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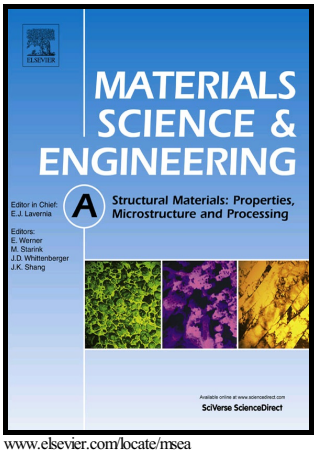

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Re-examining the relation between fracture strain and yield stress in Al-Mg-Si alloys

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Abstract

A linear relationship between fracture strain, ε_f, and yield strength first observed by Lloyd (2003) in aluminum alloys is re-examined for age-hardenable AA6063. A breakdown in the relationship is observed if AA6063 is pre-strained prior to ageing. A linear relationship is recovered for ε_f versus dislocation initial inter-obstacle spacing, ℓ.

Keywords

Age-hardening; Aluminum; Fracture; Inter-obstacle Spacing; Yield Strength; Al-Mg-Si

Understanding failure in industrial aluminum alloys is difficult due to the many elements and resulting microstructure components formed during processing. Lloyd originally demonstrated that there exists a linear relationship between the fracture strain, ε_f, and the yield strength, $\sigma_{0.2\%}$, in age-hardenable aluminum alloys, as shown in Figure 1 for AA6111.

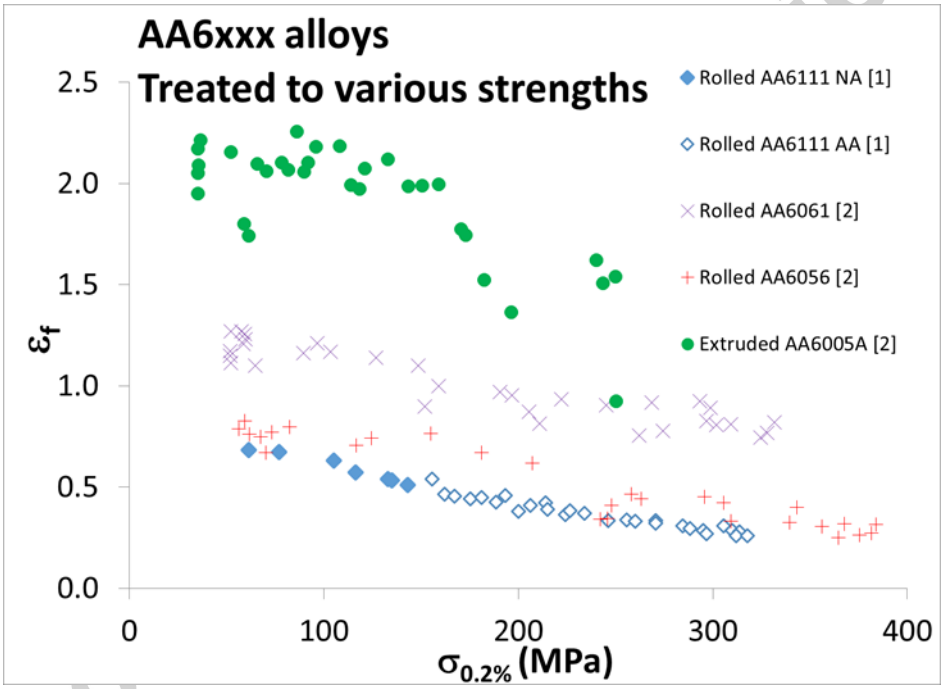

Figure 1: *Relation between fracture strain, ε_f, and yield strength, $\sigma_{0.2\%}$, for: extruded AA6005a, rolled AA6061, rolled AA6056 and rolled AA6111. Replotted from Lloyd and Hannard et al. [2].*

In what we will call the *Lloyd* plot, i.e. plotting 0.2% offset yield strength versus the logarithmic fracture strain determined from the fracture surface thickness as

$$\epsilon_f = \ln\left(\frac{t_0}{t_f}\right) \tag{1}$$

where t_0 and t_f are the initial and final thickness measurements of tensile samples, respectively, the evolution of the correlation from naturally aged (NA) to artificially aged (AA) conditions appears to be continuous, albeit with different slopes as pointed out by Lloyd. The linear relation suggests that the failure of the material is inherent to the starting microstructure prior to deformation and related to the yield strength. Hannard et al. have recently studied this correlation for different 6XXX alloys, and described it by a stress criterion to fracture hard, incoherent particles by straining a soft matrix with some pre-existing voids. Their model follows a straight-line trend, but like Lloyd's data, their