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Stir Casting of SiC Reinforced Aluminum Composites from Waste Aluminum

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Abstract – Aluminum and its alloys are widely used in automotive, aviation, defense industries because of its low density, process ability, high strength. Aluminum matrix composites are usually manufactured by powder metallurgy or liquid methods. As a liquid processing method, stir casting method is a cheaper and easier method than powder metallurgy. When waste beverage cans are recycled and used as matrix material for manufacturing composite material, cost of process is reduced and also environmental pollution is reduced. In this study, silicon carbide (SiC) reinforced aluminum matrix composites have been manufactured. From the manufactured composites specimens have been prepared and hardness, density, compressive, tensile, tests; XRD and SEM analyses have been applied. From the obtained results with the reinforcement of SiC, hardness value has been increased from 70.1 HV to 89.90 HV. Also, from SEM analyses it is observed that SiC particles have been dispersed homogeneously.

Keywords – Composite, SiC, aluminum, mechanical property, scanning electron microscope

I. INTRODUCTION

In these days, due to needs and technological improvements in especially aviation, aerospace and automotive sectors, usage of new materials are needed. Composite materials have been thought to resolve these needs. In this field metal matrix composites (MMC) are the most widely used materials among composite materials. With the combination of high mechanical properties of MMCs and superior properties of ceramics, manufacturing and usage of more superior materials have become common [1].

Among MMCs the most common matrix material is aluminum and its alloy because of properties such as low density, high corrosion resistance, high strength, ductility, being easily extruded, being recycled easily, thermal and electrical conductivity [2].

One of the most important reinforcement materials for MMCs is silicon carbide (SiC). SiC has high hardness and quite high wear resistance. Due to its superior properties like high wear resistance, high thermal shock resistance, thermal expansion and thermal conductivity coefficient it's become more important among other ceramic materials for manufacturing of gas turbines and automobile parts which are exposed wear. MMCs have become cheaper to manufacture thanks to the short, high quality fibers which are developed recently. Applications in aerospace and automotive industries of SiC and aluminium oxide (Al2O3) reinforced aluminum matrix composites are; pistons, cylinder heads etc. where tribological properties of material is highly crucial [1-2].

Manufacturing process is also important as manufacturing method with the developing technology and cheaper, simpler manufacturing methods attract attention. Based on application area of MMCs, liquid metal or powder metallurgy methods are used. While powder metallurgy method is used for production of composites contains small grain sized, high quantity reinforcement; stir casting method is used for production of composites contains large grain sized, low quantity reinforcement [3-4].

Livable environmental conditions are getting harder due to improvements in space, aviation and automotive industries. So, production of environmentally compatible and recyclable materials are becoming common. Metals are important among recyclable materials. The reason of this is metals such as aluminum etc. are used in almost everywhere. One of the most widely used and recycled areas of aluminum is beverage cans [3-4].

That's why in this study, the aim is manufacturing of SiC reinforced aluminum matrix composites (AMC) by stir casting method which is a cheaper, simpler alternative way of powder metallurgy and expensive powder raw materials. So that, environmental pollution would be reduced while matrix material of AMCs are obtained cheaply [3-4].

II. MATERIALS AND METHOD

In the study, waste aluminum beverage cans were used as matrix material and SiC powder with an average particle size of 44 was used as reinforcement material. 1%, 3%, 5%, 7% and 9% by weight SiC were added to the matrix by means of the stir casting method and composite materials were produced. The density, hardness and microstructure properties of the composite materials produced at different reinforcement ratios were investigated.

A. Density and porosity measurement

Experimental density measurements of composite materials and non-reinforcing matrix materials were determined according to Archimedes' principle, and their theoretical densities were determined according to the rule of mixtures.

By using theoretical and experimental densities of composites, their porosity ratios were calculated.

B. Hardness Measurement

The hardness values were determined by using Vickers hardness measurement method of composite materials which are produced without matrix and materials. The measurements of hardness values were determined by taking measurements of six different regions by applying 100 grf.

C. Microstructure Analysis

In order to determine whether the distribution of the reinforcing element in the matrix is homogeneous in the produced composite materials, the microstructure studies were carried out by scanning electron microscopy (SEM) on the fractured surfaces of the prepared samples.

III. RESULTS AND DISCUSSION

The density and porosity measurements of the produced composites are given below. The theoretical densities of the non-reinforced matrix material and composite materials calculated according to the rule of mixtures, the experimental intensities calculated according to the Archimedes' principle, and the porosity values obtained using these densities are given in Figure 2. As the density of SiC is higher than the density of the matrix material, it can be seen that the density of the composite materials is generally increased to above 2.65 g/cm3 with the increase of the reinforcement ratios. In Figure 2, it was determined that the porosity value of the composite materials was around 7.1% by increasing the reinforcement ratio of SiC particles.

