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Enhancement of Mechanical and Dissolution Properties of a Cast Magnesium Alloy via Equal Angular Channel Processing

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Abstract : Two decades of the Shale Revolution has transforming transformed the global energy market, in part by the adaption of multi-stage dissolvable frac plugs. Magnesium has been favored for the bulk of plugs, requiring development of materials to suit specific field requirements. Herein, the mechanical and dissolution results from equal channel angular pressing (ECAP) of two cast dissolvable magnesium alloy are described. ECAP was selected as a route to increase the mechanical properties of two formulations of dissolvable magnesium, as solutionizing failed. In this study, 1” square cross section samples cast Mg alloys formulations containing rare earth were processed at temperatures ranging from 200 to 350 °C, at a rate of 0.005”/s, with a backpressure from 0 to 70 MPa, in a brass, or brass + graphite sheet. Generally, the yield and ultimate tensile strength (UTS) doubled for all. For formulation DM-2, the yield increased from 100 MPa to 250 MPa; UTS from 175 MPa to 325 MPa, but the strain fell from 2 to 1%. Formulation DM-3 yield increased from 75 MPa to 200 MPa, UTS from 150 MPa to 275 MPa, with strain increasing from 1 to 3%. Meanwhile, ECAP has also been found to reduce the dissolution rate significantly. A microstructural analysis showed grain refinement of the alloy and the movement of secondary phases away from the grain boundary. It is believed that reconfiguration of the grain boundary phases increased the mechanical properties and decreased the dissolution rate. ECAP processing of dissolvable high rare earth content magnesium is possible despite the brittleness of the material. ECAP is a possible processing route to increase mechanical properties for dissolvable aluminum alloys that do not extrude.

Keywords : equal channel angular processing, dissolvable magnesium, frac plug, mechanical properties
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