Short Communication

An investigation into the hot deformation characteristics of 7075 aluminum alloy


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A B S T R A C T

The deformation behavior and microstructural evolution of a 7075-T6 aluminum alloy have been investigated through applying hot compression tests at different temperatures and strain rates (450, 500, 520, 550, 580 °C and 0.004, 0.04 and 0.4 s⁻¹). The peak stress levels in different conditions were extracted from the related true stress–true strain curves. Different dynamic recrystallization (DRX) mechanisms including continuous, discontinuous and geometrical ones were proposed to justify the corresponding results of various thermomechanical processing conditions. Furthermore, the results indicated that the recrystallized structure had been spheroidized in the semi-solid temperature range due to the liquid pressure and their sizes were reduced with increasing the strain rate.

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1. Introduction

The 7000 aluminum series are very attractive materials to be employed in the automotive and aerospace industries. This is mainly due to their excellent combination of properties such as high strength to density ratio, fracture toughness, and resistance to stress corrosion cracking (SCC) [1–3]. The precipitation hardening is the main strengthening mechanism in these alloys. Increasing the amount of Zn, Mg and Cu, as the major elements of the precipitation strengthening, enhances the strength of these alloys but at the same time may deteriorate their hot workability [4–6]. Therefore the investigation of mechanical behavior and microstructural evolution of these alloys during hot deformation would assist clarifying their workability behavior. In recent years the study of hot deformation behavior of 7000 aluminum series at medium temperatures has been the target of many researches [7–9].

In aluminum alloys with high stacking fault energy, the dynamic recovery (DRV) and dynamic recrystallization (DRX) may take place upon deformation at high temperatures [10,11]. Several mechanisms of dynamic recrystallization have been reported for aluminum alloys depending on the imposed deformation conditions [10,12,13]. These alloys, due to the high efficiency of dynamic recovery and the low mobility of their grain boundaries, are more prone to the continuous dynamic recrystallization (CDRX) than to the discontinuous dynamic recrystallization (DDRX).

During CDRX, the development of the recrystallized microstructure is occurred through progressive transformation of the subgrains into the new grains. As was shown in the previous investigations, the preferred softening mechanism upon hot deformation of aluminum alloys is dictated by thermomechanical parameters. For instance, Yamagata [14] has reported the occurrence of the DDRX during hot compression of single-crystalline aluminum. Besides, the GDRX has also been observed in heavily pre-deformed aluminum alloys [15].

The present work deals with the deformation behavior and microstructural evolution of 7075-T6 aluminum alloy upon compression testing at elevated temperatures (above 450 °C). As the testing temperatures were in the range of semi-solid one, the recrystallization and partial melting (RAP) process was considered as the main mechanism of microstructural evolution [16,17]. In the RAP process, the deformed material is recrystallized and the liquid infiltrates into the recrystallized grain boundaries to give spheroids surrounded by liquid [18].

2. Experimental procedure

The experimental alloy (7075-T6 Al alloy), which was received as-extruded bar, is composed of 6.09-Zn, 2.68-Mg, 1.28-Cu and 0.15-Cr. The optical microstructure of the as-received material is shown in Fig. 1. As is seen the grains are elongated (pancaked) and the second phases are stretched along the extrusion direction. The cylindrical hot compression testing specimens were machined with dimensions of ø8 mm × H12 mm in the extrusion direction. The hot compression tests were carried out using a Gotech-AI7000 universal testing machine equipped with electrical resistance furnace. The tests were performed in the temperature range of 450–580 °C under strain rates of 0.004, 0.04 and 0.4 s⁻¹. In each test TMP cycle the specimens were first preheated to deformation temperature and held isothermally for 7 min ensure a homogenous temperature distribution through the specimens. Since the microstructural changes may occur in the specimens due to slow cooling...