

Review on Effect of Various Types of Reinforcement Particles on Mechanical Behavior of 6061 and 7075 Aluminium Alloy Matrix Composite

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Abstract – This review deals with the effect of various reinforcement particles on mechanical behavior of Aluminium Alloys based composite. The composite material fabricated by various advanced processes like Stir Casting, Squeeze Casting, Mechanical Alloying and Plasma arc sintering by introducing different weight percentages of reinforcement material. In this review the improvement in mechanical properties like Hardness, Tensile Strength, Compression Strength and Wear behavior of 6061 and 7075 Aluminium Alloys matrix composites are discussed.

Index Terms – Composites, Aluminium Alloy, Hardness, Tensile Strength, Compression strength, Wear Behavior.

1. INTRODUCTION

The automobile industry is to reduce the overall weight of vehicle for making their vehicle more fuel efficient [1]. Aluminium Alloys (AA) are the primary material of aircraft industry due to their well established design methods, manufacturing method and reliable inspection techniques [2]. The cost reduction of aircraft has becoming challenging aim for aircraft industries [3]. Aluminium castings are applied to large no of components in the automobile. The material of engine block is replaced from cast iron to AA in order to reduce the weight of vehicle to make vehicle more fuel efficient [4]. The aluminium copper alloys is primary used in structure applications of aircraft where design criteria is damage tolerance [5].

2. MATERIAL

There are no. of matrix material that are used for fabrication of composite. The selection of matrix material depends upon the application of composite material. In case of aluminium based

composite the AA 6061 and 7075 are mostly used due to their light weight property and huge no of applications in defence and automobiles. The chemical composition of AA 7075 and AA 6061 are given in Table 1.

Table 1 Chemical Composition of AA 6061 and AA 7075 [6,7]

Alloy	Mg	Si	Cu	Fe	Ti	Cr	Mn	Zn	Al
6061	0.9 2%	0.7 5%	0.2 2%	0.2 8%	0.1 0%	0.0 7%	0.0 4%	0.0 6%	Balance
7075	2.4 %	0.4 %	1.7 %	0.5 %	0.2 %	0.2 3%	0.3 %	5.3 %	Balance

3. RELATED WORK

Martínez et al. [8] applied the application of ball milling in the synthesis of AA 7075/ZrO₂ metal matrix nano composite. Ball milling was used to reduce the particle size of ZrO₂ powder for the aim of introduce it into the AA 7075. It was observed that during ball milling of ZrO₂ powder the destabilization of tetragonal structure occurred which was confirmed by XRD.

The ball milling applications transform the tetragonal structure to monoclinic structure. The synthesis of composite was done by application of mechanical ball milling in order to disperse wt.% of 2 and 5 % of zirconium oxide particles. It was observed that longer time is needed in order to disperse 5% of zirconium oxide as compare to 2%. The homogenous structure was found after ball milling process is observed by SEM.

Chuandong Wu et al. [9] studied the effect of parameters of plasma activated sintering on microstructure and mechanical properties of AA 7075/B₄C composite. The parameters were temperature range and holding time. The aluminium 7075 with 7.5% B₄C were fabricated in composite by using Plasma activated sintering method. The effect of temperature was studied in the range 450°C to 540°C. The effect of porosity on mechanical behavior and microstructure had been studied. It was reported that the composite sintered at 530°C with holding time of 3 minutes leads to fully dense microstructure and strong interface between AA 7075 and B₄C and consist of highest Vicker's hardness bending strength, compression, yield strength and fracture strength.

Baradeshwaram and Perumal [10] investigated the influence of graphite on Aluminium 7075/graphite/Al₂O₃ hybrid composite. The investigation had been studied the effects of addition of Al₂O₃ as reinforcement on base AA 7075. It was done to study the effect of addition of graphite in base aluminium alloy. The fabrication of samples was done with liquid metallurgy route. The properties of composite were compared at different wt% of Al₂O₃ by keeping the wt% of graphite constant. The wt% of graphite was 5% in all samples. It had been investigated that the tensile strength, compression strength and hardness increases at all the composition of Al₂O₃ Ceramics but with addition of graphite as reinforcement material there was decrease in tensile strength, compression strength and hardness but decrease in wear rate due to formation of layer at base material. The decrease in mechanical properties can be overcome by increasing the ceramic phase.

