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Investigation on the Mechanical Properties of Silicon Carbide Particulates in Al/SiC/MoS_2

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Abstract. The present study aims to optimize the mechanical properties of Al5059/SiC/MoS_2 hybrid composites. The hybrid metal matrix composites has been fabricated through stir casting by reinforcing different size of SiC (10,20&40 µm) with aluminium at different weight fractions (5 %,10% &15%) meanwhile the addition of Molybdenum di sulphide (MoS_2) is fixed at 2% which enhances the self lubrication properties. The basic mechanical properties were investigated and the composite with minimum particle size shows high mechanical strength.

Introduction

Many of the engineering applications in the world today require materials with usual combination of properties that cannot be meet by the conventional metal alloys, ceramics or polymers [1-3] .This is especially true for the materials that are needed for aerospace and transportation applications. For example aircraft engineers are in quest for structural materials that have low densities yet strong, hard and impact resistant [4]. Due to improved mechanical properties, amenability to conventional processing technique and possibility of reducing production cost of Aluminium hybrid composites [5]. So Al5059 is selected as base metal and it is a non-heat treatable wrought alloy. It is extensively used in marine and aerospace applications because of its lightweight, low cost and it is characterized by good formability and excellent weldability [6]. It is selected as the base metal. The Silicon Carbide is characterized by good strength and high temperature capacity. It is chosen as the reinforcement. The addition of SiC will improve the mechanical properties like tensile strength, flexural strength and impact strength. But high amount of SiC will lead to brittleness [7]. MoS_2 is added as a secondary material which posses greater load carrying capacity and its manufacturing quality is better controlled.MoS_2 is the inorganic compound and it is widely used as a solid lubricant because of its low friction properties and robustness [8].

Material Selection

Al5059 is selected as a base metal because it has a maximum magnesium content act as a strengthening agent and improves wettability of Aluminium.

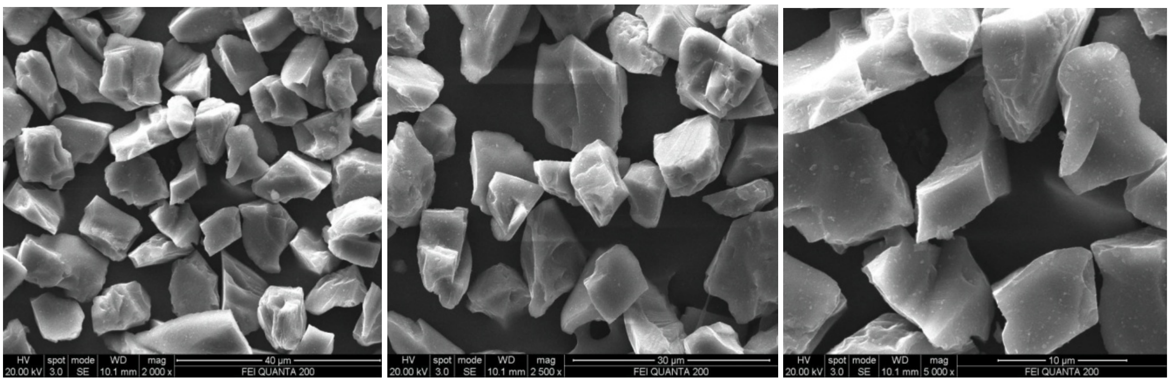
Table 1 Chemical composition of Al5059

ELEMENTS	%
Magnesium (Mg)	5-6
Chromium (Cr)	0.3
Copper (Cu)	0.4
Iron (Fe)	0.5
Manganese (Mn)	0.8
Silicon (Si)	0.45
Titanium (Ti)	0.2
Zinc (Zn)	0.75
Zirconium (Zr)	0.25
Remaining	Al

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost effective method of liquid state fabrication [9-11]. The hybrid composite of Al5059-SiC-MoS_2 were prepared by stir casting technique as shown in figure 1.

