Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 5, Issue 1; January-March, 2018, pp. 32-36

http://www.krishisanskriti.org/Publication.html

Investigation of Mechanical Properties of Hybrid Al 6061 MMCs Fabricated by Stir Casting Technique

G. Gokulakannan[1], R V Praveena Gowda[2] and S Ramesh[3]

[1]G Madegowda Institute of Technology
[2]The Oxford Engineering College
[3]Bannari Amman Institute of Technology
E-mail: [1]ggokulrajan@gmail.com, [2]praveena.gowda@gmail.com, [3]ssrames@gmail.com

Abstract—*The Advancement of technology and High Strength to less weight ration made Aluminium (Al) Hybrid Metal Matrix Composites (HMMCs) highly used in Aerospace and Automobile industry. In this research, Silicon Carbide (Sic) (5, 10 and 15 %) and Boron Carbide (B_4C) (5%) of different weight percentage was reinforced with Al 6061 by using Stir Casting technique. In order to achieve even distribution of reinforcement particles in the matrix material, Guidelines provided by various researchers was adopt during casting of Al. The Fabricated composites was characterised by optical microscopic image and Mechanical Properties, which was evaluate as per standards. From the microscopic image, it was conclude, that the reinforcement was mix properly. The Mechanical properties like Tensile strength, Compressive strength, Impact and Hardness was investigate. The dispersed SiC & B_4C in the Al enhanced the mechanical properties.*

1. INTRODUCTION

Aluminium Composite Material was widely used has a matrix material [1], numerous research was carried out in the Al-Metal Matrix Composites (MMCs). Because of the wide property to react with the different reinforcement materials and wide range of applications. The volume fraction of reinforcement used in the composite material is from the range of few percent to 70% percentage [2]. Reinforcement are generally in the form of whiskers, discontinuous or continuous fibers. Based on the application reinforcements are selected.

Particle or discontinuously reinforced MMCs are relatively inexpensive and found to possess isotropic properties compared to fiber reinforced MMCs. [3] Particulate Reinforcements such as boron, siliconnitride, boron nitride, silicon carbide, titanium carbide and alumina, are extensively used as reinforcement. Apart from the various other hybrid composites, Al-MMCs was extensively machine by using the Unconventional Machining (UCM) [4], through which we able to attain maximum surface finish, this was study through the output parameter of Material Removal Rate (MRR) and Surface Roughness (Ra).

Many ongoing researches was to make Al-MMCs more attractive for widespread use in the aerospace and automotive industries by reducing the costs of the raw materials, processing methods andfinishing operations. [5-6] In Modern aircraft like Boeing and Airbus, Aluminium alloy accounts the 70% percentage of structural weight. It is mostly use in fuselage and wings.

Stir casting is the widely used technique for fabrication of Composite materials because of the cost effective. The Mechanical properties of the composite materials were highly depends upon the volume fraction, distribution of reinforcements in the matrix material [7]. Feeding Mechanism of reinforcement and stirrer dimensions also plays an important role in the mechanical properties of composites [8-9]. The nominal processing temperature of aluminium composite for evenly distribution of reinforcements are 700^{o}C to 800^{o}C, while increasing the processing temperature will decrease the viscosity of the composite materials.

The mechanical behaviour of Al – Silicon Carbide (Sic) and Graphite (Gr) like tensile strength shows improved results when compared to the single reinforcement [10]. The Impact Strength, hardness and compressive strength of hybrid composite increaseswith increase in percentage of reinforcement up to 6% alumina in as-cast and as-hardened condition. Thiswas attain by uniform distribution of reinforcement in the matrix material [11].

Addition of alumina, SiC, Boron Carbide (B_4C) etc. particles in Al composite improves the hardness, yield strength, tensile strengthwhile ductility was decrease. Hybrid ceramic reinforcement has increased the mechanical properties much but very little research reported. [12] The mechanical properties like hardness and tensile strength improved with the increase in weight percentage of reinforcement likes SiC and Fly Ashin the Al matrix. [13].

