Strengthening of Aluminum with Iron through application of High-Pressure Torsion

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In the Al-rich portion of the Al-Fe equilibrium phase diagram, there is a very limited region of solid solubility of Fe (~0.052 wt.% Fe), an eutectic reaction between Al and Al_3Fe intermetallic (~1.8 wt.% Fe) and the formation of coarse intermetallic with different properties (> 1.8 wt.% Fe). Additional metastable phases such as Al_6Fe become present at commercial cooling rates [1]. In the present work, Al-Fe ϕ10 mm disk samples were prepared from three different types of bulk materials; an as-cast ingot, a cast and extruded rod and an annealed rod with Fe weight fractions of ~2 and ~4%. The samples were then processed by high-pressure torsion (HPT) at room temperature under a pressure of 6 GPa for up to 75 revolutions. Measurement of mechanical properties and characterization of microstructures were conducted at different levels of imposed strain.

Figure 1 shows a plot of Vickers microhardness as a function of the distance from disk center (or equivalent strain) of samples processed for N=10 revolutions. Strengthening was achieved with imposed strain, more significantly in the as-cast sample with 2% Fe. This enhanced strengthening behavior is associated with the eutectic microstructure present in the 2% Fe sample in comparison with the 4% case, where a coarse intermetallic phase co-exists with the eutectic. Additionally, the as-cast microstructure presents more advantages over granular structures in the extruded and annealed samples. These results have not been reported in previous studies, which examined materials with higher Fe contents: 7.5, 11 and 16% Fe [2], and treatments: 11% Fe with subsequent aging [3] and 5% Fe with RQ/MA prior to HPT[4].

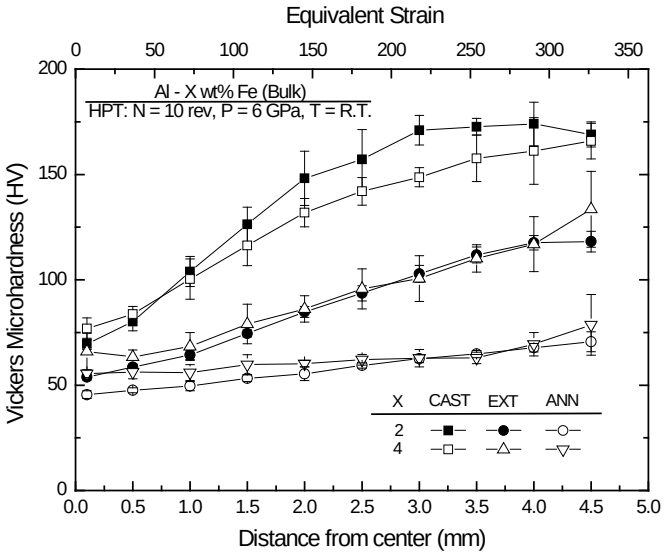

Figure 1. Hardness versus distance from disk center (or equivalent strain) of samples processed for N=10 revolutions.

References:

[1] N. Belov, A.A. Aksenov, D. Eskin, Iron in Aluminum Alloys, CRC, 2002.

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[3] O. Senkov, F. Froes, V. Stolyarov, R. Valiev, J. Liu, Nanostruct. Mater. 10 (1998) 691.

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