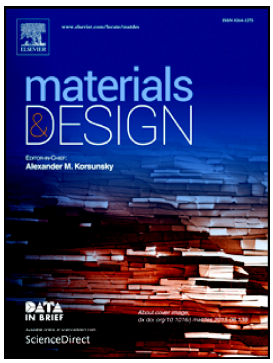

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Effect of heat treatment on the microstructure and anisotropy in mechanical properties of A357 alloy produced by selective laser melting

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Abstract

A357 alloy was manufactured by selective laser melting (SLM) and subjected to different heat treatments, by considering the stress relief step as critical, to establish the microstructure-mechanical property relationship and model the yield strength. For the as-SLM processed condition, the imposed fast cooling rate refines and limits the amount of Fe-rich intermetallic and eutectic Mg_2Si phases, and enables a higher level of supersaturation of solutes. The latter leads to significant yield strength contributions from solid solution strengthening and natural ageing. The inter-cellular Si network within the columnar grains remains unchanged but small Si-rich particles appear within cells after direct ageing. The Si network breaks up during stress relieving, leading to high ductility. The lower ductility for the vertically-built samples under as-SLM processed, directly aged, and stress relieved conditions is due mainly to the finer Si networks brittle nature. Porosity resulting from trapped hydrogen gas enlarges significantly with solutionisation, deteriorating the ductility. Grain growth is not obviously observed with heat treatment. Si particles coarsen preferentially at grain boundaries initially, however, they distribute more evenly by coarsening within the grains as well during prolonged solutionisation. Anisotropy in both yield strength and ductility subsequently disappears when a more homogeneous microstructure is obtained.

Keywords: aluminium alloys; selective laser melting; elongation to fracture; strengthening mechanism; anisotropy.