Titanium Carbide (TiC) reinforcement addition to the material will increase the mechanical properties but higher the percentage of addition of reinforcement will decrease the mechanical properties [14]. Mechanical properties by varying the different size of the reinforcement particles like Sic and B_4C and different weight percentage to the matrix material was investigated, from which it was concluded hardness was high for the particle size of 250µm. tensile strength was high for the particle size of 105µm, for the weight percentage of 8% in composite material. [15]

The mechanical properties of Al6061-Sic and Al7075-Al_2O_3 was studied, from which it was observed tensile strength properties of the composites are found higher than that of base matrix and Al6061-SiC composites superior tensile strength properties then that of Al7075-Al_2O_3 composites [16]. In overall, it was conclude that Al6061-SiC exhibits superior mechanical and tribological properties.

From the above literature survey the following observation made, Al composite finds huge application in aerospace and automobile industry. Stir casting is the commonly used technique to fabricate the composite materials. Very limited research conducted in the hybrid composites, where the reinforcement was SiC & B_4C. In addition, the mechanical properties increase with increase of the weight percentage of reinforcement.

2. MATERIALS USED.

In this research, Al6061 used as a matrix material, along with reinforcement as SiC (30-40µm) and B_4C (50-60µm). From which the weight percentage of SiC was vary as (5%, 10% and 15%) and we kept constant weight percentage of B_4C (5%), [17] because the increasing the percentage of B_4C will increase the brittle nature of the composite material, so in-order to avoid the brittle nature of the composite, we kept the B_4C as constant in this research.

3. FABRICATION OF COMPOSITE.

AL-HMMCs was fabricate through the stir casting technique, since it was cost effective and widely used, when compared to the other fabrication technique. We prepared the four sample in the dimension of 150x12mm. In this research, the amount of matrix material and the reinforcement was calculate based on the rule of mixture [17]$\rho c=\rho m Vm+\rho r_1 Vr_1+\rho r_2 Vr_2$, where$\rho c$ is the density of the composite.ρm, ρr_1, and ρr_2 are the densities of matrix material and the two reinforcements respectively and Vm, Vr_1, and Vr_2 are volume fractions of the matrix and the reinforcements respectively.

The Die and the reinforcement was preheat in the High temperature furnace at the temperature of 500^{o}C for 3 hours and 600^{o}C for 3 hours respectively. Melt the matrix material in the crucible; pour the reinforcement in the matrix material along the degasee of 1%, in order to increase the wettability of reinforcement and matrix material. Stir the poured reinforcement in the matrix material by using the stirrer @400RPM for 15 min; stirrer immersed at the 1/4th of the height of the crucible. Make sure the reinforcement was properly mix in the matrix material. Pour the molten composite in the preheated die.

Table 1: Material Composition

	Sample I	Sample II	Sample III	Sample IV
Al6061	100%	90%	85%	80%
SiC	-	5%	10%	15%
B_4C	-	5%	5%	5%

4. MECHANICAL PROPERTIES.

Mechanical properties such as Tensile strength, compression strength, Impact and hardness was investigate in this research work. All test performed by the standard ASTM E8-15a, IS 1500-13.

4.1 Tensile Strength

For tensile test, the sample was prepared based on the specification of ASTM E8-15a and the test was carried out in the Universal Testing Machine (UTM). The tensile strength indicates the pulling capacity of the material. It also indicate the point where the material goes from elastic to plastic deformation. The prepared sample was mention in the figure (Figure 1.)

Figure 1: Specimen for Tensile test

4.2 Compression Strength.

The Compression test performed in the same UTM machine by using different die, in which compression test was perform to find out the withstanding capacity of load by the specimen. The preferred specimen mentioned in the figure (see Figure 2.)

