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Research Article

Microstructure Analysis of Aluminium metal matrix alloy with Silicon Carbide

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Abstract

This work studies the microstructure of the composite materials to check whether good and uniform bonding between the matrix and dispersion phase is achieved. The different grades of Al were taken for the analysis: Al 6063, Al6066 and Al 6351. The SiC particles were added in the matrix phase of Al at three different weight percentages. Total 9 samples were ready for the analysis and to make a comment on the effect of SiC particulates on the Al alloy which is significant. The fabrication process and hardness testing of the prepared samples are already done in previous work. This work explains using the microstructure analysis for non-uniform increment in the hardness value. From microstructure analysis, the non-uniform mixing of the SiC particle was observed in the matrix may be because of the manual stirring.

Keywords: *Aluminum alloys, silicon carbide, matrix composites, microstructure.*

1. Introduction

Metal Matrix Composite (MMC) is the combination of the matrix phase (metal) and reinforced phase (ceramic particles) to get the better mechanical properties. MMC has the wide range of application bicycles, automobiles, aircraft, space shuttle etc. The achievement in the better mechanical properties depends on the matrix alloy, characteristics of the reinforced material (shape, size and location) and also depends on the fabrication method opted for mixing. Aluminium and SiC both have different mechanical properties: yield strength of 35 MPa and 600 MPa respectively. Whereas, the Young's modulus of elasticity of 70 GPa and 400 GPa for Aluminium and SiC respectively (Singla, M *et al*, 2009). The Young's modulus of 96.6 GPa and yield strength of 510 MPa was found Al composite with Al 6061 grade alloy. Further improvement in the properties can be possible depends on the stir casting method.

In the present work, manual stir casting method was used and SiC particulates were mixed at different weight % (5%, 7% and 9%) in Al matrix. The Al was melt inside a crucible which was kept in a coal-fired furnace. To achieve the uniform mixing, the stirring process was done for at least half an hour.

Fabrication steps are not explained here because they already explained in previous work (Kundu, P, 2013). This work is the extension of the previous work. In the previous work, for determining the mechanical properties of the composite; the Vickers hardness test was performed. It was observed there is the significant increase in the hardness of the composite till 7% of SiC but after that for 9% the amount was not that much significant. For explaining that variation, this paper presents the microstructure analysis of the prepared composite bar.

The present paper is organized in four sections. Section 2 mentioned the various steps involved in sample preparation for the microstructure analysis. The results obtained from microstructure analysis are explained in section 3. Section 4 concludes the paper and also presented the scope for future work.

2. Sample preparation for microstructure analysis

The sample preparation step is the key step before performing the microstructure analysis. The sample should be prepared carefully for achieving the better microstructure results. Usually over the sample surface, oxidation layer and other foreign materials are presents which hinder the microstructure results. Lapping is the first step of the sample preparation. In this grinding surface is a rotating disc whose working surface is charged with a small amount of a hard abrasive material. The abrasive charge may be pressed into lap material by means of a steal block, or the lap may be charged directly with a mixture of abrasive and distilled water during lapping (http://mimoza.marmara.edu.tr/~altan.turkeli/ files/1-sample_ preparation. pdf,). The laps have either a rotating or a vibrating motion, and http://www.steeldata.info/ etch/demo/help/sample_preparation/mechanical_polishing. html the specimen are held by hand, held mechanically, or merely confined within the polishing area. During lapping,

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the surface of the sample will not have the mirror like surface. So, polishing is done after lapping process to obtain the surface flat, scratch free and mirror like in appearance. Fig. 1 shows the photograph of the polishing machine used for the sample preparation.

Fig. 1. Polishing machine

Fig. 2. Polishing Cloths

The surface cleanliness during polishing depends on the type of polishing abrasive and quality of the polishing cloths. The polishing cloths quality depends on the ability to hold an abrasive, long life, absence of any foreign material that may cause scratches. Fig. 2 shows the polishing cloth used in the present work. Based on the literature the alumina abrasive powder is used as a polishing powder (Fig. 3).

Fig. 3. Alumina abrasive powder

Fig. 4. Etching agent (HF)

Sometime after polishing, certain information about the microstructure may not be obtained. So etching is performed to make the microstructure clearly visible. In the present work, the mixture of 0.5% HF solution and 99.5 % water solution was used an etching agent (Fig. 4). Etching should be done carefully. Because under etching will not give any information about the microstructure and over etching may result into destroy of the sample surface. After over etching, the sample needs to prepare again by following all above steps.

