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Mechanical properties, microstructure and texture of single pass equal channel angular pressed 1050, 5083, 6082 and 7010 aluminum alloys with different dies

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ABSTRACT

Four important commercial aluminum alloys, namely 1050, 5083, 6082 and 7010AA are processed through a single pass via two equal channel angular pressing (ECAP) dies with different geometries (die angles of 90° and 120°). Electron back scattered diffraction (EBSD) is applied on the flow plane of the processed samples. Large scans with a step size of 7 μm for grain size distribution and texture measurements, as well as small scans with a step size of 0.1 μm for determination of cell size distribution, were performed. Hardness and simple compression are employed to evaluate the mechanical properties of the ECAP processed samples. Shear bands in the ECAP processed 7010AA was a major feature that led to failure in all samples subjected to further simple compression. The hardness as well as the stress–strain behavior was similar in the ECAP processed 6082 and 5083AA. The die geometry and the strain involved in the single pass influenced the overall texture intensity developed in the wrought alloys (1050 and 5083AA) and had minimal influence on the texture intensity of the heat treatable alloys (6082 and 7010AA). Low angle grain boundaries dominated the microstructure of all alloys for all testing conditions.

1. Introduction

The microstructure of metals can be significantly changed by subjecting the material to severe plastic deformation through procedures such as equal channel angular pressing (ECAP). A comprehensive review on the development of ultra fine grained (UFG) materials via ECAP has been published recently [1]. ECAP is the most well developed of all potential severe plastic deformation (SPD) processing techniques. A major advantage achieved in ECAP is that the material cross section is unchanged during pressing, which means that the material can be pressed repeatedly to attain a high total strain. Bulk materials can be processed in ECAP, which also gives this process an industrial significance. This procedure has the advantage of producing ultrafine-grained bulk samples in a fully dense condition through imposing intense plastic strain by pressing a sample in a special die. During ECAP, significant grain refinement occurs together with dislocation strengthening, resulting in a significant enhancement in the strength of the alloys [2–5]. The die consists of two channels equal in cross section, intersecting at an angle ϕ which is a subject of research in ECAP usually ranging from 90° to 157° [6]. There is also an additional angle Ψ, which defines the arc of curvature at the outer point of intersection of the two channels, and also has been a subject of research. The amount of equivalent strain depends upon the two angles, ϕ and Ψ, and given through a relation, developed analytically, that depends on the geometry of the process. $\varepsilon = N/\sqrt{3}\,(2\cot(\phi/2 + \Psi/2) + \Psi\,\mathrm{cosec}\,(\phi/2 + \Psi/2))$, where N is the number of passes [7–9].

In an idealized description of ECAP, it was shown [10] that deformation takes place by simple shear confined in a narrow zone at the plane of intersection of the die channels. The theoretical shear plane is the plane of the die channel intersection (the trace of this plane is indicated by the dotted line in Fig. 1) and the shear direction is aligned with the bisector of the axes of the entrance and exit channels. Thus aluminum alloys are expected to develop a shear texture following ECAP but in relation to the axes coupled with $x'y'z'$ (*simple shear reference axes*). For ECAP of aluminum, experimental shear textures generally exhibit various rotations about the flow plane normal (z axis) [11]. Toth et al. [12] concluded that ECAP of oxygen free copper gave a simple shear texture but with deviations of 20° from ideal orientations for repetitively pressed samples. Such deviations form from ideal shear texture components were also reported by Skrotzki et al. [13].

In previous studies [14,15] that discussed the mechanical properties of different aluminum alloys subjected to ECAP, the 0.2% proof stress values were given. For 1100AA subjected to six ECAP

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