Figure 2. Specimen for Compression Test

4.3 Impact Strength.

Impact strength was determine by using the charpy Impact test. It`s used to determine the resistance of the material to fracture under dynamic loading. 'V' shaped notch was create at the centre of specimen for 45^{o} angle and 2mm depth. The preferred specimen mentioned in the figure (see Figure 3.)

Figure 3. Specimen for Charpy Impact Test

4.4 Hardness.

The hardness measured at the different location of polished surface by using the Brinell hardness testing machine at the load of (10/1000kgf).

5. RESULT AND DISCUSSIONS.

5.1 Tensile Strength.

The tensile strength of the composites increase with respect to the increase of the weight percentage of composite in the matrix material. In which the tensile strength is inversely proportional to elongation. When compared to pure aluminium and the reinforced Al composite, the tensile strength was increase to 54%, so it indicates the addition of reinforcement will increase the tensile strength of the Al.

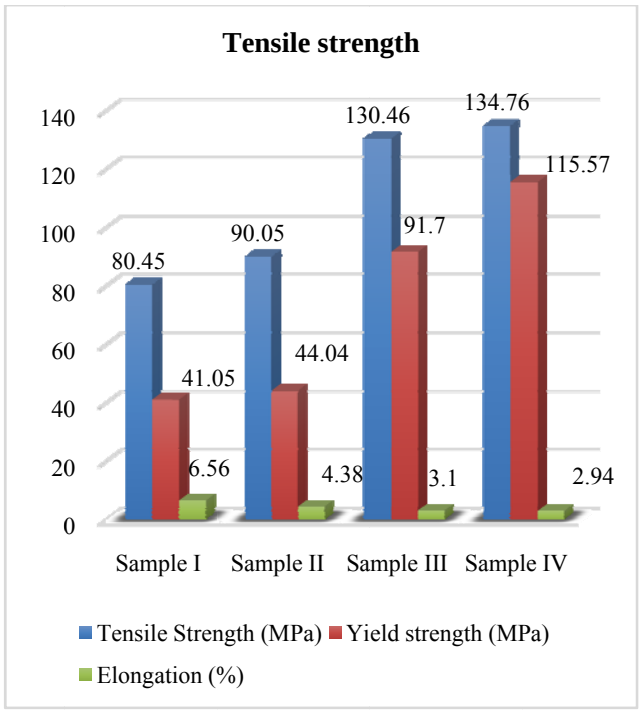

Figure 4. Tensile test results

5.2 Compression Strength.

Compression test result also indicates that the strength will increase according to the increase of weight percentage of reinforcement in the composite material.

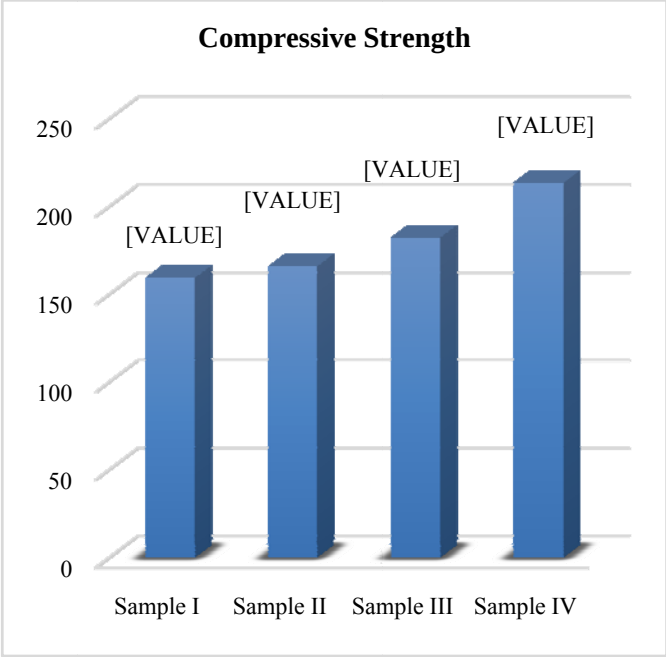

Figure 5. Compression Test Result

5.3 Charpy Impact Test.

The B4C and SiC increase the shock absorbing capacity of the composites, it indicate the impact strength of the composite material was increase to 10%, the result was provide in the figure (see Figure 6.)

