MATERIALS CHARACTERIZATION 65 (2012) 16–27

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Microstructure evolution of a modified AA5083 aluminum alloy during a multistage homogenization treatment

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ARTICLE DATA

Article history:
Received 13 September 2011
Received in revised form
6 December 2011
Accepted 14 December 2011

Keywords:
AA5083 alloy
Homogenization
Microsegregation
$Al_6(Mn,Fe)$ precipitates
ν-$Al_{11}(Mn,Cr)_4$ dispersoids
$Al_{18}Mg_3(Mn,Cr)_2$ dispersoids

ABSTRACT

The microstructure evolution of the industrially cast AA5083 modified aluminum alloy during the multistage homogenization treatment was investigated by means of optical, SEM and TEM imaging and microanalysis techniques. The effect of microsegregations on the precipitates structure was evaluated. Eutectic constituent $Al_6(Fe,Mn)$ and Mg_2Si particles form in interdendritic regions, while ν-$Al_{11}(Mn,Cr)_4$ dispersoids were observed in the dendrite cores. Homogenization treatments lead to a partial dissolution of the precipitates present in the as-cast state and formation of the new phases: rod-shaped $Al_6(Mn,Fe)$ and $Al_{18}Mg_3(Mn,Cr)_2$ dispersoids in the dendrite cores.

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1. Introduction

AA5083 is an important commercial Al–Mg alloy that has wide application in the transportation industries [1], due to high ductility combined with relatively high strength, good weldability and corrosion properties. Although dominant strengthening mechanisms of the alloy are solid solution strengthening and strain hardening, the AA5083 alloy contains number of alloying elements whose function is to improve properties such as corrosion resistance (Zn) or weldability (Zr) [2,3]. In case of the AA5083 alloy, because of heavy alloying, the homogenization treatment is a very important step in the processing procedure, strongly affecting the efficiency of subsequent hot rolling. Alloying with multiple elements such as Mn and Cr as well as impurities like Fe and Si affect solidification behavior of AA5083, as a number of intermetallic phases form. Those precipitates have significant influence on recovery and recrystallization behavior.

Sheppard and coworkers [4] showed that different homogenization schedules resulted in different microstructural characteristics. Although they suggested the identity of the dispersoids formed, they did not provide any crystallographic data nor established eventual difference in a phase composition of the specimens that underwent various homogenization treatments. Studies by Lee and Wu [5,6] were conducted on laboratory cast alloys. The alloys composition was varied in order to establish the effect of individual elements on microstructure development during the homogenization treatment. Results of their study lead them to conclude that the magnesium segregations could be removed by the homogenization, while manganese microsegregations were more persistent; even a small addition of Si (<0.05 wt.%) enhanced

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1044-5803/$ – see front matter. Published by Elsevier Inc.
doi:10.1016/j.matchar.2011.12.006

Table 1 – Chemical composition of the AA5083 alloy, wt.%.									
Mg	Mn	Cu	Fe	Si	Zn	Cr	Na	Ti	Zr
4.85	0.733	0.0077	0.286	0.109	0.100	0.112	0.0003	0.007	0.103

microsegregation [5]. Microstructural characterization of the laboratory cast alloys with and without Mg lead to conclusion that the presence of Mg promotes formation of the Al_4Mn phase over Al_6Mn [6]. However, the addition of Cr revealed different types of precipitates and more complex precipitate distribution [6], pointing out that an industrially cast alloy, with more microalloying elements and unavoidable impurities, would exhibit more complex microstructure. Observations of particle morphology and chemistry in the microstructure were reported in a number of papers [7–12], but the microstructure characterization was not the primary focus of the studies and the authors assumed that all Mn bearing particles were Al_6Mn. More recent work has been mainly focused on the superplastic properties of AA5083 alloy and the effect of alloy modification by the addition of rare earth elements on the superplasticity and stability of grain microstructure [7–10,13,14].

Despite wide application of the AA5083 alloy and interest in improving its properties by additional alloying, there is still a lack of detailed microstructural characterization of the industrially cast alloy and study of the effect of subsequent homogenization on the alloy microstructure. Type, morphology, size and distribution of eutectic constituent particles as well as fine dispersoids have significant effect on recovery and recrystallization as well as on texture development and formability of the alloy. In order to expand understanding of the effect of homogenization on the microstructure and alloy behavior during subsequent processing, we investigated the microstructure evolution during the multistage homogenization treatment of industrially cast AA5083 alloy. In this paper we report on the effect of microsegregations on formation of intermetallic precipitates and eventual changes in the precipitates' composition during the homogenization treatment.

2. Material and Methods

The material studied was an Al–Mg–Mn alloy AA5083 modified with a small Zr addition. Chemical composition of the alloy is given in the Table 1. The alloy was fabricated by DC casting at 680±5 °C in Impol Seval-Aluminum Mill Company. Characterized material was cut from the central part of the ingot cross-section.

As-cast alloy underwent multi-stage homogenization treatment. The heat treatments were conducted in an air circulating furnace in the temperature range 430-555 °C. The homogenization treatments conducted in our lab included three stages:

1) Slow heating 35 °C/h followed by an initial low-temperature annealing at 430 °C for 12 h.
2) Subsequent high temperature anneal at 555 °C for 12 h.
3) The third stage was annealing at 460 °C for 8 h.

Microstructure of the selected states was characterized by optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM) and microanalysis. Specimen preparation for the metallographic analysis and SEM involved fine mechanical polishing for the identification and characterization of distribution of the secondary phases, while grain and solidification structures were studied after electrolytic etching of the specimens using Barker's reagent. Specimens for the TEM characterization were mechanically thinned

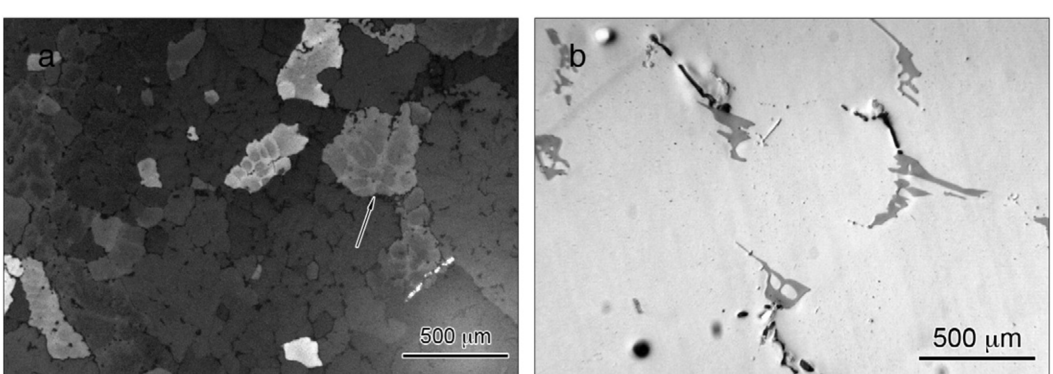

Fig. 1 – Optical micrographs of the alloy microstructure in the as-cast state: (a) Specimen is etched so that the grain and dendrite microstructures are revealed. (b) The contrast difference in the electropolished specimen indicated presence of at least two types of coarse precipitates embedded in the Al-based matrix.