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Microstructure and mechanical properties of Zn25Al3Cu based composites with large Al_2O_3 particles at room and elevated temperatures

Microstructures and compressive properties of Zn25Al3Cu alloy and Zn25Al3Cu/Al_2O_3 particulate composites with large reinforcing particles (250 μm) were examined. The composites were obtained by the compocasting technique through infiltration of 3, 8 and 16 wt.% Al_2O_3 particles into the semi-solid metal matrix. The influence of temperature in the range from 70 to 170 °C on compressive yield strength of the matrix alloy (as-cast and thixocast Zn25Al3Cu alloy) and the composites was investigated. Above 70 °C compressive yield strength of all materials decreases, but the rate of decrease is different for the matrix alloy (as-cast and thixocast) and composites. It was found that the abrupt decrease in compressive yield strength of the matrix alloy occurred at temperatures higher than 70 °C, whereas composites retained relatively high values of compressive yield strength till the end of the testing temperature range regardless of the amount of reinforcing particles.

Keywords: Metal-matrix composites; Zinc–aluminum alloys; Al_2O_3 particles; Compocasting; Compressive yield strength

1. Introduction

Among the zinc-based foundry alloys the alloys with relatively high content of aluminum (zinc–aluminum or ZA alloys) are distinguished by excellent bearing properties. The alloys are designated 8, 12 and 27 because of their approximate aluminum content. These alloys are also characterized by favorable combinations of physical, mechanical and technological properties (low melting point, high strength, fine machining and good tribological properties, excellent castability) as well as by low manufacturing costs. The alloys are suitable for a wide application range (industrial fittings and hardware, pressure-tight housings, sleeve bearings, thrust washers and wear plates). However, ZA alloys are only applicable at operating conditions up to 80 °C, due to a deterioration of mechanical properties at elevated temperatures [1].

ZA27 alloy is the lightest of the ZA alloys and offers excellent bearing and wear resistance properties. The alloy is characterized by a dendritic microstructure [2, 3] and a non-uniform distribution of chemical elements in the alloy phases [4]. ZA27 alloy solidifies in a wide temperature range and is suitable for processing in the semi-solid state. It was shown that a non-dendritic structure as well as favorable mechanical properties of the alloy could be achieved by thixocasting [5–8] with subsequent heat treatment [9, 10]. The rheological behavior of the semi-solid processing of this alloy was studied by Lehuy et al. [11].

Compocasting [12] has been used to produce ZA-based composites. This technique is characterized by infiltration of reinforcing particles into the semi-solid metal matrix. It was shown that physical and a number of mechanical characteristics (elasticity modulus, hardness, wear resistance, linear thermal expansion coefficient) of ZA27 alloy-based composites with addition of Al_2O_3, SiC [13–15] and ZrO_2 [16] particles were better with respect to the matrix alloy at room temperature. Cornie et al. [13] carried out an investigation of mechanical properties of ZA27 alloy strengthened by SiC particles and Al_2O_3 whiskers at room temperature. However, the results at elevated temperatures have not been reported.

Compressive properties of commercial bearing alloys at room and elevated temperatures (about 100 °C) are of exceptional importance for their application in the manufacturing of sliding bearings [17]. ZA27 alloy is a suitable bearing material for heavy and light load pressures with low and high surface speeds. To overcome the deterioration of the alloy mechanical properties at elevated temperatures particulate composites with base ZA27 alloy were developed.

It is well-known that the size of reinforcing particles significantly affects mechanical properties of composites. At uniform particle distribution, better mechanical properties were achieved by using small particles [18, 19]. Hard particles such as SiC, Al_2O_3 and ZrO_2 [13, 14, 20] and soft particles such as graphite and coke dust [21, 22] were used for producing composites with base ZA27 alloy. The size of particles was mostly from 50 to 150 μm. There are only a few papers [15, 23–25] concerning composites with reinforcing particles larger than 200 μm. Addition of these particles to the matrix alloy offers several advantages which are as follows:

- infiltration of particles into the semi-solid melt of matrix alloy can be easily performed with a dosator, due to the particles size

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