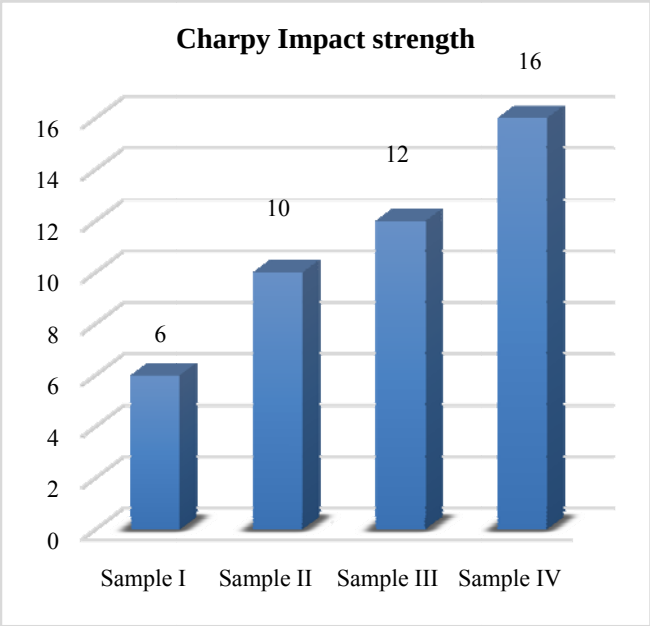

Figure 6. Charpy Impact Test result

5.3 Hardness.

Hardness usually indicates the strength of the material, in this research reinforcement plays an important role in increase the hardness of the composite material.

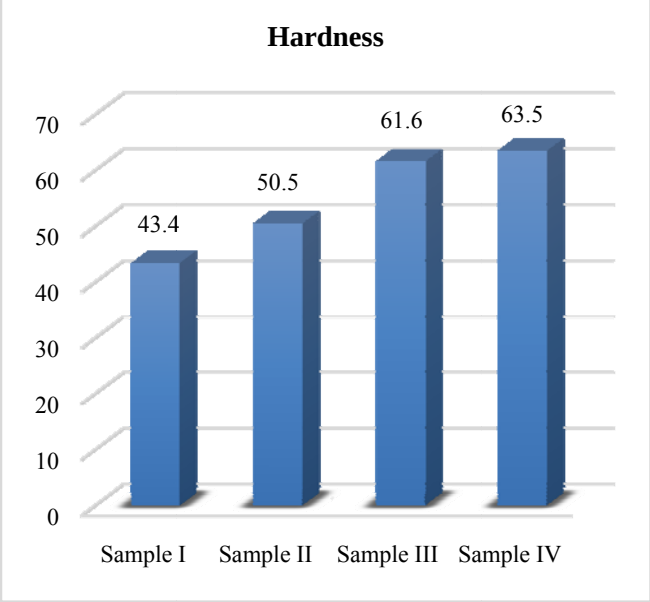

Figure 7. Hardness Test result

6. CONCLUSION

The Observation and the output of the above research was interpret, discussed and listed here,

- The Composite material of different weight percentage of reinforcement was fabricate by using the Stir casting technique.
- Reinforcement was mix properly in the matrix material.
- The overall mechanical properties was increase while increasing the percentage of reinforcement in the composite materials.
- The tensile strength was increase up to 54%, compressive strength increased up to 31%, Also the Impact and Hardness also increase respectively.

REFERENCES

[1] Gokulakannan, G., Praveena Gowda, RV., Ramesh, S, "Machining of Aluminium Hybrid metal Mtrix Composite by Wire Electrical Discharge Machine: A Review", *The IUP Journal of Mechanical Engineering*, Nov 2016, pp 46-64.

