TEST Engineering & Management

September/ October 2020
ISSN: 0193-4120 Page No. 44-48

MICROSTRUCTURAL CHARACTERIZATION OF AA6351 ALLOY BASED COMPOSITES

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Article Info
Volume 83
Page Number: 44-48
Publication Issue:
September/October 2020

Article History
Article Received*: 4 June 2020*
Revised*: 18 July 2020*
Accepted*: 20 August 2020*
Publication*: 15 September 2020*

Abstract

Materials with low weight and good performance are in great demand in applied materials science. Materials of this kind might be used in a wide range of applications, including marine, automotive, and aerospace. In the current study, an aluminium alloy AA6351 was reinforced with different percentages of TiB2 particles (0, 4 and 8 wt percent) that were effectively fabricated by potassium hexafluoro-titanate, exothermic reaction of inorganic salts, and potassium tetrafluoro-borate, with molten aluminium melt to bring out unprecedented properties. The composite's tensile, yield, compression, micro- and macro-hardness were all measured. During the in situ reaction between molten aluminium and the halide salts K2TiF6 and KBF4, TiB2 particles are formed.

Key Words: *Microhardness, Metal matrix composites, Aluminum AA6351 Alloy, aluminium.*

Introduction

Metal matrix composites (MMCs) are composite materials in which at least 50% of the volume is made up of metal, and the reinforcements, which may be one or more components, can be constructed of metal, ceramic, or biological materials. Aluminum, Al-lithium, magnesium, titanium, copper, and other super alloys are often used as the matrix in the construction of these composites. The low density, high stiffness, and wear resistance of aluminum-based (MMC) make it a popular choice in a variety of applications. Reinforcing materials with certain physical characteristics, such as oxides, carbides, and nitrides, may be used to build MMCs. In many industrial applications, aluminium and its alloys are frequently employed because of its low weight yet high strength.1. Despite this, the welding of aluminium and its alloys has always been a tremendous problem for designers and scientists since these metals, particularly heat-treatable aluminium alloys, are very difficult to connect using standard fusion welding methods. This is due to the fact that during the solidification of the welding pool, certain welding flaws such as cracks and porosity may readily emerge in the weld. As a result of phase transition and softening in the alloy, traditional welding methods frequently result in considerable strength reduction in the welded connection.

Literature Review

V. MOHANAVEL ET.AL (2020) Aluminum composites are made using an Al-Si-Mg matrix composition and reinforcing particles of silicon Q2 nitride (Si3N4) (AMCs). It was discovered that stir casting may be utilised to make varied weight percentages of Si3N4 AA6351 matrix composites (0, 1, 2, and 3 wt. percent). The Q3 composites were tested using a scanning electron microscope (SEM), XRD, and energy dispersive X-ray analysis (EDS). The EDS and XRD spectra of the AMCs demonstrate that they include Si3N4 reinforcement. According to the results of the SEM analysis, the Al alloy has an equal number of Si3N4 particles. AMCs may be tested for compression, impact, tensile, and hardness to see what influence adding reinforcing weight percent has on their mechanical characteristics. Using a pin-on-disc tribometer, researchers were able to examine the tribological characteristics of the AMCs. The hardness, compression, and tensile strength of

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the AMCs were enhanced by the addition of reinforcement. Up to a mass percentage of 3%, nano-sized Si3N4 reinforcing material has been found to minimise wear.

SAHAYAM JOYSON ABRAHAM ET.AL (2019) Friction stir processing was used to create aluminum matrix composites containing rutile (TiO_2) particles. Conventional and cutting-edge characterization methods were used to investigate the microstructure. The TiO_2 particles in the composite were found to be evenly scattered. At a higher particle level of 18 percent, clusters of TiO_2 particles were discovered. The TiO2 particle's interface with the aluminum matrix was characterized by the absence of pores and a reactive layer. Sub-grain boundaries, ultra-fine grains, and significant dislocation densities were found in the composites. The inclusion of titanium dioxide (TiO_2) particles improved the mechanical properties of composites. Cluster formation was blamed for a reduction in tensile strength with increasing particle densities. All of the composites created fractured in a ductile manner.

