ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Special Issue.24, March 2017

ANALYSIS OF TRIBOLOGICAL BEHAVIOUR OF METAL MATRIX COMPOSITES – AN EXPERIMENTAL INVESTIGATION

[a]G.Ramesh*, [b]V.C.Uvaraja, [c]Ashok Thyagarajan

[a] Assistant Professor ,Department of Mechanical Engineering,Velammal Engg College,Chennai

[c]UG student, Department of Mechanical Engineering,Velammal Engg College,Chennai.

[b] Associate Professor,Department of Mechanical Engg ,Bannariamman Institute of Technology,Sathyamangalam

ABSTRACT

The composite materials are extensively used globally in major industry. Aluminium Metal matrix composites are preferred in the fields of aerospace, military, automotive, marine and in many other domestic applications. A particle reinforced metal matrix composite consists of uniform distribution of strengthening ceramic particles embedded within metal matrix. Manufacturing of aluminum alloy based composites by stir casting is one of the prominent and economical routes for processing of metal matrix composites. Aluminum 7075 reinforced with Silicon carbide particulate with different weight percentage is fabricated using stir casting process. Tribological behaviour of fabricated specimen were analysed. The detailed comparison of various mechanical properties gives a clear idea about the mechanical behaviour of the fabricated composite specimen. In this study the results were discussed in detail about the variation of composition of reinforcement and hardness.

Keywords: Reinforcement, hardness, metal matrix composites, weight percentage, casting.

1.Introduction

The finest piece of attempt in Al matrix composite has been aimed towards development of high performance composite

ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Special Issue.24, March 2017

with high strength and good tribological properties for using Aerospace and automotive application. The Al matrix composite reinforced with SiC particulate are a new range of advanced materials. Usually a hard material is working as reinforcement because of potential improvement in mechanical properties such as hardness and tensile strength which are the enviable properties in tribological application. Hard particles such as B_4C, Al_2O_3 and SiC are commonly used as reinforcement phases in the composites. The applications of SiC particle reinforced aluminum alloy matrix composites are steadily increasing for automobile components[1-3]. SiC and Al_2O_3 particulate reinforced Al-Si alloys are investigated the influence of the reinforcement types on the microstructure of the matrix. The results also show that the presence of particulate in the aluminum alloy matrix help with civilizing its strength. Silicon carbide particles materials show excellent tensile strength and oxidization resistance at high temperature(4 ,5). D.J. Lloyd et al., studied that metal matrix composites are produced by molten metal methods and concluded that there are some unique factors which have to be considered. The microstructure of SiC reinforced aluminium alloys produced by this method is onsidered. It is shown that the stability of SiC in the melt is dependent on the matrix alloy involved and that only alloys with high silicon contents have a low reactivity with this reinforcement.[6].The addition of high strength, high modulus refractory particles to a ductile metal matrix produces a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Metals have a useful combination of properties such as high strength, ductility and high temperature resistance, but sometimes have low stiffness, whereas ceramics are stiff and strong, though brittle[7].Yoshiro Iwai et. al. [8] found that the initial sliding distance require to achieve mild wear decreased with increasing volume fraction and also severe wear rate decrease linearly with volume fraction. A P Sannino [9] suggested that the increasing particle size of SiC from 4 to 29 micron increased the coefficient of friction. Ali Mazahery and Mohsen Ostacl Shabani [10] emphasized that higher hardness of composite could be achieved by ceramic reinforced particulate

