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Mechanical Behavior on Microstructure of B_4C Particles Reinforced 2024 Aluminum Matrix Composite Obtained by Mechanical Milling

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Due to their high specific strength, superior wear resistance, lower thermal expansion and lightweight, metal matrix composites (MMCs) are used as substitute for conventional materials in some engineering applications such as aerospace, electronics, automotive, medical and military industries [1−2]. Matrix, reinforcement and nature of the interface affect the properties of these composites, and reinforcement materials are generally used in the form of particles, whiskers or fibers in different fractions ranging from few percentages up to 60%.

Raw materials were Al2024 alloy as the metal matrix and B_4C particles with a mean size of 12 μm as reinforcement agent. Initial Al2024 burhs were produced by machining a commercial solid bar. These coarse powders were mixed with B_4C in different concentrations. The mechanical milling of powder mixture was performed in a high-energy mill (SPEX 8000), under an inert atmosphere of pure argon gas. The milling container was made of stainless steel and milling media was made of hardened chrome steel, 5 drops of methanol were used as a process control agent to avoid excessive cold-welding of the powder particles. The B_4C/Al2024 composite powders used to prepare compression samples; the milling time was 1 and 2 hours. A blank (reference) sample without any reinforcement addition was produced under the same conditions for comparison purposes. The milling ball-to-powder weight ratio was set at 5:1

Microstructural characterization of the Al2024 alloy reinforced with 2wt%B_4C shown the fracture surfaces, it is carried out with the help of scanning electron microscope and are presented in Figure 1a. Figure 1b-c shows SEM microphotograph of 2% B_4C/Al2024 composite, indicating the locations of particle matrix bonding. B_4C particles clearly suggest that the solid Al2024 matrix has good wettability of B_4C particle. The hardness of the consolidated composite and the pure Al2024 is presented in figure 2. After consolidation, the hardness of matrix increased to about 95HRF for 2% B_4C/Al2024 1h (figure 2a) and 97 HRF for 2% B_4C/Al2024 2h (figure 2b) , this value is 66% more of the pure Al2024 sample for both cases. These results indicate that both, MM processing and B4C addition can significantly improve the hardness of the alloy. The figure 3 shows the variation of the 0.2% offset yield strength with different percent of B_4C, at different milling time (1 and 2h). This figure clearly shows that milling time plays a significant role controlling the compression properties of the composites [3].

References:

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[3] The authors acknowledge to the Red Temática Nacional de Aeronáutica, Red Materiales Compuestos and Red Temática de Nanociencias y Nanotecnología (152992).

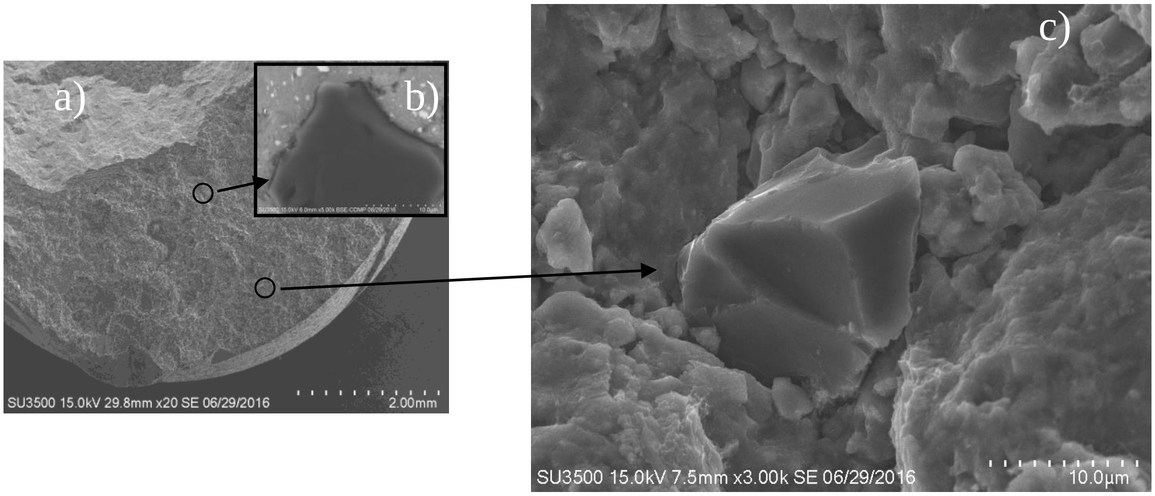

Figure 1. Scanning electron micrographs of the compression fracture surfaces. Arrows indicate the locations of particle matrix bonding of composite 2% B_4C/Al2024.

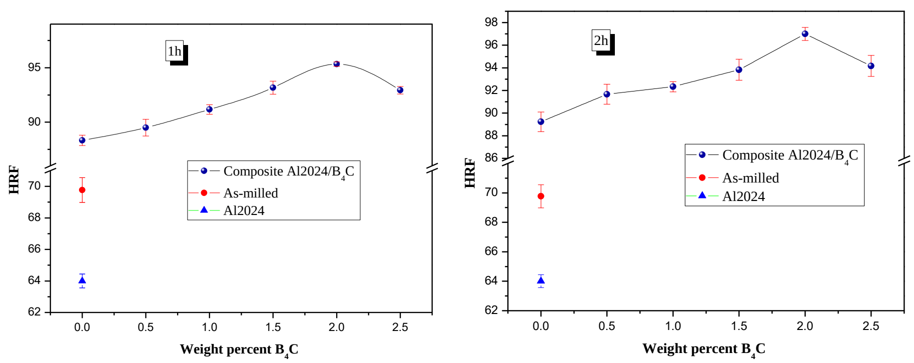

Figure 2. Hardness variation average values vs B_4C weight percentage at different milling times: (a) 1 h and (b) 2 h.

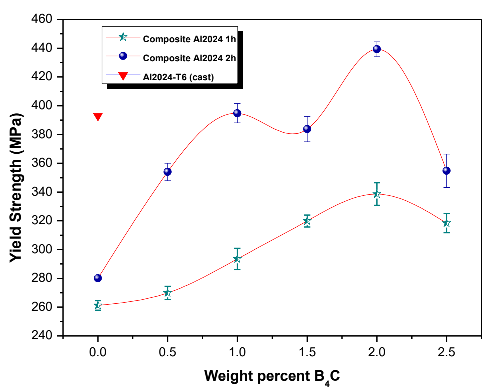

Figure 3. Yield strength as a function of B_4C content in 1 and 2 h milled composites respectively. Reported values from 2024-O and 2024-T6 commercial alloys are also included.