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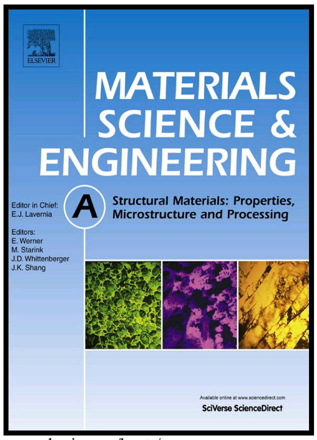

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Effects of Particle Size on the Microstructure and Mechanical Properties of Expanded Glass-Metal Syntactic Foams

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Abstract: The effect of particle size on the microstructure and mechanical properties of expanded glass-metal syntactic foams (EG-MSF) was investigated. The foams were fabricated via counter gravity infiltration of a packed bed of recycled expanded glass (EG) particles. The metallic matrix of all foam samples was A356 aluminium. Different particle sizes were considered, i.e. diameters between 1-1.4, 2-2.8 and 4-5.6 mm. The microstructures of EG-MSF were investigated by optical and scanning electron microscopy and the grain size of the aluminium alloy was found to increase with EG particle size. Uni-axial compression testing of EG-MSF indicated that its mechanical properties depend both on foam density and particle size. Smaller particles were found to dampen plateau stress oscillation and improve the energy absorption characteristics of EG-MSF.

Keywords: expanded glass particles; metal syntactic foams; particle size; A356 aluminium alloy; microstructure; mechanical characterization.

1. Introduction

Metal syntactic foams (MSF) have recently attracted considerable interest due to their unique combination of properties, i.e. low density, high stiffness, good strength-to-weight ratio, excellent impact energy-absorption capability and ductility [1-4]. These desirable properties have made MSF a versatile material for both structural and non-structural uses in aerospace, automotive, and building materials [5-7]. The properties are controlled by the porosity of embedded hollow or porous particles [8-10].

The MSF structure is governed by its components (matrix metal and filler particles) as well as the manufacturing method. Important parameters are relative density, cell shape [11], cell size [12-15], and porosity [6]. The density of MSF depends critically on the filler particle density and morphology [16]. The MSF cell size can be tailored via changing the particle size. The influence of cell size on the mechanical properties of MSF has been the focus of previous studies. Some authors reported that decreasing the size of hollow filler particles (i.e. particles containing a single large pore) leads to superior mechanical properties. This is found to often be due to the higher wall thickness to diameter ratio found in smaller hollow particles [8, 17]. Taherishargh et al. [18, 19] have investigated the effect of particle size on the microstructure and mechanical properties of perlite aluminium syntactic foam. The expanded perlite particles that were used as filler in that study exhibit a negligible strength compared to the matrix metal. However, the authors concluded that changing the particle size controlled the microstructure of the metallic matrix and, by extension, the mechanical properties of the foam.

Expanded glass particles (EG) have been introduced as a filler material in MSF in a previous study [16]. EG particles exhibit a low density and relatively high strength combined with low cost. EG-MSF, with particles' size range 2-2.8 mm were manufactured using stable (i.e. preventing thermal particle shrinkage) and pre-heated (shrunk) particles. Syntactic foams containing shrunk