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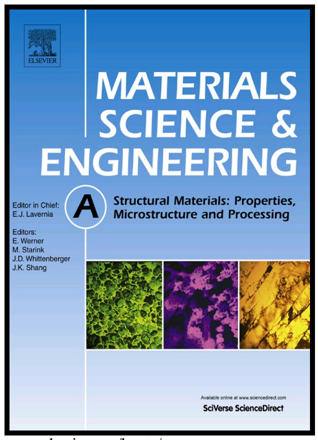

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Compressive behavior of a rolled open-cell aluminum foam

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Abstract

In this paper, we investigate compressive behavior of an open-cell 6101 aluminum foam in as-cast and as-rolled conditions. The as-cast foam with a relative density of $\rho^* = 7\%$ was rolled to create two distinct as-rolled conditions with relative densities of $\rho^* = 29\%$ and $\rho^* = 42\%$, respectively. The quasi-static and high strain rate compressive behavior was studied over a range of strain rates 10^{-4} /s ≤ $\dot{\varepsilon}$ ≤ 5×10^{3} /s. It was found that the internal structure of as-rolled foams significantly differs from as-cast foams. Rolling causes plastic bending, stretching, and buckling of individual struts and ligaments, resulting in reduced pore size and an increase in relative density. In as-rolled condition, compressive plateau strength increased with increase in ρ^*; it was up to 26 times higher as compared to the as-cast condition. In the range of strain rates considered here, strain rate sensitive compressive behavior was not observed; instead, the intrinsic strain rate sensitivity of parent material governed the compressive behavior in all conditions. Our results demonstrate the feasibility of using conventional rolling as a simple way to modify internal structure and relative density of as-cast foams, thereby enabling mechanical properties more attractive for various structural applications.

Keywords: open-cell foams; aluminum; energy absorption; strain rate; rolling

1. Introduction

Open-cell metal foams are light-weight materials which are prepared using a wide variety of metals and methods [1-5]. They possess hollow, three-dimensional cellular structure characterized by a complex network of interconnected cells and ligaments [6]. In as-cast condition, these cells and ligaments are unreformed and free of any residual stress. The cellular structure provides large surface area and thereby enables high specific mechanical and thermal properties of metal foams [7, 8]. Therefore, structural parameters such as cell geometry, shape and relative density can be varied to tailor mechanical properties of metal foams [7-10]. In this regard, rolling may present a simple method to modify cellular structure of as-cast foams to obtain a desired compressive response.

Among various metal foams, aluminum foams have been studied in great detail [7, 9]. The intrinsic attributes of aluminum alloys such as low density, high specific mechanical and thermal properties make them an attractive foam parent material. Aluminum foams are commercially available, and manufactured with a consistent and uniform matrix of cells and ligaments, throughout the entirety of the material. This repeatable, cellular structure combined with superior properties of parent aluminum alloy makes open-cell Al foams attractive for several structural and functional applications. Their porous structure is primarily responsible for considerable energy absorption by plastic dissipation in compression; making them ideal for applications as foam core in sandwich panels and crash-absorbing structures [11-15]. They also find applications in heat exchangers [16], particulate filters and catalyst substrates [17]. The relative density of Al foams can be varied by modifying the fabrication process to produce a network of smaller cells with adequate shapes. In our previous work,

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