Cleanliness is an important requirement for successful sample preparation. Specimen must be cleaned after each step.

3. Results & Discussion

The Fig. 5-13 shows the microstructure results obtained using an optical microscope. The presence of SiC is shown in black phase whereas green phase is the matrix phase (Al alloy). It was found that SiC particles tend to froze in the last stage of the solidification and contained the eutectic phases. From Fig. 5-13, the reasonably homogeneous distribution of the SiC particles was found. The microstructure for Al 6351 was not found to be good may be because of deposition of the oxidation layer over the surface of the cast. It can happen because of non-availability of the vacuum desiccator. The porosity and micro shrinkage were also observed in the cast. The porosity was found to be increase with the increase in the % of SiC. That can be main reason for the non-uniform variation in the Vickers hardness value with the increase of SiC %.

In overall, it can say that SiC particles are unevenly distributed in the cast composite and some particles lean are was also found. It means developed composites with the manual stirring have the non-uniform distribution of the SiC particulates. In the future work the stirring process will be motorized and will be validating for uniform mixing of the SiC particulates.

This happened because of SiC has the large density compared to the molten metals and they were observed to be float over the surface without stirring. Even though when manual stirring was done the particles will mix into the melt but after stopping of stirring the particle tends to return to the surface. They will stick to the surface and cause non-uniform distribution of the particulates inside the melt.

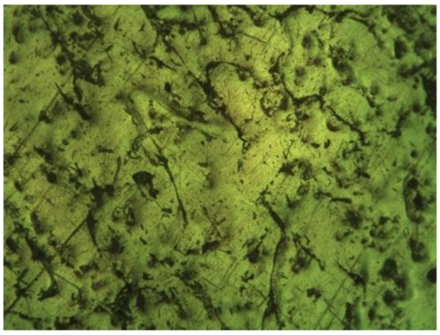

Fig. 5. Microstructure of Al 6063(95%) + SiC (5%)

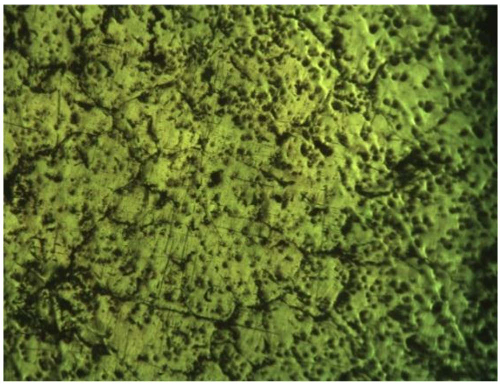

Fig. 6 Microstructure of Al 6063(93%) + SiC (7%)

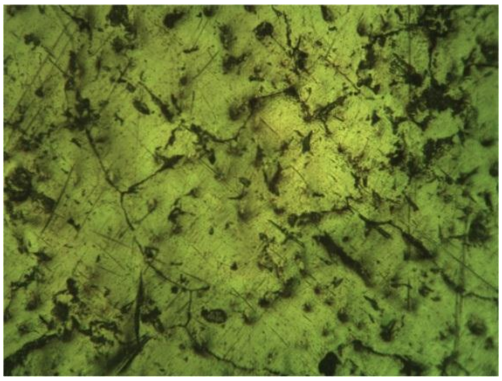

Fig. 7. Microstructure of Al 6063(91%) + SiC (9%)

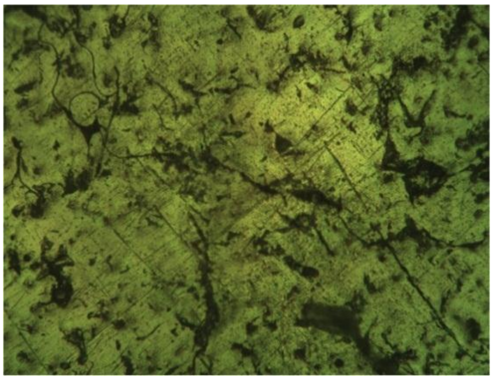

Fig. 8. Microstructure of Al 6066(95%) + SiC (5%)

