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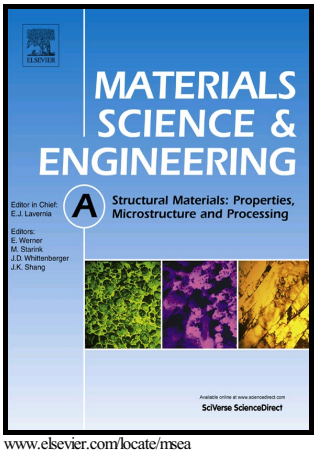

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A new hybrid process to produce ultrafine grained aluminium plates

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Abstract

The present study concerns the issues of the detailed microstructure evolution, development of grain boundaries and mechanical properties of commercially pure aluminium processed using multi-turn Equal Channel Angular Pressing (mtECAP) and upsetting processes. Both processes cause a refinement of microstructure in coarse-grained materials, though the deformation paths differ. This results in differences in microstructure, the distribution of grain boundaries, and mechanical strength and fractures. Four passes of mtECAP with a channel angles of ϕ=90˚, route C, caused a grain refinement of 1-1.2 μm and a fraction of HAGBs in a range of 41.3-53.1%, depending on the plane examined. Upsetting from a height 26 mm to 3 mm caused higher average grain size and a lower fraction of HAGBs in particular planes. The mechanical strength was lower, but the applied strain in this sample was also much lower than for the sample processed with mtECAP. Only combining the two processes resulted in an ultrafine grain structure with an average grain size of below 700 nm in the X and Y planes. The results show that this hybrid process results in a plate with low anisotropy of tensile properties and with the tensile strength close to 200 MPa.

Keywords: hybrid process, multi turn ECAP, upsetting, aluminium, plates

1. Introduction

Grain refinement is one of the efficient methods of increasing mechanical strength in pure metals. It can be performed by employing severe plastic deformation (SPD) processes [1], e.g. equal channel angular pressing (ECAP) [2], which is one of the most popular and most developed SPD methods. During this process, a billet is subjected to simple shear deformation [3] when it is pressed through two intersecting channels having the same cross-section [4]. The characteristic features that have a crucial effect on the process of grain refinement include the number of passes, the processing route [2], the angle between the die channels and the process temperature. In its traditional version, ECAP makes it possible to process billets in the form of bars or rods [5][6][7]. However, from the further processing point of view, e.g. deep drawing or superplastic forming, a plate or sheet shape is more suitable. Therefore, there is a need to develop technologies that make it possible to manufacture flat products, as these have higher application potential.