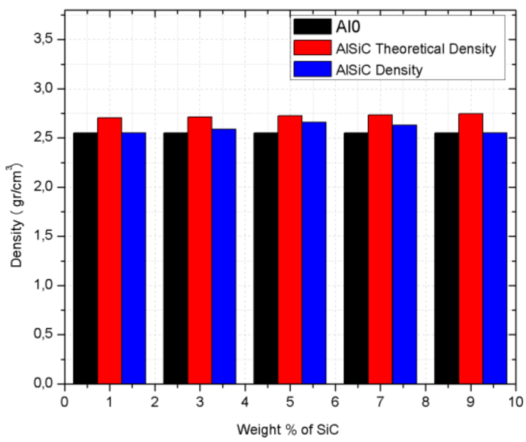

Figure 1. Density results with SiC reinforcement

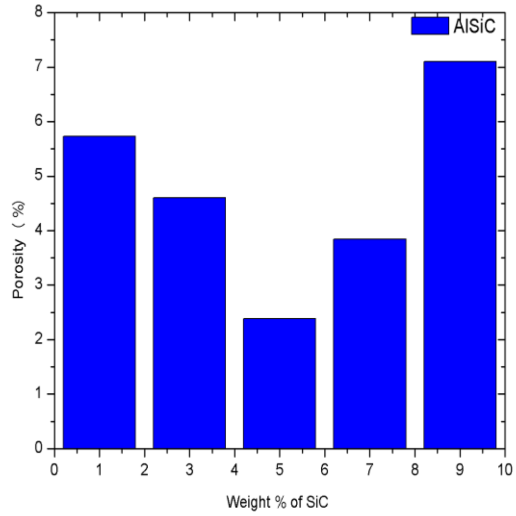

Figure 2. Porosity values with SiC reinforcement

The hardness values of non-reinforcing matrix material and SiC reinforced composite materials are given in Figure 3. With the increase of the reinforcement ratios of the composite materials produced, it was observed that the hardness values increased. The highest hardness value was obtained with 89.90 HV and 9% SiC reinforcement. The homogeneous distribution of the reinforcement material in the matrix material and the presence of hard SiC powders in the matrix resulted in an increase in the hardness value.

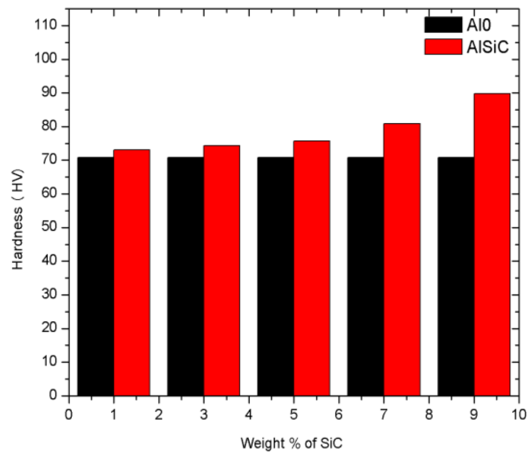

Figure 3. Hardness measurements with SiC reinforcement

Figure 4.a-d shows SEM and mapping analyzes of SiC reinforced composites produced. SiC grains show a homogeneous distribution. In the mapping analysis, aluminum is seen in blue color. The purple and red regions are the regions where Si and C are. Since the Si and C regions are similar to each other, they confirm that these regions are SiC.

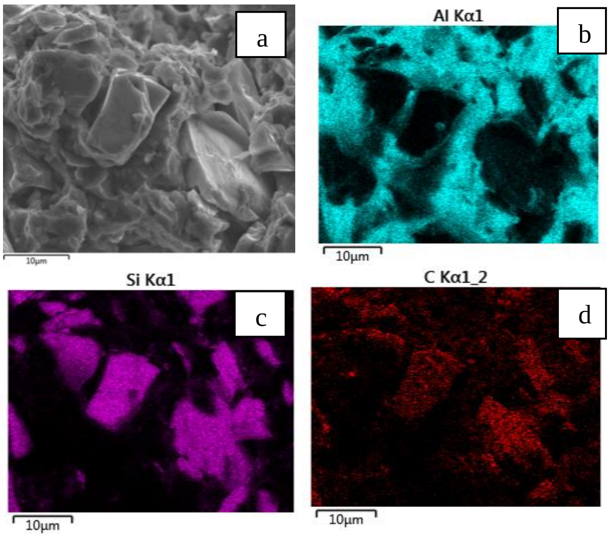

Figure 4. SEM and mapping analyses of fabricated composites

IV. CONCLUSION

In this study, waste beverage cans were evaluated and SiC reinforced composites were produced. According to the results, it was observed that SiC supplementation contributed positively to the mechanical properties of aluminum. It was determined that the density of the composite increased and the hardness value increased from 70.1 HV to 89.90 HV. According to SEM analysis, SiC was homogeneously distributed within the matrix.

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