B_4C because B_4C particle acts as an obstacle to the motion of dislocation. The metal matrix composite can be reinforced with particles, dispersoids or fibres. However, the biggest interest in composite materials is observed for those reinforced with hard ceramic particles due to the possibility of controlling their tribological, heat- or mechanical properties by selection of the volume fractions, size, and distribution of the reinforcing particles in the matrix [11]. They are used more often, compared with the composite materials of other metals, due to the broad range of their properties, and also due to the possibility of replacing the costly and heavy elements made from the traditionally used materials [12,13] Aluminum matrix composites reinforced with flyash and silicon carbide developed using conventional foundry techniques were tested for fluidity, hardness, density, mechanical properties, impact strength, dry sliding wear, slurry erosive wear, and corrosion etc., and indicates an increasing trend in all the properties with increase in flyash and SiC content, except density which decreases with increase in reinforcements[14,15]. This creates interest among the researchers to concentrate both on experimental and analytical portions of HMMCs to gain a better understanding about the mechanical behavior of these materials and their excellent wear resistance. The fabrication techniques of HMMCs play a major role in the improvement of mechanical and tribological properties. Though the fabrication technique of HMMCs has several challenges against achieving uniform distribution of reinforcement viz., porosity formation, poor wettability, and improper distribution, a new technique of fabricating cast aluminum matrix composite has been proposed to improve the wettability between alloy and reinforcement [16]. Uniform distribution of reinforcement is obtained by placing all the materials in graphite crucible and heating them in an inert atmosphere with two-step stirring action until the matrix alloy is completely melted. Aluminum based silicon carbide particulate metal matrix composites fabricated using this technique showed an increasing trend in hardness and impact strength values with increase in volume fraction of SiC [17].

2. Experimental Procedure and Materials:

2.1 Material and Sample Details:

ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Special Issue.24, March 2017

Mechanical tests were performed on SiC particulates reinforced with Al 7075 matrix composite**.** Table 1 shows the nominal composition weight percentage of matrix materials Al7075. The range of reinforcement materials SiC are 30-70 μm. Silicon carbide reinforcement material is of Angular irregular shape, high thermal conductivity and high hardness. The chemical composition of Al7075 matrix materials indicate high concentration of magnesium and zinc respectively. Consequently the thermal conductive increase in Al7075. The value of density for matrix and reinforcement materials are little closer and hence results in uniform mixing. The samples were in the form of circular rod 10mm diameter and 30mm height fabricated by stir cast techniques. Due to its high strength, low density, thermal properties and its ability to be highly polished, 7075 is widely used in mold tool manufacture. The 7xxx series aluminium alloy have good wear resistance with added reinforced particulates. Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electrochemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. It is used in abrasives, refractories, ceramics, and numerous high performance applications. The average weight percentage of SiC particulates in the composites were determined by quantities metallographic digital image analyzer.

2.3 Processing Methodology:

Metal matrix composites are normally formed either by Liquid Metallurgy Route or Powder Metallurgy Technique. In LMR the particulate phases are mechanically dispersed in the liquid phase before solidification of the melt. Stir casting technique is one of popular LMR method and also known as a very promising route for manufacturing near net shape hybrid metal matrix composite components at a normal cost. The execution of stir casting technique yields relatively homogenous and fine microstructure which improves the addition of reinforcement material in the molten metal. In addition, the porosity level of composite should be minimized and the chemical reaction

ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Special Issue.24, March 2017

between reinforcement and matrix should be avoided. The proper selection of process parameter such as pouring temperature, stirring speed, pre-heat temperature of reinforcement can produce good quality composites. In this present work, stir casting technique was used to fabricate 7075 Aluminum alloy with varying weight percentages of SiC (5, 10, and 15) The experimental set up was as shown in figure 1. The tensile strength for the fabricated composite Al7075 alloy is measured through the universal testing machine.This tensile test is carried out as per the ASTM EO8-8 standard. 10 KN is considered as the applied load to carry out the tensile test and evaluate at cross head speed of 2 m/min. The universal testing machine is used to carry out the compression test according to the ASTM E9-09 standards. The composite material Al7075 samples are compressed and the compressive value for the samples are noted and graphs are plotted. The fundamental behaviour of samples were studied when the samples are subjected to crushed or compressed by compressive test. The hardness value for the matrix alloy are calculated using the Micro Vickers hardness testing machine. This test is performed on the polished samples of composites according to the ASTM E10-07 standards. Vicker hardness test at load of 0.5Kg load for the interval of 10s was carried out on the composite samples. Various indentations at a gap of 1mm has been made and the average of hardness readings has been taken as hardness value.

