Pugazhenthi et al. 2019. *Int. J. Vehicle Structures & Systems*, 11(2), 180-182
ISSN: 0975-3060 (Print), 0975-3540 (Online)
doi: 10.4273/ijvss.11.2.11

International Journal of
Vehicle Structures & Systems
Available online at www.maftree.org/eja

Morphological and Mechanical Characteristics of Hybrid Aluminium Matrix Composites

R. Pugazhenthi[a], S. Sivaganesan[b], C. Dhansekaran[c] and A. Parthiban[d]

Dept. of Mech. Engg., Vels Inst. of Sci., Tech. & Adv. Studies, Chennai, Tamil Nadu, India
[a]Corresponding Author, Email: pugal4@gmail.com
[b]Email: sivaganesanme@gmail.com
[c]Email: dhans.se@velsuniv.ac.in
[d]Email: parthibana83@gmail.com

ABSTRACT:

In emerging trend day by day the world facing lot of new invention in automobiles and aerospace industries. They need new smart materials lighter in weight, tensile strength and hardness with good thermal shock resistance compared to available conventional metals. Especially the aluminium based Metal Matrix Composite (MMC) materials can provide these properties. In this research article an attempt is made to find the mechanical properties and morphological of the aluminium alloys of Al 356 mixed with silicon carbide particles (SiCp) and Mica. All these three different MMCs were fabricated in stir casting method. Their tensile strengths are studied and compared with the help of Vickers micro hardness tester and tensile testing machine. The morphological characteristics are tested and compared with the Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Spectroscopy (EDAX) optical microscopy. The tensile strength and hardness of MMCs were comparatively increased than the aluminium alloys.

KEYWORDS:

Mechanical properties; Metal matrix composites; Silicon carbide particle; Stir casting; SEM;

CITATION:

R. Pugazhenthi, S. Sivaganesan, C. Dhansekaran and A. Parthiban. 2019. Morphological and Mechanical Characteristics of Hybrid Aluminium Matrix Composites, *Int. J. Vehicle Structures & Systems*, 11(2), 180-182. doi:10.4273/ijvss.11.2.11.

1. Introduction

The current modern world requires smart materials that are light weight, high tensile strength with good hardness and a good thermal shock resistance compared to conventional metals. The growing automobile, aircraft and aerospace industries need the lightweight materials which can be achieved by Metal Matrix Composite (MMC). MMC is the combination of two different constituents differs in their physical properties. The main advantage of MMC are light in weight, improvement in tensile strength, hardness compared to conventional metals. Metals like aluminium, titanium, etc. are used as a matrix material; Silicon carbide, silicon nitride, mica, etc. are used as reinforcement. Aluminium is one of the lightweight material that has good strength to weight ratio, but it has lesser wear resistance and tensile strength. To improve the hardness and strength, silicon and mica reinforcements were added with aluminium

Al 356 has certain unique property, such as excellent cast ability, good wet ability and good resistance to corrosion. It has a wide range of applications in the automobile and aerospace industries. Some of the parts made of Al 356 are automotive transmission cases, water cooled cylinder blocks, and aircraft pump parts, aircraft fittings, and control parts. The chemical composition of Al 356 is Cu - 0.25%, Mg - 0.20 to 0.45%, Mn - 0.35%, Si - 6.5 to 7.5%, Fe - 0.6%, Zn - 0.35%, Ti - 0.25%, and the rest, is Al. Al 356 prevents the formation of Al_4C_3, a brittle compound while reacting with SiC which affects the hardness and other material properties. Manna & Bhattacharyya [4] proved that aluminium matrix composites have improved properties, such as greater strength, improved stiffness, reduced density, controlled thermal expansion co-efficient, improved abrasion and wear resistance and improved damping capabilities.

Aluminium matrix composites are fabricated by various methods. When comparing those methods, stir casting is considered more advantageous because it is less expensive and it does not cause any damage to reinforcement. A wide range of shape and larger size materials can also be used [6]. Al-Haidary and Al-Kaaby [1] suggested that the hybrid MMC is the combination of more than two materials in a composite. By adding soft materials such as graphite and mica to the MMC, the composite has the tendency to act as a self-lubricant. It also reduces corrosion, frictional horsepower losses and improves fuel efficiency. Automobile parts such as bearings and pistons can be made in order to reduce the corrosion and friction between the moving parts. The mechanical properties such as hardness, toughness and tensile strength of silicon carbide particles (SiCp) are increased by adding it to aluminium and it is applied in car brakes, car clutches, grinding wheels, etc [2-6].

