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Micro structural aspects of Aluminium Silicon Carbide Metal Matrix Composite

[1]C.Neelima Devi, [2]N.Selvaraj, [1]V.Mahesh

1- Department of Mechanical Engineering, S.R. Engineering College, Warangal, A.P, INDIA

2- Department of Mechanical Engineering, National Institute of Technology, Warangal, INDIA

Abstract: The role of engineering materials in the development of modern technology need not be emphasized. As the levels of technology have become more and more sophisticated, the materials used also have to be correspondingly made more efficient and effective. The increasing use of Aluminium alloy materials in structural and space applications generated considerable interest for the development of techniques to predict the response under various loading conditions. In this paper micro structural behavior of Aluminium with Silicon Carbide (grit size 60) has been studied by varying mass fractions of 5%, 10%, 15%, and 20%. In all microstructures consist of coarse grains of aluminium solid solution iron-rich (silicon carbide) inter metallic particles in the grain boundaries and this can influence the fracture behaviour.

Key words: Aluminium, silicon Carbide (SiC), micro Structure, metal matrix Composite.

1. Introduction

Materials must have combinations of properties for specific uses since present day products of modern technological origins operate in environment that are special or extreme like very high temperature (of order of 2500 K), cryogenic condition, vacuum (as in space), high hydrostatic pressure (as in deep sea). The conventional material may not always be capable of meeting the demand of such environments. Hence new materials being created for meeting these performance requirements and Aluminium alloy materials from one class of such materials developed. Aluminium silicon carbide alloy composite materials are widely used for a many number of applications like engineering structures, aerospace and marine application, automotive bumpers, sporting goods and so on. As Aluminium alloy materials are constructed by casting in specified sequence of orientation. Hence, the failure of a single aluminium alloy specimen does not give the total failure of casting. However, it leads to progressive failure of the casting. Several performance characteristics are expected from these materials. They are the materials to be used for sophisticated applications like aircraft and space applications should have higher performance, efficiency and reliability. Materials have to be of light-weight for many applications so that the resulting products can be efficient and cost effective.

2. Literature review

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 considered. 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. With other alloy matrices, SiC reacts to form Al_4C_3, and the nature of this reaction and its kinetics are considered in this paper. Initially, the reaction rates are very rapid but almost saturate after about 1 h. It is also shown that the distribution of the reinforcing particles is dependent on the solidification rate because particles are rejected and pushed ahead of the meniscus. At low solidification rates, and hence for large cell sizes, the reinforcing particles are clustered and form a

*Corresponding author (e-mail: neelima882@yahoo.com)

network which delineates the cell walls. Because the SiC particles are in the interdendritic regions they will be associated with any coarse intermetallic particles present and this can influence the fracture behaviour.

K.S. Foo ,W.M. Banks, A.J. Craven and A. Hendry presented a paper on electron microscope examination of the interface of an SiC particulate reinforced 6061 aluminium composite produced by a powder metallurgy process is presented. Conventional transmission electron microscopy (TEM) revealed a faceted interface between the SiC particulate and the aluminium matrix. It is postulated that the faceted interface is the result of the dissolution of the SiC particle by the liquid metal during the transient liquid sintering stage. It is concluded that this faceted interface provides very strong bonding at the interface and this is further evidenced by fractographic results. Energy dispersive X-ray spectroscopy (EDX) and electron energy loss spectroscopy (EELS) were used to identify the intermetallic compounds such as Mg_2Si and $FeSiAl_5$, some of which are found at the SiC/matrix interface. Initial results suggest that these intermetallic particles have a detrimental effect as they cause early debonding at the interface.

L.M.Tham, M.Gupta and L.Cheng**, a**n unconventional approach to strengthening Al/SiC composites through controlled matrix–reinforcement interfacial reactions was studied. Composites with two distinct interfacial microstructures were prepared by varying the contact time between the SiC particles and molten aluminium during processing. The formation of a thin Al_4C_3 reaction layer along the particle–matrix interface was found to increase the composite yield strength, ultimate tensile strength, work-hardening rate and work-to-fracture, and change the fracture pattern from one involving interfacial decohesion to one where particle breakage was dominant. These changes were attributed to a stronger interface bond, which is thought to result from the tendency for the Al_4C_3 reaction layer to form semi coherent interfaces and orientation relationships with the aluminium matrix and SiC particles and for it to be mechanically “keyed-in” to both these phases. The stronger interface bond also enhanced the levels of plastic constraint which, when coupled with the greater work hardening, promoted local matrix failure, thereby reducing the composite ductility.