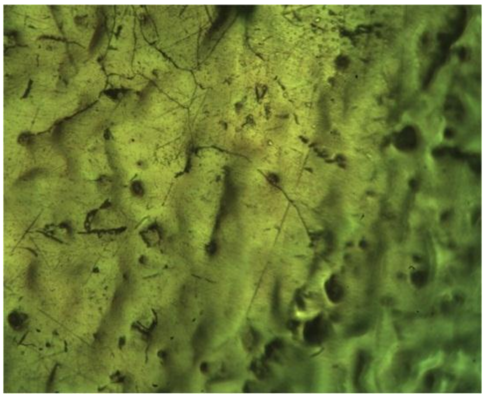

Fig.9. Microstructure of Al 6066(93%) + SiC (7%)

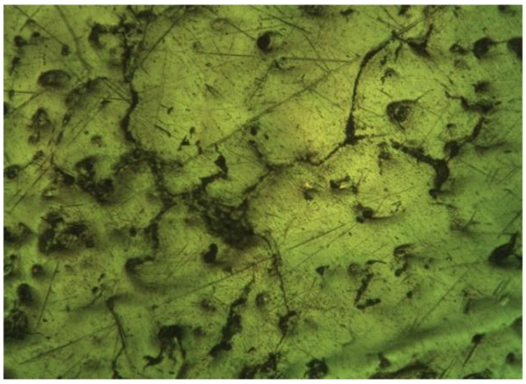

Fig.10. Microstructure of Al 6066(91%) + SiC (9%)

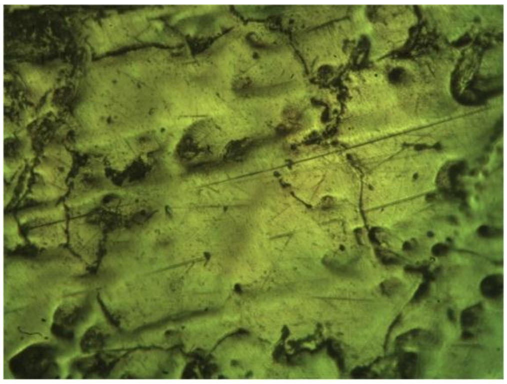

Fig.11. Microstructure of Al 6351(95%) + SiC (5%)

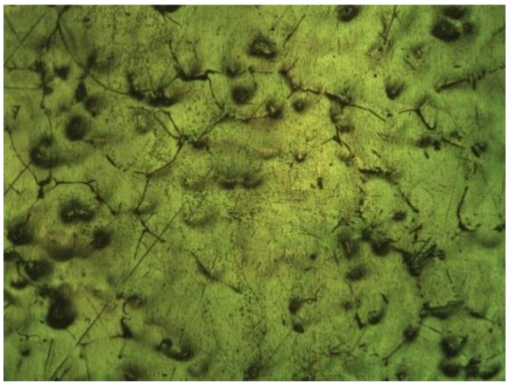

Fig. 12. Microstructure of Al 6351(93%) + SiC (7%)

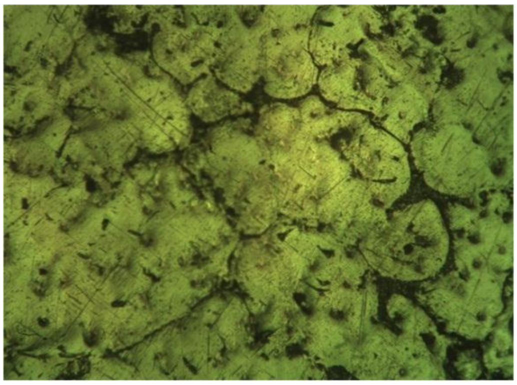

Fig. 13. Microstructure of Al 6351(91%) + SiC (9%)

Conclusions and scope for future work

This work is the extension of the previously done work. In the previous work, the rapid increase in hardness was found from 5% to 7% compared with 7% to 9%. To validate this, microstructure analysis is done in this work. Usually, sample has the oxidation layer on the top and also some amount of foreign material is present on it. Sample preparation is the key step before seen the microstructure and that was done carefully. After sample preparation, the microstructure was seen and saved for future analysis using inverted microscope. It was observed from the microstructure that there is non-uniform mixing of the SiC particulate in the Al melt. This could be the one reason of the variation in hardness. This non-uniform mixing may be because the stirring was done manually. The work will be done in the future to perform the stirring action with the help of motor; so that uniform mixing can be obtained.

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