between reinforcement and matrix should be avoided. The proper selection of process parameter such as pouring temperature, stirring speed, pre-heat temperature of reinforcement can produce good quality composites. In this present work, stir casting technique was used to fabricate 7075 Aluminum alloy with varying weight percentages of SiC (5, 10, and 15) The experimental set up was as shown in figure 1. The tensile strength for the fabricated composite Al7075 alloy is measured through the universal testing machine.This tensile the polished samples of composites according to the ASTM E10-07 standards. Vicker hardness test at load of 0.5Kg load for the interval of 10s was carried out on the composite samples. Various indentations at a gap of 1mm has been made and the average of hardness readings has been taken as hardness value. test is carried out as per the ASTM EO8- standard. 10 KN is considered as the applied load to carry out the tensile test and evaluate at cross head speed of 2 m/min. The

ISSN (ONLINE): 2395-695X
ISSN (PRINT): 2395-695X

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Special Issue.24, March 2017

Fig 1 Stir casting Setup

3 .Results and Discussion

3.1Tensile Test (Graphs)

It is clear that tensile strength of composites containing 15 wt% SiC particulates is higher when compared to other two composites. Increase in strength is possibly due to the thermal mismatch between the metallic matrix and the reinforcement, which is a major mechanism for increasing the increasing the composite strength. It is obvious that plastic deformation of the mixed soft is more difficult than the base metal itself. The presence of the reinforcing particles causes a significant increase in tensile strength. This uniform reinforcement will surely improve the tensile strength of composite. The presence of SiC particles in aluminum matrix during deformation causes the interface to crack and debonding since the matrix undergoes plastic flow while the particles do not deform. The ductility of the Al alloy-based composites, quantified in terms of tensile elongation, decreased with an increase in SiC particle size. This high strength of SiC particle composite was contributed to both the fine microstructure produced by the increase in fracture resistance. The addition of SiC particles into composites increased the tensile strength.

Compression Test

A compression test is a method for decisive the behavior of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates, and then applying a force to the specimen by moving the crossheads together. During the test, the specimen is compressed, and deformation versus the applied load is recorded. The compression test is used to determine elastic limit, proportional limit, yield point, yield strength, compressive strength. As deformation occurs, internal inter-molecular forces arise that oppose the applied force. If the applied force is not too great these forces may be sufficient to completely resist the applied force and allow the object to assume a new equilibrium state and to return to its original state when the load is removed. A larger applied force may lead to a permanent deformation of the object or even to its structural failure.

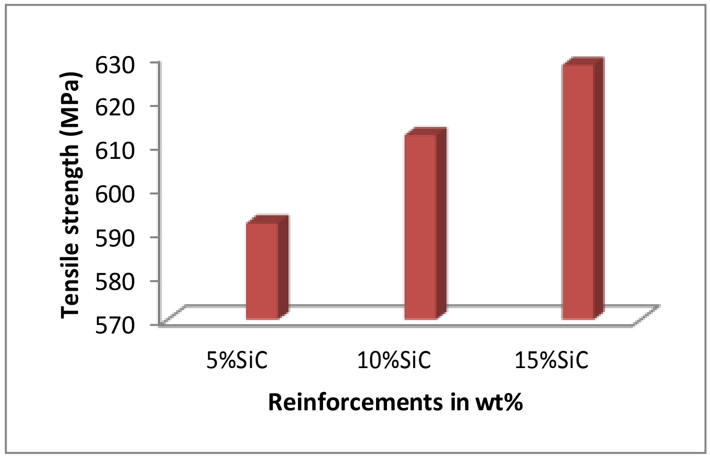

Fig.2. Ultimate Tensile strength of Al7075 composite alloy

Hardness Evaluation

A significant increase in hardness of the alloy matrix was seen with the addition of SiC particles. This indicated that the existence of particulates in the matrix improved the overall hardness of the composites. This is due to the fact that aluminum is a soft material and the reinforced particles being hard, contribute positively to the hardness of the composites. The presence of stiffer and harder SiC reinforcement leads to the increase in resistance to plastic deformation of the matrix.

