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Short communication

Effects of pre-deformation on the microstructures and corrosion behavior of 2219 aluminum alloys

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ABSTRACT

In this work, effects of different pre-deformation on the microstructures and corrosion behavior of 2219 aluminum alloys were investigated. The results showed that the size of grains decreased gradually and the distributions of the precipitated phases was improved effectively during the aging processes, leading to an obvious increase in tensile strength and corrosion resistance. It demonstrated that the large amount of dislocations induced by the pre-deformation processes providing the preferential conditions for the θ′ precipitated phases. The fined and dispersed θ′ phases for this alloy subjected to 20% pre-deformation effectively hindered the movement of dislocations which enhanced the tensile strength. The tensile strength decreased slightly because of the uneven distributions of θ′ phase if the pre-deformation reaches to 30%. The rank of corrosion resistance of different pre-deformation after aging process from the highest to the lowest can be drawn as: 20% > 30% > 10% > 5%, which was attributed to the change of population of θ′ precipitates and the width of precipitation free zone (PFZ).

1. Introduction

Because of its excellent high and low temperature properties, high specific strength, sound weldability performance and fracture toughness, the 2xxx aluminum alloy is widely applied in the aviation and aerospace fields [1–4]. As a typical 2xxx aluminum alloy, the working temperature of 2219 (Al-Cu-Mn alloy) can reach − 250 °C~300 °C, implying a very excellent structural material for the welding oxidant tank of launch rockets, the skin and structural parts of supersonic aircraft [5–8].

The microstructures and mechanical properties of the aluminum alloys can be improved by thermo-mechanical treatment (TMT) processes. In particular, pre-deformation treatment before aging process has been widely used for Al-Cu alloys to further enhance the strength, ductility and uniform distributions of the precipitated phase. Lu et al. [5] employed the cold deformation treatments before aging and found out that the precipitated phase was obviously refined after aging and the mechanical properties of the 2219 aluminum alloy were enhanced. Chen et al. [6] indicated that pre-deformation could change the microstructure of materials and increased the corrosion driving force as well as the anodic dissolution rate. For 2519 A aluminum alloys, Zhang et al. [7] used the cold-pre-deformation treatments after quenching and revealed that the θ′ phase precipitations could be promoted whereas the θ″ phase precipitations could be effectively inhibited.

Over the past decade, most studies focused on the effects of pre-deformation and heat treatment process on the microstructures and mechanical properties of 2219 aluminum alloy [5,8–11]. An et al. [8] investigated the effects of pre-deformation on the microstructure and mechanical properties of 2219 aluminum alloy sheet by TMT process. Wang et al. [9] employed the pre-deformation to 2219 aluminum alloy forgings prior to ageing and found out that the ageing process was accelerate effectively. Yang et al. [10] investigated the influence of the pre-deformation on thermal stability and mechanical behavior at high temperatures. They revealed that the pre-deformation enhanced the thermal stability of the second phase and improved the strength at a temperature of 300 °C. However, for this alloy, the studies addressing its corrosion behavior [12–15], especially, with an emphasis on the influence of different pre-deformationthere are quiet few. Furthermore, the relationship between corrosion mechanism and microstructure has not established very well. For example, Babua et al. [12] discovered the effects of mechanical, metallurgical and corrosion properties of cryorolled AA2219-T87 aluminum alloy. Zhu et al. [13] studied the effect of post weld heat treatment (PWHT) on the microstructure and corrosion behavior of AA2219 aluminum alloy joints welded by variable polarity tungsten inert gas welding. The results showed that the microstructure of the joint was more homogeneous than the welded joint by

