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Effects of Anisotropy, Strain Rate, and Size in Bimodal Aluminum 5083

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Aluminum alloy 5083 has been strengthened by a relatively new process involving cryomilling, cold isostatic pressing (CIP), and extrusion. The resulting aluminum alloy has a bimodal microstructure consisting of ultrafine grains (UFGs) with a grain size of about 200 nm and coarse grains (CGs) with a grain size of about 1 μm. This material exhibits greatly improved strength when compared to conventional aluminum. This study focuses on the characterization of the mechanical characteristics of this new material under different conditions. Tensile tests were conducted and the material direction, strain rate, and specimen thickness were varied to gain an understanding of the effect of these parameters on the elastic and plastic behavior of the material. The fracture surface of failed specimens was observed using both optical and scanning electron microscopes in order to detect differences in the failure behavior of the specimens under different test conditions.

It was found that specimens tested such that the direction of tension was perpendicular to the direction of the extrusion (the transverse direction) showed greatly reduced strength and ductility when compared to specimens tested with the tension and extrusion direction parallel (the longitudinal direction.) The observed fracture surfaces in these two cases were drastically different and indicate that the specimens tested in the transverse direction fail in a more brittle manner. The effect of strain rate was evaluated at strain rates of 1E-5 and 1E-4 s^{-1}. It was found that at lower strain rates, the strength and ductility increased. No significant differences were observed between the fracture surfaces of specimens tested at the two strain rates. The size effect was investigated using specimens with thicknesses of 1 mm and 0.5 mm. Further testing is necessary to come to a conclusion on the size effects on the strength and ductility of the material. However, preliminary results suggest that 1 mm thick specimens have a slightly lower strength than 0.5 mm ones. Differences in the failure surfaces of the two sizes were noted when they were microscopically observed.