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Procedia Materials Science 4 (2014) 157 – 162

Procedia Materials Science

www.elsevier.com/locate/procedia

8th International Conference on Porous Metals and Metallic Foams, Metfoam 2013

Variation of quasi-static and dynamic compressive properties in single Aluminium-alloy foam block

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Abstract

The variation of the density and compressive properties through a single closed-cell aluminium alloy foam block were evaluated. For this purpose a rectangular block of aluminium foam was fabricated and cut into identical small cubic representative volume specimens in three horizontal layers (bottom, middle and top). The mechanical characteristics of these cubic representative volume specimens were determined using quasi-static and dynamic compression tests, parallel and perpendicular to the foaming direction. The visual observation of the cubic representative volume specimens revealed that the pore size and the relative density vary across the original foam block, particularly on the different horizontal layers. Accordingly, the variation of the compressive properties and the energy absorption characteristics also proved to be significant.

Peer-review under responsibility of Scientific Committee of North Carolina State University

Keywords: Powder metallurgy; Compressive properties; Density variation; Pore size variation; Anisotropy

1. Introduction

Large volume metal foam parts manufactured by powder metallurgy method usually exhibit a density gradient and large size distribution of cellular pores with irregular cell shape as the consequence of the coalescence and drainage mechanisms involved during the foam formation (Baumgärtner (2000), Duarte (2012), Duarte (2000)). This could result in a layered structure with anisotropic mechanical properties. An irregularly structured foam with a non-

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Peer-review under responsibility of Scientific Committee of North Carolina State University
doi:10.1016/j.mspro.2014.07.580

uniform density distribution can be considered as a multiphase material consisting of an arrangement of sub-domains of various cellular materials, each exhibiting different properties. Their inhomogeneties have to be quantified by their variation range and with respect to their location within the sample. The non-uniformity can be described by different volume elements. In this paper, the variation of the density and compressive properties through a single closed-cell aluminium foam block were evaluated with particular emphasis on the effects on the density gradient that develops during the fabrication.

2. Materials and Methods

2.1. Preparation of Aluminium Alloy Foam Specimens

A rectangular block of aluminium alloy foam of 200 x 80 x 50 mm was prepared by powder metallurgy method described in detail in refs. Baumgärtner (2000) and Duarte (2000). A foamable precursor of 160 x 20 mm cross-section was prepared using a combination of a cold isostatic pressing and a hot extrusion of a powder mixture of pre-alloyed AA 6061 containing 0.5 wt.% titanium hydride (Baumgärtner (2000)). This foam block was prepared placing a single precursor piece of 200 x 20 x 50 mm into a stainless steel closed mould subjected to heating at pre-heated furnace at 750ºC. The resulting solid block of closed cell foam is covered by an external dense metal skin, as shown in Fig. 1a. This solid block was cut by electro-discharge machining into identical small cubic representative volume specimens of 20 x 20 x 20 mm in three horizontal layers (bottom, middle and top) removing the external layer (skin) around the sample, as it is sketched in Fig. 1b. Then, the cubic specimens were marked attending their position within the horizontal layer. Each horizontal layer is formed by two groups of eight cubic samples. For example, the A-layer has two groups: A11-A18; A21-A28.

2.2. Quasi-Static and Dynamic Compression Tests

The uniaxial compression tests on the cubic specimens subjected to quasi-static and dynamic were carried out using a servo-hydraulic dynamic INSTRON 8801 machine (Vesenjak (2009)). The crosshead rates were 0.17 mm/s and 284 mm/s, respectively. The total number of the specimens tested was 48. The cubic specimens of each horizontal layer were divided into 4 sets of 4 samples for compressing in two different directions (parallel and perpendicular) regarding to the foaming direction under two loading conditions - quasi-static and dynamic. Four specimens were compressed for each condition. The dimensions of these specimens were 20 x 20 x 20 mm. The force and the displacement have been recorded. The effect of foam direction and position on the compressive properties of Al-alloy foams under quasi-static and dynamic loading was studied at room temperature.

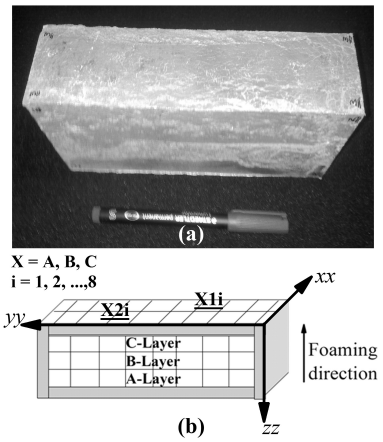

Figure 1. (a) Al-alloy foam block (200 x 80 x 50 mm). (b) Scheme of single block visualising the horizontal layers.