Abstract

A study has been carried out to examine the effect of mushy state rolling on microstructure-property relations, wear and mechanical behavior of in-situ Al-4.5(wt.%)Cu-5(wt.%)TiB_2 composite, prepared through precipitation of TiB_2 particles in the melt by reactions between K_2TiF_6 and KBF_4, and then stir-casting into plate-shaped moulds. Mushy state rolling with single or multiple passes with each of these causing 5% thickness reduction of as-cast specimens, has been carried out at a temperature corresponding to 20 vol. % liquid. Microstructures of the mushy state rolled composites have shown equiaxed grains in the alloy matrix, compared to rosette-shaped grains in their as-cast condition. Moreover, grain size distribution in the mushy state rolled composites has been found to be bimodal with finer grains in greater volume fraction near the rolling surface. With increase in number of mushy state roll passes, the distribution of both TiB_2 particles and dissolved Cu in the matrix appears more homogeneous, whereas the average grain size and hardness have been found to decrease and increase, respectively. Furthermore, measurements taken along the short-transverse cross-section have shown moderate decrease in average grain size and increase in hardness along the rolling direction. Studies involving solution-treatment (495 ^oC) and aging (170 ^oC) on both alloy and composites have shown peak-aging times of mushy state rolled composite matrices as ≈7.5-10% of that of as-cast alloy, with the peak microhardness increasing with number of roll passes. Such enhancement in aging kinetics has been attributed to homogeneity in Cu atom distribution, increased matrix dislocation density due to mismatch in coefficient of thermal expansion between Al and TiB_2, matrix grain refinement and particle redistribution, as achieved by mushy state rolling. Uniform precipitate distribution in mushy state rolled composite matrices leads to greater peak-age microhardness with higher yield and ultimate tensile strengths than those in as-cast alloy and composite. A comparative study on dry sliding wear behavior of composite subjected to single or multiple mushy state roll passes using a pin-on-disc machine has shown that wear resistance of rolling surface is superior to that of long-transverse surface, and improves with increasing number of roll passes, due to accompanying increase in matrix hardness. Studies of surfaces and cross-sections of worn specimens as well as wear debris have shown evidence of Fe-enrichment, plastic deformation and work hardening. The studies on creep behavior of the alloy and composite in as-cast, hot-rolled or mushy state rolled condition as evaluated by uninterrupted tensile creep tests have shown that both TiB_2 particles as well as mushy state rolling have a distinct positive impact on creep resistance of the composites.

Keywords: In-situ Composite, Semisolid processing, Mushy state rolling, Microstructure, Mechanical properties, Wear behavior, Age hardening, Creep behavior.