Figure 1 Stir casting experimental setup

Before casting, 5% of SiC and 2% of MoS_2 were kept in a small crucible and heated in a small crucible and heated by a preheating furnace at 400-500^{o}C for 30 minutes [12-14]. After preheating the reinforcement, the Al5059 was melted at 600-700^{o}C in a graphite crucible using furnace. Then, the reinforcement is mixed with base alloy and magnesium is also added with aluminium foil to reduce explosion and stirred for 5 minutes at 800rpm in the range of 750-850 rpm. The graphite crucible is taking away from the furnace, and then the crucible is titled and poured into the die and then allowed to solidify in atmospheric air for 3-5 minutes [15]. Similarly the eight composite samples with different weight percentages and different micron sizes were manufactured by above process.The figure 2 shows the different sizes of SiC at 10 µm 20 µm and 40µm**.**



2a) SiC at 10 µm 2b) SiC at 20 µm 2c) SiC at 40 µm

Result and Discussion

Tensile Test

Below figure 2 (a) and (b) shows the before and after testing the specimen in UNIVERSAL TESTING MACHINE(UTM) as per ASTM E8 standard.

Figure 2 a) Before testing b) After testing

The tensile strength of composite material shows below the 8th samples show the higher tensile strength compared to other composite samples and base alloy. The figure 3shows the tensile strength increases with increasing SiC reinforcement particles. The tensile strength of composite material is high compared to base alloy [10]. Tensile strength of the composites increases with small particle size. The particle size at 40 µm and at 5% of SiC having high tensile values. This is due to particle size exhibits higher bonding strength between matrix and reinforcement. Figure 2 shows the tensile specimen before and after test.

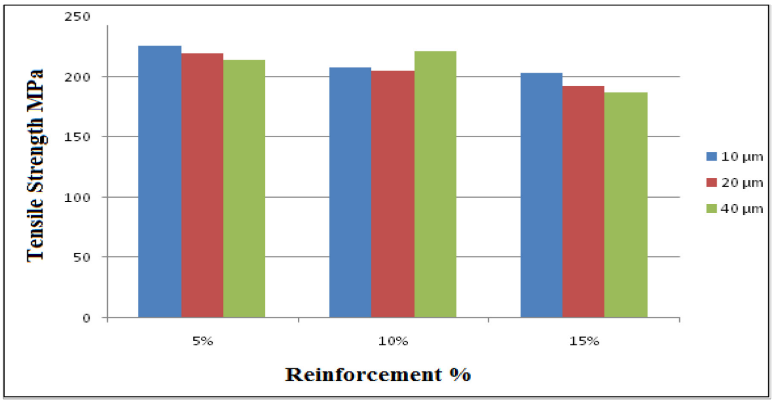


Figure 3 Variation for tensile test value

Impact Test

The table 3 shows the impact energy of composite material shows the pure AA5059 is equal to adding 10% of SiC particles with base metal in 40microns and other weight percentage of SiC reinforcement slightly decreases. The figure 5 shows impact strength. This graph shows the 8th sample (10% weight percentage of SiC with 40µm) is equal to base alloy. And other composite material show the impact energy is below than the base alloy. Figure 4 shows the after testing the specimen,