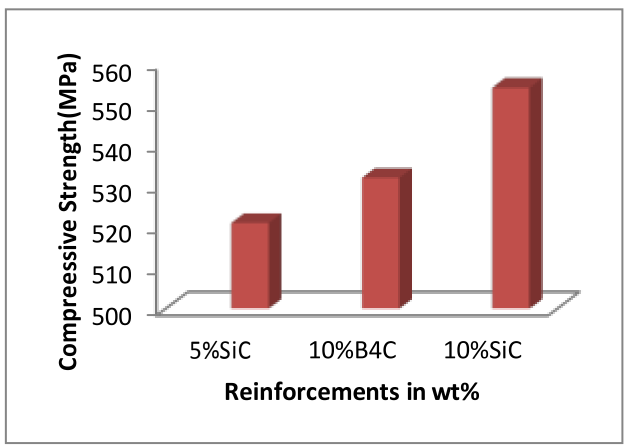

Fig 3.Ultimate Compressive strength of Al7075 composite alloy

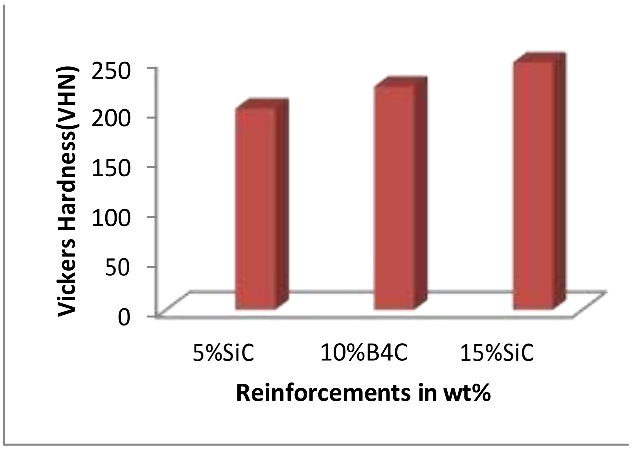

Fig 4. Hardness Evaluation of Al7075 Composite alloy

Microstructure Characterization

The microstructure analysis of these specimens shows that the SiC particles are uniformly distributed in the matrix. However, a presence of porosity around the SiC particles was detected. This observation may be attributed to the wetting behavior of aluminum alloy. It is also observed from the optical micrographs that the porosity of the specimens increases with increasing volume fractions of the particulate reinforcements. Some amount of segregation was happened due to the density differences while solidifying. This structure indicates that successful reinforcement of aluminum matrix is achieved. Reinforcement particles are almost spherical in shape and their distribution is reasonably uniform throughout the matrices in a company with clustering of particles and porosity at some locations. Type of interaction layer depends on the elements present at the interface during processing. The interfacial reaction between the metal matrix and reinforcement in metal matrix composites is very important because strong interfacial bonding permits the transfer and distribution of the load from the matrix to the reinforcement. Therefore, the nature of the interface is one of the most important factors to consider when designing a Metal matrix composies.

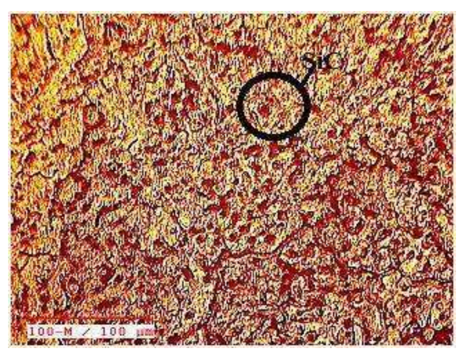

Fig 5 Microstructure Photograph SiC in Al7075 alloy

4. Conclusion

The presence of the higher reinforcing particles causes a momentous increase in tensile strength.

The incidence of stiffer and harder SiC reinforcement leads to the increase in resistance to plastic deformation of the matrix.The microstructure of the specimen shows the uniform distribution of SiC particles in the matrix. It is also observed that in the Al7075 matrix alloy ,SiC reinforcements act as a good bonding. A compression test results the decisive behavior of materials..