[2] Surappa, M. K, "Aluminium matrix composites: Challenges and opportunities", *Sadhana - Academy Proceedings in Engineering Scien*ces, 28(April), pages 319–334, 2003

[3] Thandalam, Satish Kumar., Ramanathan, Subramanian., Sundarrajan, Shalini, "Synthesis, microstructural and mechanical properties of ex situ zircon particles (ZrSiO4) reinforced Metal Matrix Composites (MMCs): A review", *Journal of Materials Research and Technology*, 2015, pp 333-347.

[4] Ramesh, S., Gokulakannan, G., Natarajan, N., Krishnaraj, V, "Investigation of Thermal damage layer in WEDM of Hybrid Metal Matrix Composites", *International journal of applied engineering research*, 2015, pp 29321-29326

[5] Peters, M., Leyens, C., "Aerospace and Space Materials BT - Materials Science and Engineering: Vol. III", *Materials Science and Engineering: Vol. III*, 20018, pp 1-11

[6] Smoljan, B., Tomašić, N., & Smokvina, S. "Composites in manufacturing of vehicles", *Proceedings of the 11th International Scientific Conference "Achievements in Mechanical and Materials Engineering" AMME*, 1960, pp 515-518.

[7] Sijo, M.T., Jayadevan, K.R., "Analysis of Stir Cast Aluminium Silicon Carbide Metal Matrix Composite: A Comprehensive Review", *Procedia Technology*, 2016, pp 379-385.

[8] Sozhamannan, GG., Balasivanandha Prabu, S., Venkatagalapathy, VSK, "Effect of Process Parameter of Stir Casting on Metal Matrix Composites", 2012,pp 11-15.

[9] Thomas, A. Tony., Parameshwaran, R.., Muthukrishnan, A.., Kumaran, M. Arvind, "Development of Feeding & Stirring Mechanisms for Stir Casting of Aluminium Matrix Composites", *Procedia Materials Science*, 2017, pp 1182-1191.

[10] Krishna, M. Vamsi., Xavior, Anthony M. "An investigation on the mechanical properties of hybrid metal matrix composites", *Procedia Engineering,* 2014 pp 918-924.

[11] Saravanakumar, A., Sasikumar, P., Sivasankaran, S. "Synthesis and Mechanical Behavior of AA 6063-x wt. % Al2O3-1% Gr (x = 3, 6, 9 and 12wt. %) Hybrid Composites", *Procedia Engineering*, 2014, pp 951-960.

[12] Kala, Himanshu., Mer, K.K.S., Kumar, Sandeep, "A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites." *Procedia Materials Science,* 2014, pp 1951-1960.

[13] Selvam, David Raja J., Dinaharan, David Raja I. "Synthesis and characterization of Al6061-Fly Ashp-SiCp composites by stir casting and compocasting methods", *Energy Procedia,* 2013, pp 637-646.

[14] Raviraj, M.S.., Sharanprabhu, C.M.., Mohankumar, G.C. "Experimental Analysis on Processing and Properties of Al-TiC Metal Matrix Composites", *Procedia Materials Science,* 2014, pp 2032-2038.

[15] Saikeerthi, S P., Vijayaramnath, B., Elanchezhian, C, "Experimental Evaluation of The Mechanical Properties Of Aluminium 6061- B 4 c-Sic Composite", *international journal of engineering research,* 2014, pp 70-73.

[16] Kumar, G B Veeresh., Rao, C S P., Selvaraj, N., Bhagyashekar, M S, "Studies on Al6061-SiC and Al7075-Al 2 O 3 Metal Matrix Composites", *Journal of Minerals & Materials Characterization & Engineering,* 2010, pp 43-55.

[17] Ramesh S., Natarajan N., Krishnaraj V., Gokulakannan G, "Determination of cutting operation number formultipass cutting in WEDM of composite materials", *International Journal of Applied Engineering Research,* 2014, pp 27041-27051.