Lara et al. [11] observed the change in microstructure and mechanical properties of Al 7075/graphite composite. The samples for experiment were fabricated by mechanical alloying and hot extrusion. It was observed that microstructure and mechanical response are direct functions of milling time and graphite concentration. The milling time varies from 0 to 10 hours in the experiment and graphite concentration varies from 0 to 1.5%. It was observed that the mechanical property can be enhance by increasing both milling time and graphite content in the composite.. It had been observed that there was inverse relation between particle size and dislocation density and direct relation between particle size and yield strength it means that the yield strength increases as particle size decreases.

Mindivan et al. [12] studied the tribological behavior of aluminium alloy composite fabricated by squeeze casting technique. The AA 2618, 6082, 7012 and 7075 were used as matrix material. The SiC was used as reinforcement. It was concluded that at high test load the AA 7012 and 7075 has superior tribological performance as compare to AA 2618 and 6082.

Baradeshwaran et.al. [13] optimized the wear parameters of Aluminium 7075/B₄C/graphite and Aluminium 6061/

B₄C/graphite hybrid composite and also investigated the mechanical behaviour of these two hybrid composite. The base material Al 7075 and Al 6061 was reinforced with 10% Boron Carbide and 5% graphite. The fabrication was done by liquid metallurgy route. The characterization had been studied by using SEM and EDS. The experiments had been conducted on different applied load, sliding speed and sliding distance in order to studied wear characteristics of both hybrid composites. RSM technique used to analyse the results. It was concluded that the aluminium alloy 7075 hybrid composite had good hardness and %age elongation as compared to aluminium alloy 6061 hybrid composite. The wear resistance of hybrid composites was increased at 10% of B₄C and 5% of graphite.

Lara et al. [14] studied the tribological characterization of Aluminum 7075/graphite composite fabricated by mechanical alloying and hot extrusion. The effect of milling time and graphite concentration on friction hardness and wear resistance had been studied. The milling time varies from 0 to 10 hours and graphite concentration varies from 0 to 1.5%. The wear resistance was studied in pin and disc apparatus on 20 and 40 N normal loads and 0.367 m/s sliding velocity. The examination of worn surfaces has been done SEM. The composite consists of 10 hour milling time and 1.5% graphite concentration had homogeneous distribution of reinforcement particle in composite and improvement in hardness and wear resistance as compare to others extruded samples.

Floras campos et al. [15] investigated the microstructure and mechanical characterization of AA 7075 silver carbide nano composite. The AA 7075 and carbon coated silver nano particles were prepared by milling process. The Al 7075-T6 was the base material it was annealed at 415°C in order to remove T6 condition. The size of nano particles was 10 to 20 nm. The s was prepared at different milling times. The samples were prepared at the milling time of 0, 5, 10, 15, 20 and 25 hours. The characterization was done by using SEM at the current value of 20KV. It was concluded that at less milling time the morphology was observed irregular but with increase in milling time more equiaxed was observed. The increase in microhardness on Vicker's scale was observed but at some saturation point the hardness was not increased further. The maximum hardness was observed at the concentration of 2% beyond that value the hardness was not further increase.

Baradeshwaran and Perumal. [16] investigated the mechanical behavior and tribological characteristics of AA 7075/graphite composite. The samples were prepared using conventional casting technique and were subjected to heat treatment. The stirring was done at 500 rpm for 5 min by using electric motor driven impeller. The composite was fabricated at the percentage of 5, 10, 15 and 20. The all samples were treated to T6 condition before testing. The hardness test was carried on Rockwell hardness testing machine using load of 100kg. The

wear test done by using pin-on-disc apparatus at room temperature 30°C at the sliding speed of 0.6, 0.8 and 1.0 m/s at applied force of 10, 20 and 30 N. It was concluded that there was decrease in hardness with increase in percentage of graphite. The wear rate of composite was decreased with increase in the percentage of graphite and it was found less at 5% value of graphite beyond that value the wear rate found to be increase. The Flexural Strength decrease with increase in %age of graphite but at the value of 5% the effect was less. It was concluded that 5% was optimum value of graphite in AA 7075/graphite composite.