SiCp is usually produced using the Acheson process, which uses petroleum coke and silica as raw materials

[5, 7]. Mica is the hydrated silicate of potassium and aluminium. It is flexible, elastic, tough, and resistant to weather and has high tensile strength and bending strength. It reduces cracking and shrinking due to its good lubrication properties [9]. The main objective of this work is to improve the mechanical properties by adding ceramic material SiCp to aluminium alloy.

2. Materials and methods

Al 356 is got in the form of the ingot from Sargam metals. SiCp is of the size of 25µm and has 69.71% silicon and 29.79% carbon. Mica used is muscovite of grade SYA-21R, particle size 26.82µm and bulk density of 5.45ml/g [8]. Using stir casting, three different samples, hybrid metal matrix composites (Al 356/SiCp/Mica), metal matrix composites (Al 356/SiCp) and aluminium alloy (Al 356) were prepared. The specimen dimensions are shown in Table 1. The tensile test standard used is ASTM E8M. Aluminium is heated to 800ºC for 50 minutes in muffle furnace [10]. Simultaneously, the SiCp particles are heated in muffle furnace 2 at 1000ºC. The die is also preheated at 300ºC inside the furnace. The mixture of aluminium and SiCp and mica are stirred for 10 minutes at 125 rpm. The molten metal is poured in to the die and allowed to solidify.

Table 1: Tensile test specimen size

Dimension	Size in mm
Overall Length, L	200
Gauge Length, G	50
Length of Reduced parallel section, A	57
Length of grip section, B	20
Width of grip section, C	20
Width, W	12.5
Thickness, T	0.5

3. Results and discussions

The tensile test specimens past testing are shown in Fig. 1. Table 2 and 3 give the summary of tensile test and hardness test results. Tensile strength and percentage elongation values of Al 356, (Al 356/SiCp) and (Al 356/SiCp/Mica) are obtained. By comparing three different samples, the tensile properties of the MMC were found to be greater than hybrid MMC and aluminium alloy. The hardness value of the specimen is obtained by the resistance against indentation on the specimen. The hardness of the MMC is superior when compared to hybrid MMC and aluminium alloy.

Fig. 1: Casted specimen after tensile test

Table 2: Tensile strength test results

Sample	Tensile strength (kN/mm^2)
Al 356	0.126
Al 356/SiCp	0.127
Al 356/SiCp/Mica	0.116

Table 3: Hardness test results

Sample	Micro hardness	Brinell hardness
Al 356	59.3	58.11
Al 356/SiCp	70.3	68.89
Al 356/SiCp/Mica	67.5	66.15

The microstructure of three different samples are taken using SEM and shown in Fig. 2 to Fig. 4. The distribution of reinforced material on the molten metal is viewed through optical microscope microstructure. The distribution of reinforced material is equal in hybrid MMC when compared to MMC, which resulted in agglomeration of the reinforced particle. Since, there is a poor bonding between aluminium and SiCp. By adding mica, the wettability of composites increases and there was a proper bond between the aluminium and SiCp which resulted in the equal distribution of composite materials. Topographic features (size and shape of the particles in a particular area) of the specimen are determined using SEM. The composition of materials is also obtained using EDAX and their corresponding weight percentage is C -7.58%, Si-7.96% and Al-84.46% are shown in Fig. 5.

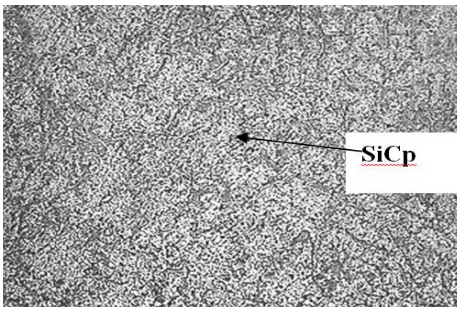

Fig. 2: Optical micrograph (200X) of Al 356/SiCp

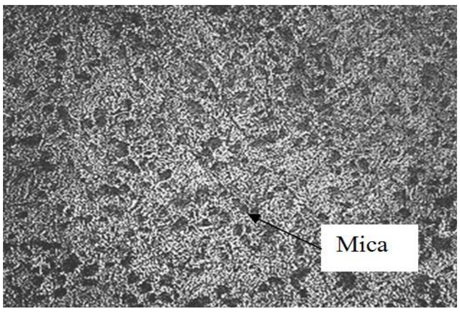

Fig. 3: Optical micrograph (200X) of Al 356/SiCp/mica

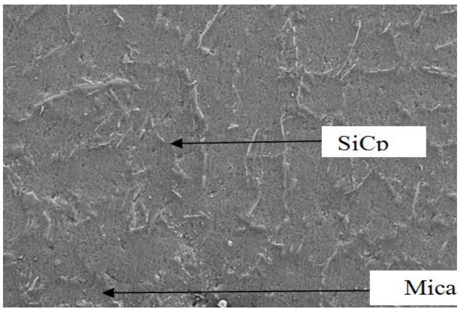

Fig. 4: Field emission SEM of Al 356/SiCp/Mica (500X)

