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Microstructural characterization and artificial aging of compo-casted hybrid A356/SiC_p/Gr_p composites with graphite macroparticles

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ABSTRACT

Hybrid A356/SiC_p/Gr_p composites were produced via compo-casting using the A356 aluminum alloy as the composite matrix, with silicon carbide microparticles (SiC_p) and graphite macroparticles (Gr_p) as reinforcements. The effect of the thixocasting process on the microstructure of a modified A356 alloy (with 0.03 mass% of strontium) was considered. The microstructures of the thixocast A356 alloy and the synthesized composite materials were examined by means of optical microscopy (OM), scanning electron microscopy (SEM), energy dispersive X-ray spectrometry (EDS) and X-ray diffraction (XRD). The fracture surfaces of the composite matrix and the composites were also analyzed. The thixocast A356 alloy and the composites were subjected to artificial aging after a solution heat treatment. Aging kinetics was followed by hardness measurements. Differential scanning calorimetry (DSC) was applied to reveal the presence of phases formed during artificial aging. The composites reached maximum hardness faster than the thixocast A356 alloy. The time required to attain peak hardness decreases with the increase in the content of particulate reinforcements.

1. Introduction

Aluminum-matrix composites (AMCs) reinforced with SiC particles have high strength and wear resistance. The production of these composites has been continuously increasing in the automotive and aircraft industries for constructive parts where the tribological properties of the materials are highly important [1,2]. Graphite has also been used in the production of AMCs because in the presence of graphite, the wear rate and the friction coefficient decrease. However, the mechanical strength of the composites with graphite is reduced [3]. AMCs with both SiC particles and graphite particles are known as hybrid composites, Al/SiC_p/Gr_p. Hybrid AMCs have exhibited improved tribological behavior over AMCs with single reinforcement [2,4–7]. Hybrid AMCs have been produced by different techniques [4–7].

In this work compo-casting was applied to synthesize composite materials with A356 base alloy. Compo-casting involves incorporation of particulate reinforcements in the semisolid metal matrix using mechanical mixing [8]. A good distribution of particulate reinforcements in the metal matrix and a weak agglomeration of particles have been achieved in the composites synthesized through compo-casting [1,9,10]. The composites can be afterwards processed by means of squeeze casting [11] or extrusion [12]. Due to a relatively low operating temperature in the production of AMCs with SiC particles via compo-casting, a chemical reaction between molten aluminum and silicon carbide will not occur, i.e. the formation of the chemical compound Al_4C_3 can be avoided [13]. In addition, compo-casting enables energy saving and longer tool life [14] because of lower operating temperatures than when using liquid metal matrices.

Hybrid A356/SiC_p/Gr_p composites have been recently obtained via compo-casting, with microparticles of SiC (39 μm) and graphite (35 μm). The wear resistance of the obtained hybrid composites was shown to be higher than for the conventional A356/SiC_p composite [7].

However, during the addition of graphite microparticles into the semisolid melt of the matrix alloy (within compo-casting) the strict control of the particles behavior was not achieved because of the convective airflow above the melt surface, which could lead to the loss of graphite particles. Besides, graphite microparticles tend to form agglomerates, which can result in non-homogeneous distribution of particles in the composite matrix [7]. To overcome

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