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Effect of Mechanical Milling on the Microstructure and Morphology of Al_{2024}/SiC Nanocomposite

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Aluminum based metal matrix composites are used in aerospace, defence and selected automotive applications such as high performance racing applications [1]. The most commonly used materials as reinforcement are SiC, Al_2O_3 or B_4C into the aluminum matrix. These materials are used to improve elastic modulus, enhanced heat and wear resistance [2]

A huge variety of research has been focused on the synthesis and application of metal matrix composites (MMC) in recent years. Metal and Ceramic particles have mainly been used as reinforcing materials. Aluminum and its alloys have been reinforced with ceramics in order to improve properties like wear behavior or mechanical strength [3]. However, most of them are related to the use of micron sized particles.

The purpose of the present studies is to investigate the influence of MM processing on the particle size, crystallite size and microstructural changes in powder particles and distribution of SiCp reinforcement.

Aluminum alloy Al_{2024} (Al–4.00% Cu–0.83% Mg–0.21% Fe–0.67% Mn–0.12% Si–0.03% Cr) was used as a matrix of composites and silicon carbide nanoparticles (SiC_{NP}) as reinforcement. SiC_{NP} were dispersed into the aluminum matrix to form the nanocomposites by a milling process. Al_{2024} was received as a metal bar, where debris, were obtained by drilling it. The milling times were 1, 2, 3, 4, 5, 7, 10, 15 and 30h.

The Al_{2024} powder was produced by machining a solid extruded bar. The machined metal shavings were mixed with SiC_{NP} in different concentrations (0.00, 0.50, 1.00, 1.50, 2.00, 2.50, 5.00 and 7.00 wt. % SiO_2NP). Mixtures were mechanically milled in a high- energy ball mill SPEX8000 under argon atmosphere. Milling products were cold consolidated at 330 MPa by a cylindrical steel die (compacting device) in order to obtain samples with 5 mm of diameter and 10 mm high. Green products were pressure-less sintered for 3 h at 500°C.

Figure 1 shows the variation of crystallite size the matrix aluminum alloy 2024 as a function of milling time. It may be noted that the crystallite size was reduced from 280 nm in the reference sample (0h milling time) to about 19 nm after milling for 30 h.

Figure 2 presents the SEM micrographs showing the morphology and size of the Al_{2024}/SiC nanocomposites powder after milling for different times. The average particle size of Al_{2024}/SiC nanocomposites , in the first hour of milling time, was calculated to be 101 μm, which reduced to 68, 58, 47, 32, 24, 16 and 9 μm, respectively after milling for 2, 3, 4, 5, 7, 10, 15 and 30 h, respectively.

In the present investigation, we are dealing with ductile Al alloy and brittle SiC_{NP} phases. During the initial stages of milling, the soft phase powder particles will get flattened and the brittle phase will get fragmented. Subsequently, with continued milling, the fine brittle particles will continue to decrease in their size and will get occluded on to the softer flattened particles. With further milling, these brittle particles get continuously kneaded and the particles get uniformly dispersed in the matrix. Also similar situation is observed in the present investigation, as confirmed by the SEM images.

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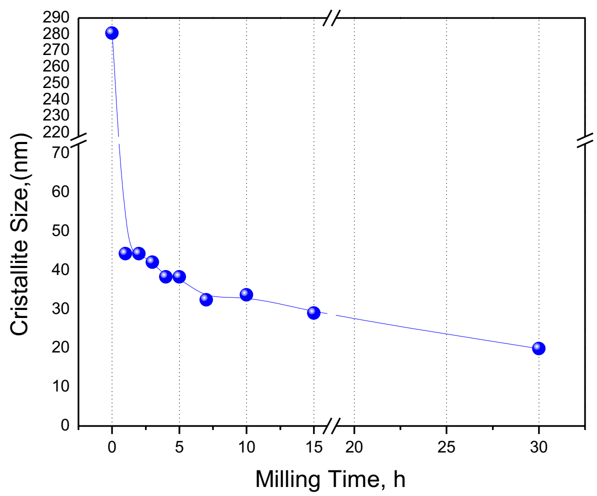

Figure 1. Graph showing crystallite size (CS) for Al_{2024}/SiC nanocomposites containing 2.0, wt.% SiC milled for 0, 1, 2, 3, 4, 5, 7, 10, 15, 30 h.

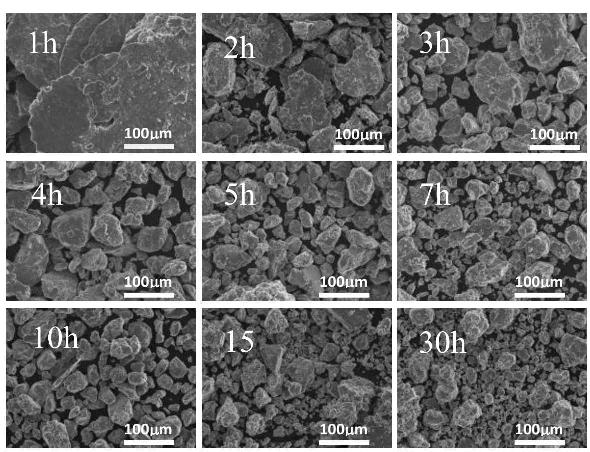

Figure 2. SEM micrographs of Al_{2024}/SiC_{NP} particle size milled for 1, 2, 3, 4, 5, 7, 10, 15 and 30h. shows the variation of size as a function of milling time.