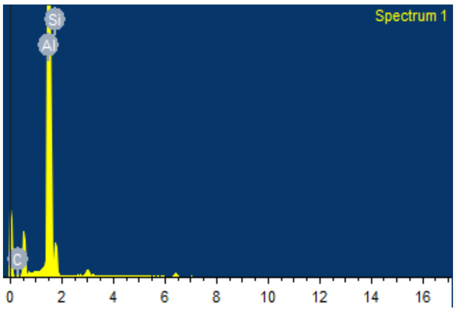

Fig. 5: Energy dispersive x-ray spectroscopy of Al 356/SiCp/Mica

4. Conclusion

Al 356, Al 356/SiCp and Al 356/SiCp/Mica MMCs were fabricated by stir casting and their morphology and mechanical behaviours were studied. It was found that the distribution of reinforcement in hybrid MMC is equal when compared to MMC. The mechanical behaviour of MMC is more than aluminium alloy and hybrid MMC. The tensile strength and hardness were increased in MMC compared to aluminium alloy. By adding mica (hybrid MMC), the hardness was reduced by 4% when compared to MMC. The hardness of hybrid MMC was increased by 12% compared to aluminium alloy.

REFERENCES:

[1] J.T. Al-Haidary and A.J. Al-Kaaby. 2007. Evaluation study of cast Al-SiCp composites, *Mater. Sci.-Poland*, 25(1), 155-165.

[2] S.V. Ananth, K. Kalaichelvan and A. Rajadurai. 2012. Effect of thermo cycling process in Al6063/SiCp composites, *European J. Scientific Research*, 88(3), 403-408.

[3] M.M. Boopathi, K.P. Arulshri and N. Iyandurai. 2013. Evaluation of mechanical properties of aluminium alloy 2024 reinforced with silicon carbide and fly ash hybrid metal matrix composites, *American J. Applied Sci.*, 10(3), 219-229. https://doi.org/10.3844/ajassp.2013.219.229.

[4] A. Manna and B. Bhattacharayya. 2003. A study on machinability of Al/SiC-MMC, *J. Materials Processing Tech.*, 140(1-3), 711-716. https://doi.org/10.1016/S0924-0136(03)00905-1.

[5] R. Saravanan, M. Santhanam, S. Nadarajan and R. Pugazhenthi. 2015. Mechanical and surface morphological investigation on duplex ageing behaviour of Al (7075) Al-Zn-Mg-Cu alloy, *J. Advanced Microscopy Research*, 10(4), 296-302. https://doi.org/10.1166/jamr.2015.1279.

[6] R. Jino, R. Pugazhenthi, K.G. Ashok, T. Ilango and P.R.K. Chakravarthy. 2017. Enhancement of mechanical properties of luffafiber/epoxy composite using B4C, *J. Advanced Microscopy Research*, 12(2), 89-91. https://doi.org/10.1166/jamr.2017.1324.

[7] R. Saravanan, R. Pugazhenthi and T. Gopalakrishnan. 2015. Experimental investigation of EN-31 steel surface grinding performance with Al_2O_3 and CuO nano fluids, *J. Advanced Microscopy Research*, 10(4), 284-291. https://doi.org/10.1166/jamr.2015.1277.

[8] S.V.V. Ananth, K. Kalaichelvan and M. Kumaresan. 2012. Thermo cycling process in Al6063/SiC composites during superplastic forming, *Int. J. Engg.*, 6(2).

[9] J.M. Torralba, C.E. da Costa, F. Velasco. 2003. P/M aluminum matrix composites: An overview, *J. Materials Processing Tech.*, 133(1-2), 203-206. https://doi.org/10.1016/S0924-0136(02)00234-0.

[10] J. Hashim, L. Looney and M.S.J. Hashmi. 1999. Metal matrix composites: Production by the stir casting method, *J. Materials Processing Tech.*, 92-93, 1-7. https://doi.org/10.1016/S0924-0136(99)00118-1.