3. Samples preparation for microstructure

Aluminium (6061) and Silicon Carbide (grit size 60) are mixed by casting process in mass basis ratio of 100:5, 100:10, 100:15, and 100:20. The prepared specimens are shown in figures (1, 2, & 3). In this paper, the microstructures of aluminium silicon Carbide metal matrix composite of varying proportions are revealed that at lower stirring speed with lower stirring time, the particle clustering was more. Uniformity in stirring speed and stirring time resulted in better distribution of particles which results in high strength and low weight composition for aerospace and structural applications with cost effective casting process.

4. Results and discussions

In the Figures 4 & 5, the micro structures of Aluminium with 5% Silicon Carbide samples of 100 microns and 200 microns respectively. In the Figures 6 & 7, the micro structures of Aluminium with 10% Silicon Carbide samples of 100 microns and 200 microns respectively. In the Figures 8 & 9, the micro structures of Aluminium with 15% Silicon Carbide samples of 100 microns and 200 microns respectively. In the Figures 10 & 11, the micro structures of Aluminium with 20% Silicon Carbide samples of 100 microns and 200 microns respectively.

Figure 1: Specimen 5 % SiC with Aluminium

Figure 2: Samples of Aluminium-Silicon Carbide

100:5 **100:10** **100:15** **100:20**

Figure 3: Aluminium silicon carbide alloy specimens for microstructure study

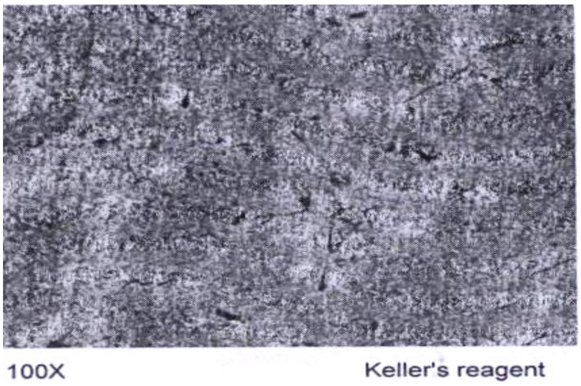

Figure 4: Microstructure of sample containing 5% SiC by weight (100microns)

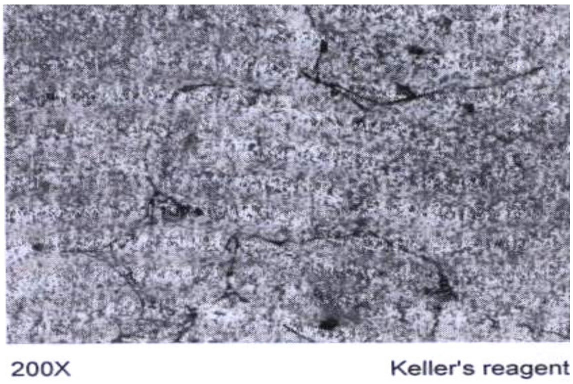

Figure 5: Microstructure of sample containing 5% SiC by weight (200microns)

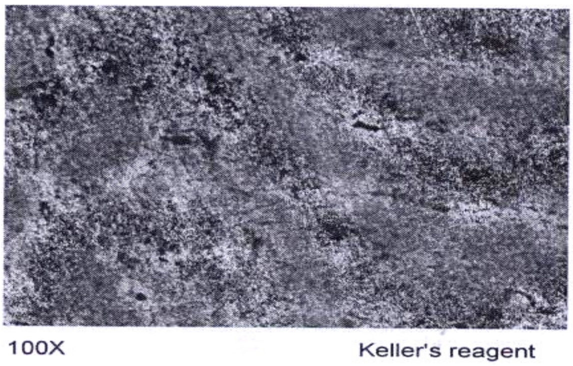

Figure 6: Microstructure of sample containing 10% SiC by weight (100microns)

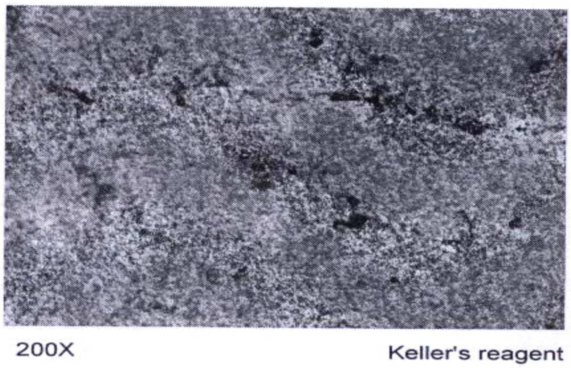

Figure 7: Microstructure of sample containing 10% SiC by weight (200microns)

