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Effect of nano alumina particles on mechanical properties of AA2219 nano metal matrix composites

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ABSTRACT

AA2219-Al_2O_3 (nano) metal matrix composite was fabricated by stir casting method. The fabricated composites were subjected to microstructure investigations, tensile tests and hardness tests. The addition of nano Al_2O_3 (0, 0.75 and 1.5 wt.%) particles increased the mechanical properties of the composites. The microstructures show the almost uniform distribution of Al_2O_3 particles in the matrix. Hardness and tensile strength of AA2219-Al_2O_3 composites is considerably greater when compared with unreinforced alloy. The mechanical properties of the composites increase with increasing in weight percentage of Al_2O_3 particles.

KEY WORDS: Mechanical Properties, Aluminium Matrix Composite, Nano particles, aluminium oxide.

1. INTRODUCTION

There is always demand to create the new materials to match the developing industrial needs. Aluminum matrix composites (AMCs) have received improving attention in recent years as engineering materials with most of them possessing the advantages of high strength, hardness and wear resistance (Baradeswaran, 2013). Ceramic particles such as Al2O3 and SiC are the most widely used materials for reinforcement of aluminium. Alumina have attractive properties like high strength, extremely high hardness, good wear resistance and thermal conductivity (Baradeswaran, 2013). Aluminum matrix composites gives unique balance of physical and mechanical properties. The aluminum matrix composites are fabricated by different methods such as squeeze casting, compo casting, stir casting, powder metallurgy and liquid infiltration (Mohanavel, 2015). Among the fabricating methods, the stir casting is an attractive processing method for producing aluminum matrix composites. Stir casting usually involves prolonged liquid reinforcement contact, which can cause substantial interface reaction (Sajjadi, 2011; Mohanavel, 2015). Koli (2015) have investigated that the Al6061 alloy based metal matrix composites have been showing high hardness and tensile strength by the addition of nano sized aluminum oxide particle ranging from 1 to 4 weight percentages. Bharath (2014) have reported the results of the test examination of hardness and tensile strength of aluminium alloy (AA6061) containing micron sized aluminum oxide particles. From the results it is evident that the mechanical properties of specimen containing aluminum oxide has been comparable to that of base AA6061 alloy. Akbari (2013) reported that the fabrication of A356/Al2O3 nano composite was prepared by stir casting method and they showed the mechanical behavior of the Al matrix composites is greater than that of its cast matrix alloy. Hence, the present work aims to develop the Al2219-Al2O3 nano composites with improved mechanical properties through stir casting method.

2. MATERIALS AND METHODS

The fabrication of metal matrix composite used in present investigation is carried out by using stir casting method. Aluminium alloy 2219 is used as the matrix material and the reinforcement particles was nano Al_2O_3 (20nm). The amount of Al_2O_3 addition was varied as 0.75 and 1.5 wt.% during the stir casting process. Nano alumina particles are preheated to 300°C before adding into aluminum melt which is maintained at 750°C. After addition of the nano particles stirring is performed for about five minutes at 300 rpm by a zirconium coated stirrer. After that, stirrer was stopped and then the melt was poured into preheated die. The macro hardness was measured using brinell hardness tester. Hardness was tested on at a load of 500kg and a dwell time of 5 seconds. Macro hardness was measured at five different locations and the average value was taken as hardness of the composite specimens. The tensile test was estimated using computerized universal testing machine and average values were recorded. Tensile test specimens were prepared from the cast samples according to ASTM E8 standards.

Figure.1. Stir casting setup

3. RESULTS AND DISCUSSION

Microstructural studies: Figure.2 (a-b) shows the SEM micrographs of composites. This micrographs shows almost uniform distribution of nano Al_2O_3 particles in the composites. Suitable stirring causes the particles to be uniformly spread in the melt.

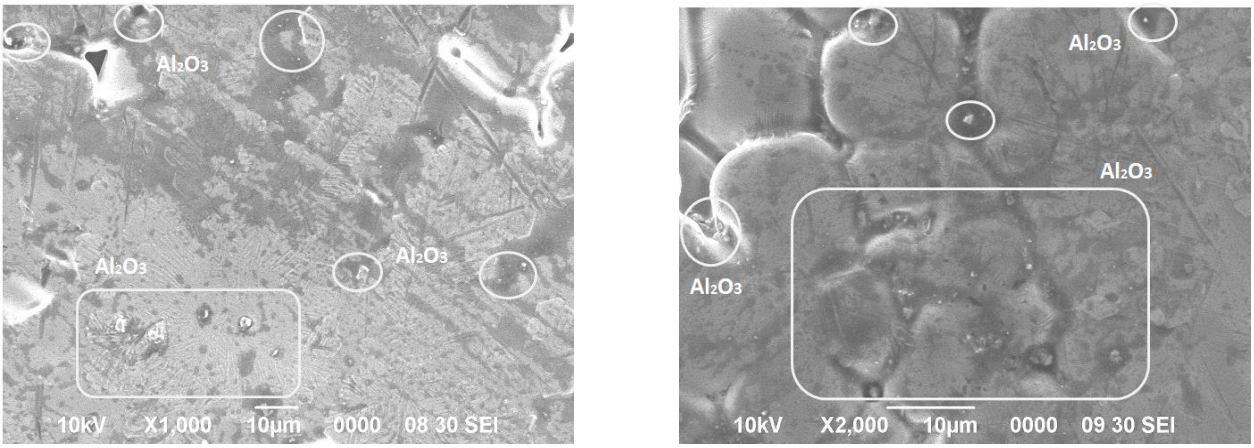

Fig.2. SEM micrographs of AA2219-Al_2O_3 composite: (a) AA2219/0.75wt% Al_2O_3 composites and (b) AA2219/1.5wt% Al_2O_3 composites

Hardness of the composite: Table.1 shows the variation of hardness of the composite. This indicates that the macro hardness increased with the addition of Al_2O_3 particle content. The hardness of the composite linearly increase with increase in weight percentage of nano Al_2O_3 particles occasion by increment in surface area of the matrix with reduction in grain sizes. Therefore, the hardness of the composites is increased.

Table.1. Hardness of the AA2219-Al_2O_3 composite.

Sample Designation	Hardness (BHN)
AA2219	59
AA2219/0.75% Al_2O_3	66
AA2219/1.5% Al_2O_3	74

Tensile strength of the composite: Table.2 shows the increase in tensile strength from 183 MPa to 212 MPa respectively in the produced AMCs because of increased content of hard particles and almost uniform distribution of reinforcement particles. The prepared composites have higher tensile strength than the AA2219 base alloy. The tensile strength of the composites increase with increasing in weight percentage of Al_2O_3 particles. The Al_2O_3 particles act as hindrance to dislocations motion, Therefore strength of the composites is increased.

Table.2. Tensile strength of the AA2219-Al_2O_3 composite.

Sample Designation	Ultimate Tensile Strength (MPa)
AA2219	183
AA2219/0.75% Al_2O_3	190
AA2219/1.5% Al_2O_3	212

4. CONCLUSION

In this paper, a study on mechanical behavior of AA2219-Al_2O_3 is carried out. The following are the conclusions that are observed:

- AA2219 aluminum alloy reinforced with (0, 0.75 and 1.5 wt%) nano alumina composites have been successfully fabricated by stir casting method.
- The hardness and tensile strength of the composite linearly increase with increase in weight percentage of nano Al_2O_3 particles.
- SEM micrographs show the almost uniform distribution of particles throughout the matrix.
- The mechanical properties of the composites increase with increasing in weight percentage of Al_2O_3 particles.

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