ABHISHEK KUMAR ET.AL (2018) Metal matrix composite materials are gradually replacing traditional materials in a variety of sectors, including architecture, aeronautics, mechanical engineering, and more. You may use this procedure to get practically any combination of beneficial properties of the material, such as a high coefficient of vibration dampening, high abrasion resistance, high Young's modulus, low specific gravity, and a low thermal expansion coefficient. Using the stir casting technique, this study created MMC from an aluminum AA6351 alloy reinforced with Al2O3. The microstructure of AA6351/Al2O3 was explored in this study to investigate the impact of mechanical properties such as hardness, toughness, and tensile strength on the experimental set-up for stir casting.

RAO ET AL. (2017) investigated the mechanical properties of an Al-7075 hybrid metal matrix composite using a non-dominated sorting evolutionary algorithm (NSGA-II). As a consequence of the stir casting process, the composite was formed by mixing silicon carbide (SiC) with titanium dioxide in different weight fractions (percent) such as (0, 10), (2.5, 7.5), (5, 5) and (10/0). The optimal ratios for both SiC and TiO2 were found to be 9.513 percent and 0.487 percent, respectively, in the best compromise solution. According to these data, SiC particles are the most important component in all three mechanical parameters, whereas TiO2 particles have a minor role.

Fabrication of Hybrid Composites

In order to produce AA6351 hybrid composites with SiC, RHA, and Pr6O11 ball-milled reinforcing, stir casting was employed. As shown in Table 1, the AA6351 employed in this study has a chemical composition. There are a variety of AA6351 hybrid composites with different reinforcing ratios listed in Table 2.

Table 1 "Chemical composition of AA6351 matrix alloy"

Element	Si	Mn	Mg	Cu	Fe	Cr	Zn	Al
Weight %	0.95	0.59	0.72	0.077	0.187	<0.025	<0.017	Balance

Table 2 AA6351 hybrid composites designations. **o n**

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Composition ($SiC:RHA:Pr_6O_{11}$)	6:2:0.0	6:2:0.4	6:2:0.8	6:2:1.2
Designation	A11	A12	A13	A14

As soon as the graphite crucible was heated to 830°C, the AA6351 ingots were placed inside and allowed to melt fully. SiC, RHA, and Pr6O11 ball-milled reinforcements were heated and incorporated into the matrix melt for AA6351 hybrid composites. At this point, warmed reinforcement was added to the matrix melt, which was agitated at a speed of 400 rpm. Stirring went on for another 10–12 minutes even after all of the reinforcements had been included. In order to generate characterization samples, the mixture was collected after it had solidified spontaneously in the crucible and allowed to cool to room temperature.

"Characterization of AA6351 Hybrid Composites"

Density and Porosity Measurement

AA6351 hybrid composites have been created and are shown in Table 3 for their measured density and predicted porosity levels. Between 1.144 and 1.399 percent of AA6351 hybrid composites are considered porous. The findings showed that the estimated % porosity of the composites rose when the Pr6O11 concentration in the composites was increased. A higher percentage of porosity may have been achieved using RHA and stir-casting; however, the highest permissible value for cast aluminum matrix composites (4%), which were employed in this study, was 1.399 percent. Density was increased in the resulting composites by using high-density Pr6O11 as reinforcing material.

Table 3 "Density and Porosity Measurement of AA6351 Hybrid Composites"

Sample Designation	Theoretical Density (g/cm^3)	Experimental Density (g/cm^3)	Estimated Percentage Porosity
A11	2.709	2.678	1.144
A12	2.735	2.702	1.207
A13	2.761	2.725	1.304
A14	2.787	2.748	1.399

Microstructural characterization

Fig. 1 (a–d) shows the SEM images of the AA6351 hybrid composites that have been changed with rare earths (0.4, 0.8%, and 1.2 wt%). SEM pictures show that the reinforcement is evenly distributed. According to SEM picture of hybrid composite in Figure 5 (a), the grains are arranged in a random fashion. Refinement in grain size may be readily seen by scanning electron microscopy (SEM) images taken from hybrid composites with the addition of Pr_6O_{11}, as illustrated in Figure 1. (b-c). It is demonstrated in Figure 1 that Pr_6O_{11} addition results in a more equiaxed structure with more refined grain boundaries (d).