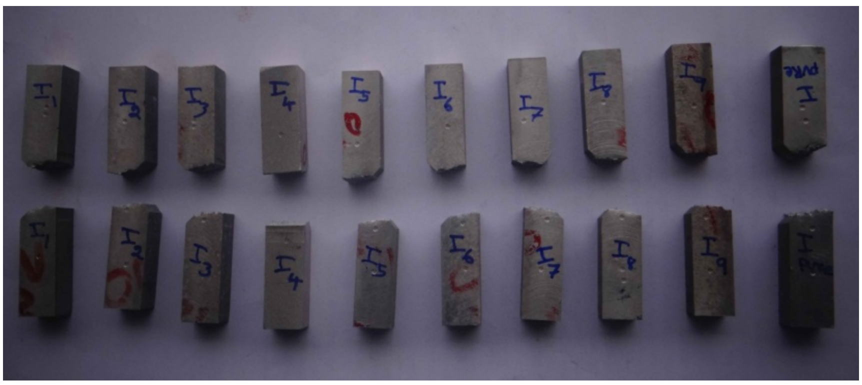


Figure 4 After testing

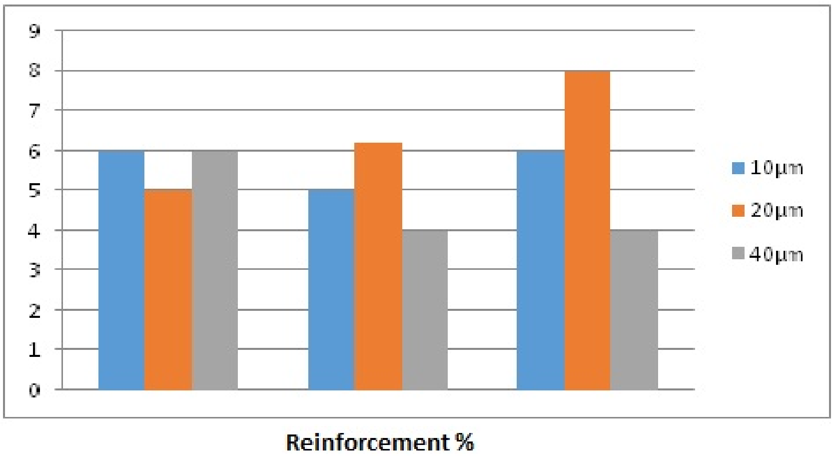


Figure 5 Variation for impact test value

Hardness Test

The composite reinforced with 15 % SiC at 10 μm particle size have the better hardness value. From the figure 6 it can be noted that MMC hardness increases with increase in SiC percentage and also higher hardness values are exhibited by the smaller particle reinforced MMCs. Higher hardness value of reinforced SiC leads to increase in hardness of the MMC. Surface area of the smaller particles is higher when compared to larger particles in the matrix which can be attributed to the higher hardness of the smaller particle reinforced MMC.

Figure 6 Variation for hardness test

Microstructure

Microstructure of the developed composites was analyzed through scanning electron microscope (SEM) in order to identify the distribution of reinforcement particles on matrix material. The specimens were prepared as per the required size with the help of wire cut EDM and polished with 300, 600, 1200 and 2000 grit emery sheets. Figure 7a shows the presence of SiC at 5% level at 10μm and constant weight percentage of MoS_2.Similarly figure 7b and 7c illustrate the occurrence of SiC at 10% at 10μm and 15% at 10 μm.

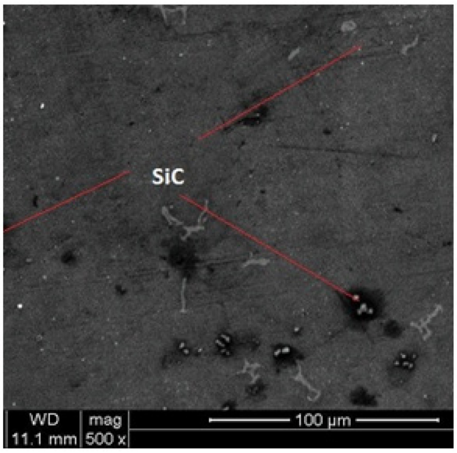


Fig 7(a)

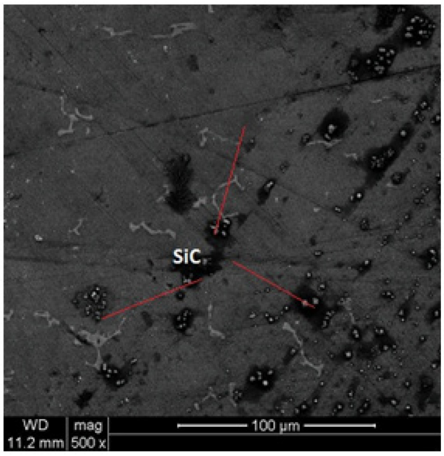


Fig 7(b)

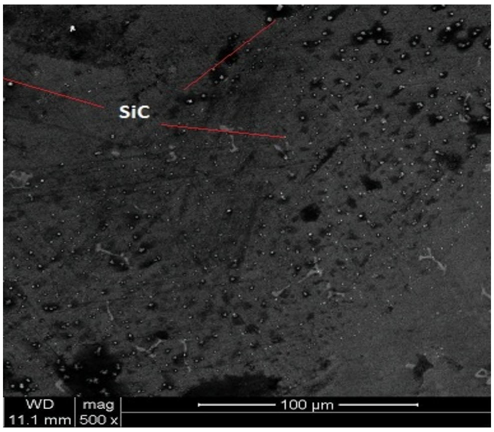


Fig 7(c) Fig 7 SEM image of different composites

Conclusion

From results of investigation and discussion of this work, the following conclusion can be made.The tensile strength increases with increasing the SiC reinforcement particle. The specimen with the composition of 15% of SiC in 40microns exhibits maximum tensile strength than base alloy. Hardness of the composites increases with increase in weight percentage reinforcement due to the higher density of SiC and decreases with increase in particle size. Since SiC is a harder ceramic the density and hardness of the composite also increase with its addition. Also small particle size exhibits better hardness than coarse particles due to the higher surface area and it fills the small pores in the matrix than coarse particles. The impact strength of base alloy is equal by adding 10% of SiC particles in the matrix at 40microns.

