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Design of Titanium Alloy Equal Channel Angular Extrusion Process Using Taguchi Method

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Abstract

The shear plastic deformation behavior of a material during equal channel angular (ECA) extrusion is governed primarily by the die geometry, the material properties, and the process conditions. This paper employs the rigid-plastic finite element (FE) DEFORMTM 2D software to investigate the plastic deformation behavior of Ti-6Al-4V titanium alloy during ECA extrusion processing. Under various ECA extrusion conditions, the FE analysis investigates the damage factor distribution, the effective stress-strain distribution, and the die load at the exit. The relative influences of the internal angle between the two die channels, the friction factors, the titanium alloy temperature and the strain rate of billet are systematically examined. In addition, the Taguchi method is employed to optimize the ECA process parameters. The results have shown that: (1) the internal angle between the two die channels, the friction factor, the temperature of the Ti-6Al-4V titanium alloy, and the strain rate applied by the ram all have a significant effect upon the Y-load of the ECA extruded product; (2) the maximum damage value occurs in the surface region of the billet in the outer die channel; and (3) the maximum effective stress occurs in the vicinity of the corner of the outer die channel. The simulation results confirm the effectiveness of the Taguchi robust design methodology in optimizing the ECA extrusion process for the current Ti-6Al-4V titanium alloy.

Key words: Finite element; Titanium alloy;
Equal channel angular extrusion; Taguchi method