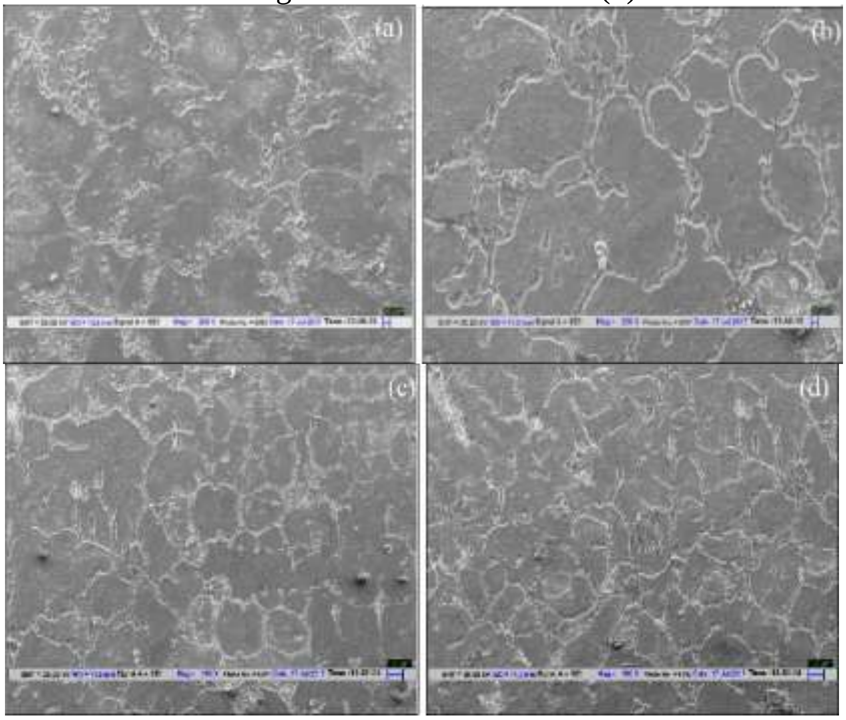

Fig:1 "SEM images of AA6351/ 6%SiC/ 2%RHA Hybrid Composite: (a) 0 wt.%, (b) 0.4, wt.% (c) 0.8 wt.%, and (d) 1.2 wt.% Pr_6O_{11}."

Compression strength of AA6351/AL2O3/GR AMCS

The compression strength of the composites is shown to be affected by the presence of dual particles. Dual particles have been shown to boost compression strength, and their strength surpasses that of the basic matrix alloy. The higher dislocation density caused by a thermal coefficient expansion (CTE) mismatch between the matrix and reinforcement may help enhance compression strength in composites.

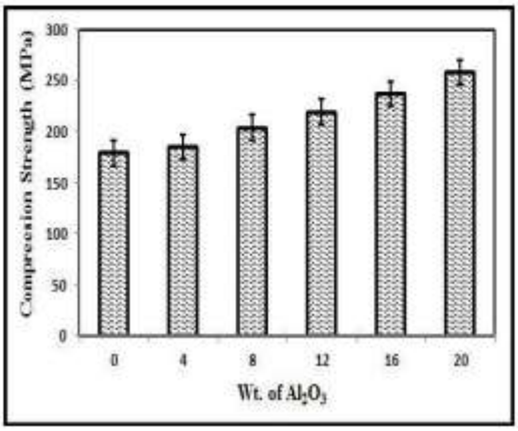

Fig 2 Variation of compression strength with varying content of Al2O3 and 3 wt.% graphite hybrid composites.

Conclusion

The rare earth element Pr_6O_{11} was successfully stir cast into AA6351/SiC:RHA 6:2/ Pr_6O_{11} hybrid composites. Microstructural, mechanical, and wear resistance hybrid composites have been created utilising AA6351/SiC:RHA 6:2/1.2 wt. % Pr_6O_{11} as the base. In addition to the rise in tensile strength, the composite's hardness rose from 86.12 to 104.67 Hv. The hybrid composites' wear resistance was also improved by the addition of Pr_6O_{11}. The overall performance of AA6351 hybrid composites was greatly enhanced when a little amount of Pr_6O_{11} was introduced. Several different reinforcing ratios of Al-4032/SiC/GMP composites were made using a stir casting technique (0-3-6-9 percent by weight). Al-alloy-based hybrid composites have been developed using SiC (conventional reinforcement) and granite marble powder (industrial waste ceramic particles).

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