RELEVANCE OF COPPER AND SILICON IN INTERCRYSTALLINE CORROSION OF AA6000-SERIES ALUMINIUM ALLOYS

MAGNUS HURLEN LARSEN AND KEMAL NISANCIOGLU

Department of Materials Science and Engineering
Norwegian University of Science and Technology
N-7491 Tronheim, Norway

ABSTRACT: Aluminium 6000-series alloys are normally corrosion resistant. Susceptibility to intergranular (IGC) of alloys with low Cu content may occur, and this is often attributed to excess Si content. In this study we investigate the role of low Cu content and heat treatment on IGC susceptibility of an extruded model alloy containing nominally 0.5% Mg, 0.6% Si, 0.2% Fe, 0.2% Cu and 0.1% Mn. As-extruded material in the T4-temper was resistant to IGC. Underaging introduced significant IGC susceptibility. By aging to the T6 condition, IGC was reduced or eliminated. Overaging introduced susceptibility to pitting. A model alloy of similar composition, but lower (0.02%) Cu content, was not susceptible to IGC in any of these tempers. Detailed transmission electron microscopy of the susceptible specimens revealed the presence of a continuous, few monolayers thick Cu film along the grain boundaries together with discrete precipitates of AlMgSiCu Q-phase. By increasing the aging time, the Cu film became discontinuous, and coarsening of the precipitates, as well as precipitation in the matrix, occurred. These phenomena reduced the IGC susceptibility. The IGC-susceptibility of low Cu-containing 6000-series extrusions is therefore attributed to the formation of the Cu film along the grain boundaries, and depletion of Si in a narrow adjacent zone is a contributing factor. Judicious heat treatment prevents IGC of these materials.

Keywords: Aluminium alloy AA6000, intercrystalline corrosion, microstructure, TEM

1. INTRODUCTION

Al-Mg-Si-(6000series) alloys are medium to high strength alloys with good formability, and they are widely used in architectural and automotive applications. 6000-series aluminium alloys are generally known to be resistant to intergranular corrosion (IGC). However, unfavourable alloying and thermomechanical history may introduce susceptibility to IGC. Excess silicon relative to that needed to form Mg_2Si has been claimed to introduce IGC-susceptibility due to the strong cathodic nature of elemental Si [1-3]. Copper additions may form noble grain boundary precipitates with an adjacent Cu-depleted active zone. Svenningsen et al.[3-6] studied the effect of thermomechanical history on the corrosion performance of AlMgSi(Cu)-alloys, and found that slow cooling after extrusion introduced susceptibility to intergranular corrosion. Artificial ageing reduced the IGC-susceptibility. The IGC-susceptibility was related to a nanoscale Cu-rich film along the grain boundaries, along with coarse Cu-containing precipitates at the grain boundaries. The purpose of this work is to contribute to the understanding the relationship between small (0.2%) Cu content, heat treatment and IGC susceptibility by studying the effect of artificial ageing on grain boundary structure and IGC of a water quenched 6000-series model alloy.

2. EXPERIMENTAL

Two model alloys with similar composition were used. The main difference between the materials was the Cu-content. The compositions are given in table 1