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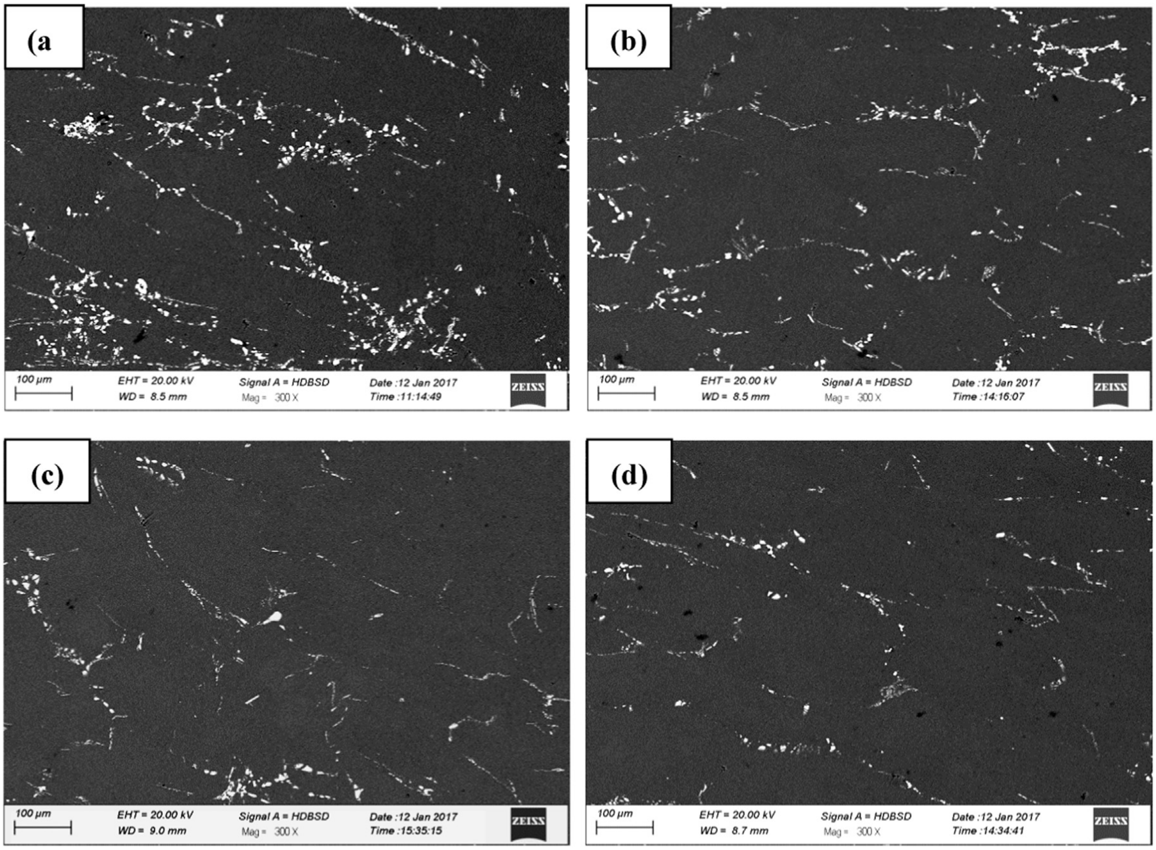

Fig. 1. SEM images of 2219 aluminum alloy with different cold rolling pre-deformation (a) 5%; (b) 10%; (c) 20%; (d) 30%.

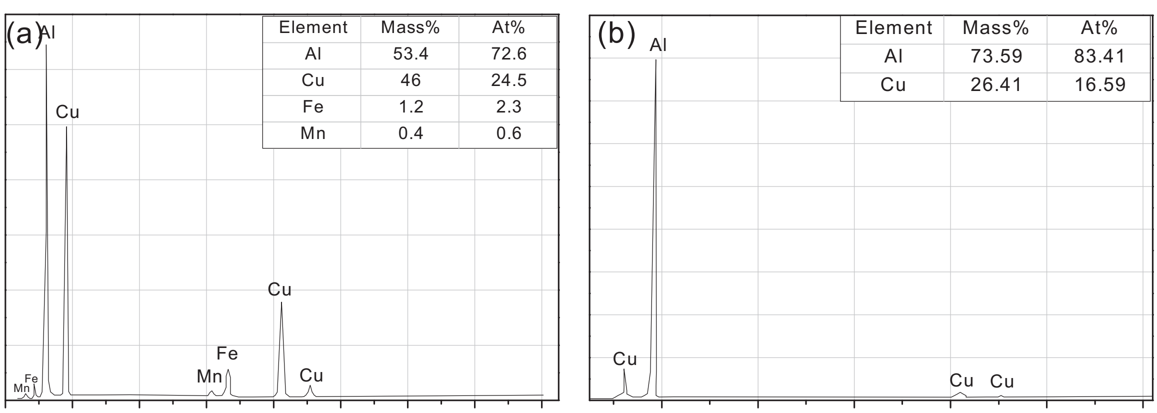

Fig. 2. Second-phase particle component detected by EDS.

implementing PWHT and the corrosion resistance of the PWHT joint was superior to that of the welded joint. Grilli et al. [14] and Scholar et al. [15] used the graphene blended polyvinyl alcohol (G-PVA) nanocomposite or chromate conversion as an effective corrosion resistance coating. They demonstrated that the alloys with protective coating displayed better corrosion resistance than the substrate alloy.

The purpose of present work is to investigate the effects of the different pre-deformation of 2219 alloy sheets on the mechanical property and in particualr, the corrosion behavior by means of scanning electron microscope (SEM) and transmission electron microscopy (TEM). A comprehensive analysis on the effect of pre-deformation on intergranular corrosion and exfoliation corrosion will be conducted, and a correlation between corrosion mechanism and microstructural evolution will be established in detail.

2. Experimental procedures

The materials used in the present work were 2219 aluminum alloy sheets and the chemical composition (wt. %) is 6.23Cu-0.24Mn-0.14Fe-0.06Si-0.18Zr-0.04Ti-0.09V. The sheets with the thickness in 6 mm were processed by cold rolling. The deformation was selected as 5%, 10%, 20% and 30%, respectively. Then the specimens were put in the resistance furnace for solution treatment, holding 3 h at the temperature of 535 °C, and quenched in the water with the temperature of 35 °C, finally put them into the electro-thermostatic blast oven for the aging treatments, holding 12 h at the temperature of 180 °C, and then they were cooled in the air.

In order to test the mechanical properties of samples, standard tensile specimens were proceed tensile experiment at room temperature on the CMT-5205 universal testing machine, the tensile strength, yield