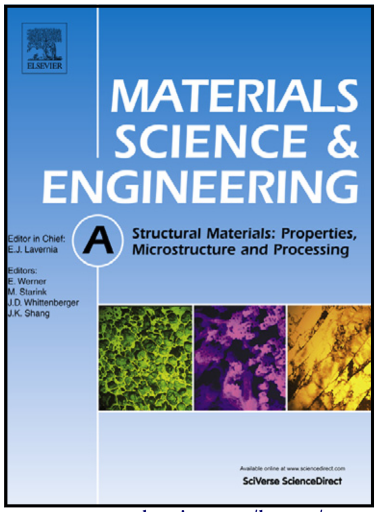

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PII: S0921-5093(15)00098-2
DOI: http://dx.doi.org/10.1016/j.msea.2015.01.071
Reference: MSA32009

To appear in: *Materials Science & Engineering A*

Received date: 9 October 2014
Revised date: 21 January 2015
Accepted date: 25 January 2015

Cite this article as: Bilal Mansoor, V.C. Shunmugasamy, H. Nassar, M.K. Khraisheish, Three dimensional forming of compressed open-cell metallic foams at elevated temperatures, *Materials Science & Engineering A*, http://dx.doi.org/10.1016/j.msea.2015.01.071

Three dimensional forming of compressed open-cell metallic foams at elevated temperatures

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Abstract
Metal foams are known for their attractive characteristics including light weight, high stiffness, superior fluid flow and heat transfer properties. Currently, products made of metallic foams are fabricated to the final shape through foaming process, limiting their widespread applications. Developing effective downstream processes to shape metallic foams into complex geometries would promote this class of materials in various sustainable applications such as in fuel cells, advanced heat exchangers and concentrated solar power plants. Limited data is available on the deformation behavior of metallic foams under various loading conditions including at elevated temperatures, which requires further understanding. In this regard the present study deals with understanding, the deformation behavior and failure characteristics of aluminum foams under tensile loading at various strain rates and temperatures in the as-cast and compressed form. The result from the tensile test showed that at room temperature the compressed aluminum foam specimens showed 8 – 9 times higher tensile strength in comparison to the as-cast foams specimens. In addition, a novel approach to shape compressed foams into three dimensional shapes using pneumatic bulge forming is introduced. The reduction on the thickness in the bulge formed foam specimen was 20%, in comparison to 80% observed for the as-cast foam specimen. Results demonstrate the possibility of applying this technique to form compressed metal foam sheets into complex shapes while maintaining very good thickness uniformity and homogeneity in pore distribution without causing significant densification.

Keywords: forming; ductility; layered material; porous material; mechanical testing; metal foam

1 Introduction
Metal foams are known for their light weight, high specific stiffness (specific stiffness is the foam stiffness divided by the density), excellent sound and vibration damping, and superior fluid flow and heat transfer properties [1, 2]. Metal foams can operate at significantly higher temperatures compared to polymeric foams, and can resist impact and shock much better than ceramic foams. The combination of these properties makes these materials attractive for use in various applications such as light-weight structural components, heat exchangers, filters, catalysts, insulation, and even biomedical implants for bone ingrowths [3]. Open cell metal foams are also used as reinforcement in interpenetrating phase foam composites wherein the metal foams are interpenetrated with polymer matrix foam [4].

Applications in which metals foams can be utilized require the foams to be made into a three dimensional component, from sheets or a foam-cored composite panel. For example, in an automotive vehicle, forming a sheet of metal bonded to a metal foam plate would yield a compactable structure with good sound and vibration damping properties and energy absorbing crash members. Metal foams can be used as lining around a jet engine which can greatly help in