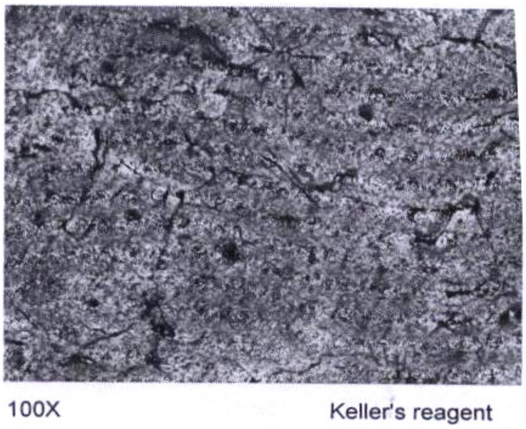

Figure 8: Microstructure of sample containing 15% SiC by weight (100microns)

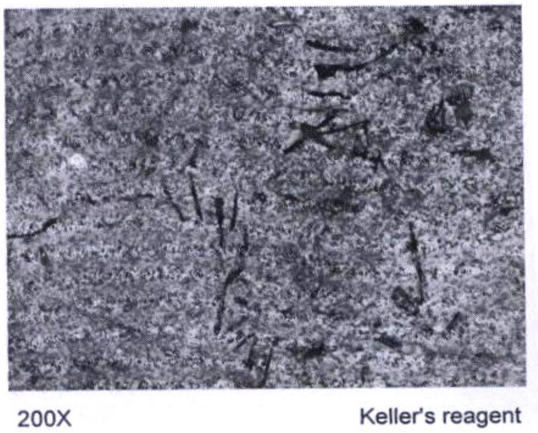

Figure 9: Microstructure of sample containing 15% SiC by weight (200microns)

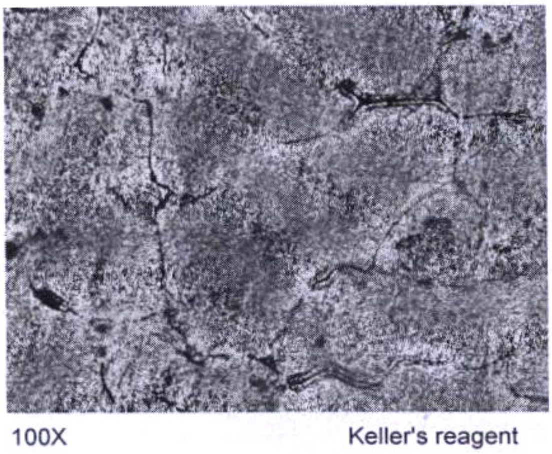

Figure 10: Microstructure of sample containing 20% SiC by weight (100microns)

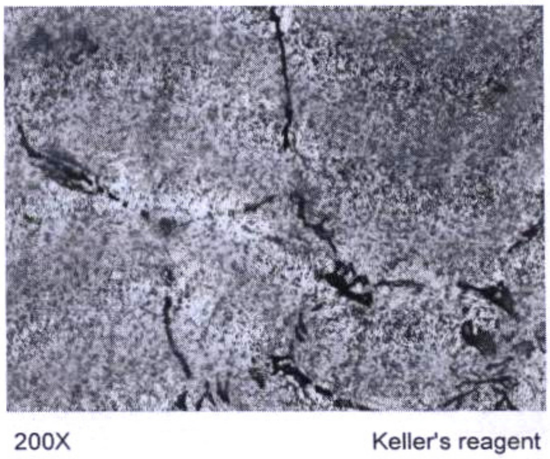

Figure 11: Microstructure of sample containing 20% SiC by weight (200microns)

From micro structural analysis, it was observed that Aluminium Silicon Carbide composite having cluster particles and some places are identified without SiC inclusions. This was due to varying the contact time between the SiC particles and molten aluminium during processing and high surface tension and poor wetting behavior between Aluminium and SiC particles. To overcome the surface tension problem and improve wetting properties, a mechanical force can be applied uniformly during distribution of reinforcement in the metal matrix composites.

4. Conclusions

From the observation of interfacial macrostructure, there were micro structural variations of aluminium and silicon carbide grains are obtained due to density of SiC particles decreases inspite of an increase in concentration. This may be attributed to the fact that SiC particles greatly interact with each other leading to clustering of particles and consequently settling down. The micro structural behavior of Aluminium with Silicon Carbide (grit size 60) has been studied by varying mass fractions of 5%, 10%, 15%, and 20%. In all microstructures consist of coarse grains of aluminium solid solution iron-rich (silicon carbide) inter metallic particles in the grain boundaries are observed and this can influence the fracture behavior.

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5. References

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