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Finite element simulation and experimental study of the effect of combining ultrasonic vibration with ECAP process on pure aluminum 1050

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ABSTRACT

Application of high-intensity ultrasonic vibration (UV) on manufacturing processes to improve efficiency of these methods has increasingly been developed in recent years. Equal channel angular pressing (ECAP) is one of the most applicable severe plastic deformation (SPD) methods for producing ultra-fine grain (UFG) materials. The main goal of this paper is to improve limitations of this method, such as high frictional forces (channels/billet interface), high forming force, a large number of required passes, and microstructure inhomogeneity of product, investigated on the effect of combining UV using ECAP method. Experimental set-up was prepared for imposing the UV in the plastic deformation zone (PDZ) in the opposite direction of extrusion direction on commercially pure aluminum (AA1050) samples. Moreover, the finite element (FE) simulation by commercially code ABAQUS/Explicit was carried out to understand the variation in strain and stress distributions of ECAPed samples with ultrasonic vibration. The experimental observations indicated that the use of high-intensity UV can cause more grain refinement than conventional ECAP by sub-grains formation with size ~2 μm after one pass from annealed samples with initial grain size ~160 μm. The microhardness of samples affected by superimposed UV increased to 51 Hv than initial value 24 Hv versus the value 41 Hv after one pass of conventional ECAP. Also, the verified FE simulation results demonstrated achieving better homogeneity with a larger steady-state region and lower forming force for ECAP process assisted by UV.

KEYWORDS: finite element simulation, ECAP, ultrasonic, plastic strain, microhardness, microstructure