References

[1] Vencl A, Bobic I, Arostegui S, Bobic B., "Structural, mechanical and tribological properties of A356 aluminium alloy reinforced with Al2O3,SiC and SiC + graphite particles", Journal of Alloys and Compound, 2010, vol.9, pp.506 to 631.

[2] Sajjadi SA, Ezatpour HR, Beygi H., "Microstructure and mechanical properties of Al–Al2O3 micro and nano composites fabricated by stir casting. In: Proceedings of 14th National Conference on Materials Science and Engineering, Tehran, Iran, 2010, p.325.

[3] Mazahery A, Abdizadeh H, Baharvandi HR., "Development of high-performance A356/nano-Al2O3 composites", Material Science Engineering A , 2009, vol.4, pp.518-61.

[4] Altinkok N, Demir A, Ozsert I. Processing of Al2O3/SiC ceramic cake preforms and their liquid Al metal infiltration Composites: Part A, 2003; 34: 577–82.

[5] Altinkok N. Microstructure and Tensile Strength Properties of Aluminum Alloys Composites Produced by Pressure-assisted Aluminum Infiltration of Al2O3/SiC Preforms Journal of Composite Materials, 2004; 38: 1533-1543

[6] C.Neelima Devi, N.Selvaraj, V.Mahesh . Micro structural aspects of Aluminium Silicon Carbide Metal Matrix Composite. Int. Journal of Applied Sciences and Engineering Research, Vol. 1, No. 2, 2012

[7] Manoj Singla, D. Deepak Dwivedi, Lakhvir Singh, Vikas Chawla .Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite. Journal of Minerals & Materials Characterization & Engineering, Vol. 8, No.6, pp 455-467, 2009

[8]Yoshiro.Iwai, Hidetomo.Yonede and Tomomi.Honda, Sliding wear behaviour of SiC whisker reinforced aluminum composite, Wear. 181-183 (2) (1995) 594-602.

[9] A.P.Sannino and H.J.Rack, Tribological investigation of 2009 Al-20vol% SiC/17-4PH Part I: Composite performance, Wear. 197 (1-2) (1996) 151-159.

[10] Ali. Mazahery and Mohsen. Ostacl Shabani, Mechanical properties of squeeze-cast A356 composites reinforced with B4C particulates, J. of Mater. Process. Technol. 21 (2) (2011) 247-252.

[11]G. Mrówka-Nowotnik, J. Sieniawski, M. Wierzbi□skaAnalysis of intermetallic particles in AlSi1MgMn aluminium alloy, Journal of Achievements in Materials and Manufacturing Engineering 20 (2007) 155- 158.

[12]A. Wodarczyk-Fligier, L.A. Dobrzaski, M. Adamiak Influence of heat treatment on properties and corrosion resistance of Al-composite, Journal of Achievements in Materials and Manufacturing Engineering 21/1 (2007) 55-58.

[13]L.A. Dobrzaski, A. Wodarczyk, M. Adamiak, Composite materiale based on EN AW-Al Cu4Mg1(A) aluminium alloy reinforced with the Ti(C,N) ceramic particles, Materials Science Forum 530-531 (2006) 243-248

14] Mahendra, K. V., Radhakrishna, K., 2010, “Characterization of Stir Cast Al-Cu-(Fly AshþSic) Hybrid Metal Matrix Composites,” Journal of Composite Materials.,44(8), pp. 989–1005.

[15] Basavarajappa, S., Chandran Mohan, G., Mukund, K., Ashwin, M., and Prabu,M., 2006, “Dry Sliding Wear Behaviour of Al2219/Sic/Gr Hybrid Metal MatrixComposites,” Journal Materials Engg. Performance., 15(6), pp. 668–674.

16] Jasmi, H., 2001, “The Production of Cast Meta Matrix Composite by a Modified Stir Casting Method,” Journal of Technology., 35(A), pp. 9–20.

[17] Manoj Singla, D., Deepak, D., Lakhvir, S., and Vikas, C., 2009, “Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite,” Journal of Mineral, Materials Characterization. Eng., 8(6), pp. 455–467.
18.www.mec.inc.com