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Short Communication

Closed-cell Al alloy composite foams: Production and characterization

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ABSTRACT

Foamy Al alloy SiCp composites of different densities ranging from 0.4 to 0.7 g/cm^3 were manufactured by melt-foaming process, which consisted of direct $CaCO_3$ addition into the molten A356 aluminum bath. Mechanical properties and morphological observations indicated that the three-stage deformation mechanism of typical cellular foams is dominant in the produced A356 aluminum foams. Middle-stage stress plateau shrinkage plus compressive strength and bending stress enhancements were observed in denser foams. With the same Al/SiCp ratio, energy absorption ability and plastic collapse strength of the closed-cell foams were increased with the foam density. Doubling cell-face bending effects resulted in larger compressive than bending strengths in the closed-cell foams; while stiffness lowering was due to the cell-face stretching conditions.

1. Introduction

In recent years, the demand for light-weight high strength metallic foams usable in automobile, railway, construction and aerospace industries has substantially increased [1]. Al alloy foams have been utilized more extensively than other foams in such services as energy absorber, light-weight structures, widely-used indoor sound absorbers, bonnets and boot lids, sliding automobile roofs and crash-energy absorption elements of space vehicles [2].

Rabiei, et al. [3] have studied production of high strength composite Al–steel cast foams of less than 15% porosities. Alizadeh and Mirzaei-Aliabadi [4] have produced open cell Al–Al_2O_3 composite foams by high energy mechanical milling and then sintering of Al and Al_2O_3 powders mixed with the carbamide as space-holder. Gergely and Bill Clyne [5] have used pre-treated titanium hydride powder in a two-stage foam making process for production of up to 23% porous Al–Si foamy alloy. Although all these researchers have reported of positive findings like enhanced strength to weight ratio, controllable porosity percentage, manageable pore shape and increased capacity for energy absorption, but technical complexity, foam inhomogeneity and high cost of production are still matters of concern which stimulate further research.

From among various techniques usable for production of foamy objects, Al foams have mostly been synthesized via powder metallurgical, spray foaming and melt-foaming methods [2]. Melt-foaming has especially attracted researchers' attention for being inexpensive and capable of manufacturing close-cell foams [6]. This has consisted of adding a gassing agent into a pool of molten aluminum. Instantaneous release of the gas which contacts with the metal helps formation of the metallic foam.

Low viscosity of the melt prohibits, however, stabilization of the produced foam. A homogeneous foamy phase with controllable density is hence difficult to obtain in traditional ways [7,8]. The purpose of this study is to develop homogeneous Al alloy foams of desirable density with appropriate mechanical properties by a simple inexpensive stable method. Effect of density on compression/bending strengths and energy absorption capability of to foams is presented in this paper.

2. Materials and experimental techniques

2.1. Materials

Commercial A356 cast aluminum alloy (7Si–0.3Mg) was used as base material for making the foamy samples. Reinforcing SiC particles with purity of 98.0 wt.% and mean particle size of 10 μm was used to stabilize the foamy melt. SiC particles (SiCp) were heated at 950 °C for 1 h and then at 650 °C for 2 h in a conventional furnace to remove gases adsorbed on the surface of the particles and improve SiCp wettability with molten Al alloy. Powdery $CaCO_3$ with purity of 99.5 wt.% and average size of 5 μm was used as gas blowing agent. Prior to injection, $CaCO_3$ powders were heat-treated at 200 °C for 2 h to remove humidity and adsorbed gases and to improve wetting properties and dispersivity of $CaCO_3$ powders in the molten alloy. Scanning Electron Microscopy (SEM) images of heat-treated SiC particles and $CaCO_3$ powders are shown in Fig. 1.

2.2. Processing methodology

SiCp aluminum slurry was prepared at 650–680 °C and stir-casted into a steel mould to obtain ingots of composite alloy. The ingots were re-melted at 650–700 °C while being continuously

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