Jiang and Wang [17] studied the microstructure and mechanical properties of nano sized AA7075/SiC composite prepared by ultrasonic assisted semisolid stirring. The ultrasonic treatment and semisolid stirring method were combined together in order to disperse nano sized silicon carbide particles and breakup the primary dendrites of matrix. The Mechanical properties and microstructure of semisolid slurries and rheoformed cylinder was also investigated. The results shows that the ultrasonic treatment can well disperse the nano particle of silicon carbide. It was observed that with increase in stirring time the amount of spheroidal of semisolid slurries increases. That means the better semisolid slurries achieved. High semisolid slurries was achieved only when the temperature was 615 to 620°C upon 20 minutes of stirring time. The yield strength and ultimate tensile strength of rheoformed cylinder component of AA7075 SiC/ with T6 condition were large as compare to without T6 treatment.

Ezatpour et al. [18] investigated the microstructure, mechanical analysis and optical selection of aluminium 7075 based composite reinforced with alumina nanoparticles. The aluminium metal matrix composite was prepared by conventional stir casting process. The poor distribution of reinforcement and very high porosity was observed. To avoid that porosity the nano size Al_2O_3 were injected in the presence of argon gas into molten metal aluminium 7075. The mechanical behavior was studied by tensile and compression tests, hardness measurements, Scanning Electron Microscopy, High Resolution Transmission Electron Microscopy and Optical Microscopy. It was concluded that the porosity is decreased after extrusion. The mechanical experiment results confirmed that addition of Al_2O_3 nano particles and extrusion process effectively increases the tensile strength, compression strength and hardness.

Chuangdong Wu et al. [19] investigated the effect of particle size and spatial distribution of B_4C reinforcement on the microstructure and mechanical behavior of aluminium alloy matrix composite. Aluminium alloy 7075 was used as matrix material. Boron carbide is used as reinforcement consists of three sizes 56.9 μm , 4.2 μm and 2.0 μm . The wt% of Boron carbide is kept constant. The composite with coarse reinforcement had homogeneous distribution of boron carbide

particles and the composite with fine reinforcement had agglomeration of the B_4C particles. The composite had smallest size reinforcement particle had highest yield strength and fracture strength.

Alaneme and Sanusi [20] investigated the Microstructural characteristics, mechanical and wear behavior of AA matrix hybrid composites reinforced with alumina, rice husk ash and graphite. AA 6063 was used as matrix material. Alumina consists of particle size of 30 μm . Rice husk and graphite had particle size of greater than 50 μm . The liquid metallurgy route is used to fabricate the samples for various type of testings. SEM micrographs shows that proper dispersion of reinforcement particles in the aluminium matrix. It was observed that hardness was decrease with increase in rice husk ash and graphite in all composites. The tensile strength and yield strength was also decreased with increase in weight %age of alumina and RHA.

Saravanan and Kumar [21] reported the effect of RHA reinforcement on AlSi10Mg. The fabrication was done by using stir casting technique. The fabrication was done with different wt %age of RHA. The wt %age of reinforcement was 3, 6, 9 & 12%. SEM was used to analyze the dispersion of RHA into AlSi10Mg. It was found that the ultimate tensile strength increased with increases RHA content. It was increased upto 12% after that it started to decrease. The compressive strength was increased with increase wt %age of RHA. The hardness of composite increased with increase in the RHA contents.

Narasaraju and Lingaraju [22] characterized the Hybrid Rice Husk and Fly ash-Reinforced Aluminium alloy (AlSi10Mg) Composites. AlSi10Mg was used as matrix material. Rice husk ash and fly ash was used as reinforcement material consists of particle size between 0.1 to 100 μm . The mixture of reinforcement was 5% fly ash 15% RHA, 10% fly ash 10% RHA and 15% fly ash 5% RHA. The stir casting technique was used to fabricate the samples. The tensile strength increased with increase in wt % of RHA and fly ash. But beyond 10% RHA and 10% fly ash in composite the tensile strength start decreasing. The ductility increased with increase in wt %age of RHA and fly ash. But beyond 10% RHA and 10% fly ash in composite the ductility start decreasing. The hardness increased with increase in wt %age of RHA and fly ash. But beyond 10% RHA and 10% fly ash in composite the hardness start decreasing. It can be concluded that the 10% RHA and 10% fly ash were the optimized value for this composite.

Raghavendra and Ramamurthy [23] investigated the tribological characterization of Al7075/ Al_2O_3 /SiC reinforced hybrid particulate metal matrix composite developed by stir casting process. The fabrication was done by kept constant wt% of silicon carbide at 3% and variation in the wt% of Al_2O_3 as 3%, 6%, 9% and 12%. The fabrication was done by using stir casting technique. The density of composite was increased with increase in wt %age of reinforcement. The wear test was done

on pin on disc wear tester. The results revealed that the wear resistance increase with increase in wt %age of reinforcement.

