Grain Structure Evolution during Friction-Stir Welding of 6061-T6 Aluminum Alloy

Authors : Aleksandr Kalinenko, Igor Vysotskiy, Sergey Malopheyev, Sergey Mironov, Rustam Kaibyshev

Abstract : From a thermo-mechanical standpoint, friction-stir welding (FSW) represents a unique combination of very large strains, high temperature and relatively high strain rate. The material behavior under such extreme deformation conditions is not studied well and thus, the microstructural examinations of the friction-stir welded materials represent an essential academic interest. Moreover, a clear understanding of the microstructural mechanisms operating during FSW should improve our understanding of the microstructure-properties relationship in the FSWed materials and thus enables us to optimize their service characteristics. Despite extensive research in this field, the microstructural behavior of some important structural materials remains not completely clear. In order to contribute to this important work, the present study was undertaken to examine the grain structure evolution during the FSW of 6061-T6 aluminum alloy. To provide an in-depth insight into this process, the electron backscatter diffraction (EBSD) technique was employed for this purpose. Microstructural observations were conducted by using an FEI Quanta 450 Nova field-emission-gun scanning electron microscope equipped with TSL OIMTM software. A suitable surface finish for EBSD was obtained by electro-polishing in a solution of 25% nitric acid in methanol. A 15° criterion was employed to differentiate low-angle boundaries (LABs) from high-angle boundaries (HABs). In the entire range of the studied FSW regimes, the grain structure evolved in the stir zone was found to be dominated by nearly-equiaxed grains with a relatively high fraction of low-angle boundaries and the moderate-strength B/-B {112}<110> simple-shear texture. In all cases, the grain-structure development was found to be dictated by an extensive formation of deformation-induced boundaries, their gradual transformation to the high-angle grain boundaries. Accordingly, the grain subdivision was concluded to the key microstructural mechanism. Remarkably, a gradual suppression of this mechanism has been observed at relatively high welding temperatures. This surprising result has been attributed to the reduction of dislocation density due to the annihilation phenomena.

Keywords : electron backscatter diffraction, friction-stir welding, heat-treatable aluminum alloys, microstructure
Conference Title : ICFSWP 2021 : International Conference on Friction Stir Welding and Processing
Conference Location : Auckland, New Zealand
Conference Dates : December 01-02, 2021

Open Science Index, Materials and Metallurgical Engineering Vol:15, No:12, 2021 publications.waset.org/abstracts/130602.pdf