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Structural and Mechanical properties of open cell aluminum foams

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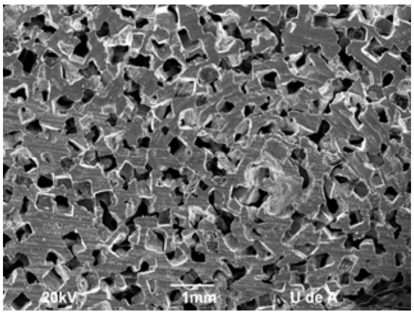
Abstract – Cellular metals are receiving increasing attention in recent years due to their high specific mechanical properties and unique functional performance. The mechanical properties of metals foams have been extensively investigated and the purpose of the present study is to establish the influence of the structure characteristics on the mechanical properties of open cell aluminum alloy foams fabricated by metal infiltration of removable preform. Foams of several pore sizes were prepared and evaluated by mean uniaxial compression, optical microscopy, scanning electron microscopy and metallographic preparation in order to identify failure behavior and to characterize the macrostructure and microstructure, respectively.

The present study describes the mechanical properties of open-cell aluminum alloy (Al-Si) foams associated with metallographic phases, size and morphology cells. Open cell aluminum foams have been obtained using a preform of salt particles sieved, which determine the shape and size of the cells of the porous structure. Then, molten aluminum alloy is infiltrated into the preform using vacuum pressure. After solidification of Al/NaCl composite, dissolution of the salt reveals the foam with open cells and interconnected porous structure. The foams manufactured had pore size from 2.0 mm to 550 µm and a relative density of 0.33 (~0.9 g/cm^3).

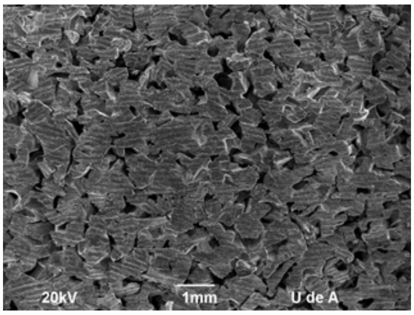
Mechanical properties associated with structural morphology and metal microstructure were evaluated. Uniaxial compression test was carried out to measure the porous structure influence on plasticity and damage accumulation within open-cell metal sponges. An Instron 5582 Testing Universal Machine was used for quasi-static compression tests. A constant cross-head speed of 0.5 mm/s was used for the test, and the specimens were 20 mm in diameter and 20 mm in height.

The present open-cell aluminum foams deform uniformly and some mechanisms of work hardening were observed during the compression tests: (1) the intrinsic work hardening caused by deformation of the metal making the foam and (2) the struts re-orientation mechanism is suggested that it involves the compaction of struts, which making a new solid material contacts across the open pores of the foam (figure 1b), such as is described by Markaki and Clyne [1]. The compressive stress-strain curves of aluminum foams investigated in this study, exhibit three deformation regions reported as well for other authors, figure 2. [2]

Aluminum–silicon alloy consisted of a single-phase and aluminum matrix containing hard, brittle silicon particles that essentially do not deform. Fracture of the Si phase is evident in Al–Si foam deformed in compression and this is evidently one special mechanism of damage accumulation in this foam during compression, such as is reported by San Marchi *et al*. [3]. An increase in strength with reduction in cell diameter was observed by the uniaxial compression tests carried out.



a)



b)

Figure 1: a) SEM images of open cell aluminum foam of porous size around 550µm before compression test **b)** SEM image of vertical section of foams compressed

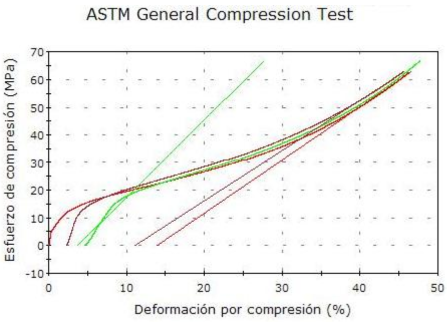


Figure 2: Compressive stress-strain curves of open cell aluminum foam (550µm).

[1] A. E. Markaki and T. W. Clyne, Acta Mater. 49 (2001) 1677–1686.
[2] Cao, X., Wang, Z., Ma, H., Zhao, L., Yang, G.. Trans. Nonferrous Met. SOC. China 16(2006) 351-356.
[3] C. San Marchi, J.-F. Despois, A. Mortensen, Acta Mater. 52 (2004) 2895–2902.