Veeresh Kumar et al. [24] had done study on Al 6061/SiC and Al 7075/Al₂O₃ metal matrix composites. The aluminium 6061 and aluminium 7075 is chosen as base material for composite. The addition of SiC is done in aluminium 6061 in varying wt% of 2, 4 and 6% and addition of SiC is done in aluminium 7075 in varying wt% of 2%, 4% and 6%. The fabrication was done by Stir casting technique. It is concluded that the microhardness and tensile strength increases with increase in wt %age of reinforcement particle. It is concluded that the AA7075/Al₂O₃ had better mechanical properties than Al 6061/SiC.

Karunesh G et al. [25] analyzed the mechanical properties of AA 7075/Al₂O₃ composite. The fabrication of samples were done by using Stir casting technique at different wt% of 0, 1, 3, 5 and 7%. The hardness testing was done by Brinell's hardness tester equipment. The tensile strength and compression strength were also checked. The results of microstructure were showed that the particles of Al₂O₃ disperse uniformly in AA7075/Al₂O₃ composites. The results revealed that the ultimate tensile strength and yield strength start decreasing with increase in wt% of Al₂O₃ in of AA 7075/Al₂O₃ composite. The %age elongation decreased with increase in wt %age of Al₂O₃.

Singla and Mediratta[26] evaluated the mechanical properties of AA7075-Fly ash composite. The composite was fabricated by Stir casting technique. Magnesium was added to increase the wettability of fly ash in AA 7075 by reducing its surface tension. The Charpy and Izod test are used to determine the toughness of fabricated composite. The results revealed that toughness was increased with increase in fly ash contents upto some level beyond that level it diminish the hardness and tensile strength. The density of composite was decreased with increase in fly ash contents.

Kumaravel S et al. [27] reported the change in Production and Mechanical Properties of Fly ash and Basalt ash reinforced Al 6061 composites. The fabrication was done by using Stir casting technique. Aluminium 6061 was chosen as matrix material. Fly ash and basalt ash was chosen as reinforcement material. Three samples of metal matrix composite were prepared. The results reveal that the tensile strength and impact strength was increased with increase in fly ash. The hardness was increased with increase in Basalt ash.

Sundarrajan et al. [28] studied the mechanical and tribological properties of AA LM25 reinforced with cotton shell ash. The AA LM25 was chosen as matrix material and cotton shell ash was used as reinforcement. The fabrication was done by using Stir casting technique. The samples were prepared at the wt %age of 2%, 4% and 6%. The results revealed that the hardness,

tensile strength and impact strength increase with increase in wt %age of cotton shell ash.

Baradeswaran and Perumal [29] studied the effects of B₄C on tribological and mechanical properties of AA7075/B₄C composites. The fabrications was done by using stir casting technique. K₂TiF₆ was used as flux to overcome the wettability problem between B₄C and liquid melted AA7075. The samples of AA7075/B₄C composite was subjected to hardness, tensile and wear testing. The results revealed that the hardness of composite increase with increase in B₄C content due to increase in ceramic phase. The wear resistance of composite increased with increase in B₄C content. The ultimate tensile, compression and flexural strength was also increased with increase in B₄C contents. The coefficient of friction was decreased with increase in B₄C contents and it reach minimum at the weight %age of 10%.

4. INFERENCES DRAWN FROM LITERATURE REVIEW

- The AA 7075 based composite has superior properties as compare to AA 6061 based composite. AA 7075 is better matrix material as compare to AA 6061.
- The composite has smaller size reinforcement which has more yield Strength as compare to composite having large size reinforcement particles.
- Magnesium can be used to increase the wettability between matrix material and reinforcement in AA 6061 and AA 7075.
- Stir casting process is considered as best fabrication process for AA 6061 and AA 7075 matrix composite.
- There were decreases in mechanical properties like tensile strength, compression strength, hardness with addition of graphite as reinforcement at all wt.% of AA 6061 and AA 7075.
- There were increases in mechanical properties like tensile strength, compression strength, hardness with addition of hard ceramics like B₄C Al₂O₃ and SiC with AA 6061 and AA7075

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