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Characterization of the microstructure, texture and mechanical properties of 7075 aluminum alloy in early stage of severe plastic deformation

1. Introduction

Severe plastic deformation (SPD) is recognized as one of the most effective methods in grain refining of metallic materials. A tremendous amount of strain is applied to a workpiece through SPD, but in the same time it is postulated that its final shape should be similar to its initial one [1–3]. This incident would mainly result in an improvement of mechanical properties, in companion with altering electrical conductivity and corrosion resistance in some alloys [4–7]. Moreover, the microstructural and textural inhomogeneities can be reduced [8]. Hence, the final product would be a multifunctional material due to the combination of aforementioned characteristics [6]. To this end, various types of SPD methods have been designed including HPT (High pressure torsion which was the first SPD method that was scientifically used for material processing by Bridgman) [9], ECAP (Equal Channel Angular Pressing) [10], CGP (Constrained Groove Pressing) [11], MAF (Multi-axial Forging) [12], FSP (Friction Stir Processing) [13], TE (Twist extrusion) [14] , ABE (Accumulative Back Extrusion) [15], etc.

The up-to-date studies related to SPD commonly deal with some limited approaches. Most of which considering post-processing improvements of initial properties in terms of particular mechanical characteristics. Moreover, there are some other researches associated with involved fundamental mechanisms, chiefly the microstructural modification induced by applying SPD methods [16,17]. These detailed micromechanisms had been discussed mainly based on the nature of the alloys (crystal lattice or chemical composition), or the process parameters (e.g., temperature, strain rate and strain). In terms of process variables, the strain is known as the most efficient factor and the mode of straining, which can be affected by geometry of the methods, would be an important and influential matter too. Subsequently, the developed SPD routes significantly differ with each other in the resulting deformation mode. Furthermore, the straining mode could range from pure shear to simple shear as well as monotonic loading to cyclic and cross loading in terms of different routes [18,19].

To shed a light into the effect of process variables in SPD, Zener-Hollomon parameter ($Z = \dot{\varepsilon} \exp(\frac{Q}{RT})$) has been used by some previous researchers. In this regard, Li et al. [20] used this parameter to clarify the relation between grain size and grain refinement mechanism during quasi-static compression. An almost similar method is performed by

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