References

[1] N. Radhika, T.V. Balaji, S. Palaniappan, Studies on mechanical properties and tribological behavior of LM25/SiC/Al_2O_3 composite, J. Engg. Tech .10 (2015) 134-144.

[2] K. Suryanarayanan , R. Praveen, S. Raghuraman ‚Silicon Carbide Reinforced Aluminium Metal Matrix Composites for Aerospace Applications" , Vol. 2, Issue 11, November 2013; ISSN: 2319-8753

[3] B.N.Saradaa , P.L.Srinivasa Murthy, G.Ugrasen, Hardness and wear characteristics of Hybrid Aluminium Metal Matrix Composites produced by stir casting technique , Int. Conf. Mat. Process. Char. 2 (2015) 2878 – 2885.

[4] Subhankar Biswas, Sweety Shahinur, Mahbub Hasan, QumrulAhsan, Physical, Mechanical and Thermal Properties of Jute and Bamboo Fiber Reinforced Unidirectional Epoxy Composites, Pro. Engg. 105 (2015) 933 – 939.

[5] S. Dhanalakshmi, M. Jaivignesh. A. Suresh Babu, Dr. K. Shanmuga Sundaram, “Microstructural and Mechanical behaviour of Aluminium Matrix Composites reinforced with coated SiC particles fabricated by Stir Casting , App. Mech. Mat. 766-767 (2015) 301-307.

[6] P. K. Liaw , J. G. Greggi , W.A. Logsdon , Microstructural Characterization of a Silicon Carbide Whisker Reinforced 2124 Aluminium Metal Matrix Composite , J. mat. Sci. (1987) 1613-1617.

[7] B. VijayaRamnath , C. Elanchezhian , RM. Annamalai , S. Aravind , T. Sri, Aluminium Metal Matrix Composit , Rev. Adv. Mater.sci.38 (2014) 55-60.

[8] B.C. Pai, Geetha Ramani, R.M. Pillai K.G. Sathyanarayana, Role of Magnesium in Cast Aluminium Alloy Matrix Composite” , J. mat sci. 30 (1995) 1903-1911.

[9] A.Saravanakumar, P.Sasikumar ,S. Sivasankaran, Synthesis and mechanical behavior of AA 6063-x wt. % Al2O3-1% Gr hybrid composites, Pro. Engg. 97 (2014) 951 – 960.

[10] R. S. Rana, Rajesh Purohit, V. K. Soni and S. Dasd, Characterization of Mechanical Properties and Microstructure of Aluminium Alloy-SiC Composites , Mat. Pro. 2 (2015) 1149 – 1156.

[11] N. Rajesh Jesudoss Hynes, R. Kumar, Electrochemical Machining of Aluminium Metal Matrix Composites, Surface Engineering and Applied Electrochemistry, July 2018, Volume 54, Issue 4, pp 367–373

[12] N. Rajesh Jesudoss Hynes, R. Kumar, R. Tharmaraj, P. Shenbaga Velu Production of aluminium metal matrix composites by liquid processing methods, 1728, 020558 (2016);

[13] Ajith Arul Daniel, R. Pugazhenthi, R.Kumar, S.Vijayananth.,2019 Multi objective prediction and optimization of control parameters in the milling of aluminium hybrid metal matrix composites using ANN and Taguchi -grey relational analysis, Defence Technology,

[14] Ajith Arul Daniel, M Sakthivel, PM Gopal, S Sudhagar Study on Tribological Behaviour of Al/SiC/MoS_2 Hybrid Metal Matrix Composites in High Temperature Environmental Condition, Silicon 10 (5), 2129-2139

[15] Sudhagar S, Sakthivel M, Ashok A, Ajith Arul Daniel S, Investigation of Discontinuities in Friction Stir Welding of 2024 Aluminum Alloy using Radiography, Materials Evaluation 75 (8), 1032-1037