluminium LM25 with the reinforcement of silicon carbide, graphite and fly ash and found that the Brinell hardness increased till 4% reinforcement and then decreased.Alaneme et al. studied the microstructural characteristics of alumina, rice husk and graphite and observed that with the increase in weight fraction of rice husk, hardness decreases but becomes less effective with more than 50% of rice husk ash.N. Fatchurrohman et al. investigated the solidification properties of titanium carbide particle reinforced aluminium alloy matrix composites. They used an aluminium 11.8 % silicon alloy (LM6) specimen as the matrix material, which was then reinforced by gravity casting with weight fractions of 5 and 15% titanium carbide particulate (TiCp). They found that by adding TiCp as a reinforcement to LM6, the solidification time is sped up, and the grain size and mechanical properties are improved. The author also noticed that as additional TiCp particles is added to the matrix material, the hardness number increases.Mali et al. investigated certain properties on aluminium alloy 356 with fly ash and alumina as reinforcement in varying percent. It was observed that hardness of the composite increased to 94 BHN up to 12% and then decreased due to porosity.

4. Thermal properties

Samuel Dayanand et al prepared Insitu composites having 3 and 5 wt. % of AlB2 were successfully fabricated using 6061Al and premixed salts KBF4 and Na3AlF6 halide salt in a electrical resistance furnace.Addition of Cryolite (Na3AlF6) shows best results when premixed with the KBF4halide salt to the melt in the form powder or pressed tablets.Okumus et al. investigated the thermal expansion and conductivity of Al-11.8 wt% SiC matrix with silicon carbide and graphite. Using a thermal stress response curve for varied amounts of SiC and graphite, it was discovered that increasing the quantity of graphite in a SiC reinforced base alloy leads to higher strain rates but lower coefficients of thermal expansion. Grain refining occurs when the graphite concentration of primary and aluminium dendrites, as well as eutectic silicon, is increased. As a result, it has a low thermal expansion. The addition of more graphite,

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on the other hand, gives the composite dimensional stability since the graphite particles absorb thermal expansion due to their layered structure.Behera et al experimented the solidification behavior and forgebility of Aluminium LM6 with the reinforcement of silicon carbide using stir casting. Cooling curves were obtained at different modulus of casting and it was observed that silicon carbide plays a crucial role in decreasing the cooling rates. Also, analysis of forgebility stated that deformation decreases with the increase in the weight percent of silicon carbide.Marwaha et al. statistically investigated the wear parameters of aluminium/silicon carbide/graphite using Taguchi's technique L9 orthogonal array. The software ANOVA was used to find out the effect of sliding speed, applied load and track diameter on the coefficient of friction. A detailed analysis was done which consisted of finding weight loss, the mean value and S/N ratio for the coefficient of friction etc. After developing a mathematical model, the author concluded that the track diameter had the highest influence on the coefficient of friction which was then followed by sliding speed and applied load. Muthu and Rajesh fabricated a hybrid metal matrix composite with aluminium 7075/silicon carbide/fly ash. The combination which established the lowest coefficient of friction was Al7075/3%SiC/5%fly ash. From the literature review, nothing much has been revealed about the coefficient of friction and its performance depends solely on the composition. 3.3. Uniform distribution Saheb conducted experiments by adding silicon carbide and graphite to aluminium and when observed under a microscope, it was revealed that the aluminium-silicon carbide was less uniformly distributed in comparison to that of the aluminium-graphite composite. The barriers that occur at the surface were eliminated with the help of the stirrer and this is due to the property of poor wettability of the graphite. Flow transition such as axial and radial flow takes place and results in proper distribution and settling. The interfacial analysis showed a strong bond between the composite and the alloy. In the matrix, the particles were well embedded in the alloy and there was no sign of any voids or separation. Prashant et al. noticed the uniform distribution of Al-6061 silicon carbide and Al-6061-graphite during the microstructural studies. Kumar et al. investigated certain parameters by mixing Al6061 with fly ash and observed a uniform distribution of the fly ash particles due to good bonding between the Al6061 and fly ash. No voids and discontinuities were seen when examined under scanning electron microscope. Prasad and Krishna demonstrated that the addition of composites such as rice husk resulted in a consistent distribution. They blended well and have good retention properties. Organic composites, in addition to silicon carbide and graphite, exhibit similar property. The microstructure of silicon carbide and titanium boride was examined by Mahajan et al. , who concluded that the silicon carbide is uniformly distributed throughout the matrix. The structure of silicon carbide was discovered to be interdendritic, whereas the structure of titanium boride was hexagonal.

Conclusions:

1. The hardness, tensile strength, and yield strength of aluminium composites are improved by increasing the wt% and decreasing the particle size of reinforced material.
2. When compared to monolithic alloy, the tribological properties of aluminium composites are increased to some extent by reinforcing with diverse materials, as per the above investigations.
3. Hardness increases as silicon carbide concentration rises, but drops as graphite concentration rises.As a result, in order to achieve an optimum hardness of the desired number, both reinforced materials can be used in proper proportions.
4. Fly ash particles are the best for increasing compressive strength because they indurate the base alloy.
5. The addition of silicon carbide consistently produces noticeable results in terms of increasing wear resistance.
6. Uniform distribution appears to be more visible in aluminum-graphite composite than in aluminum-silicon carbide.
7. The addition of graphite results in the decrease in the thermal expansion of the composite
8. Aside from mechanical and tribological properties, thermal properties are one area where additional research can be focused.

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