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Short Communication

Corrosion behavior of aluminum 6061 alloy joined by friction stir welding and gas tungsten arc welding methods

V. Fahimpour [a], S.K. Sadrnezhaad [a,*], F. Karimzadeh [b]

[a] *Department of Materials Science and Engineering, Sharif University of Technology, P.O. Box 11365-9466, Tehran, Iran*
[b] *Department of Materials Engineering, Isfahan University of Technology (IUT), Isfahan 84156-83111, Iran*

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ABSTRACT

Wrought aluminum sheets with thickness of 13 mm were square butt-welded by friction stir welding (FSW) and gas tungsten arc welding (GTAW) methods. Corrosion behavior of the welding zone was probed by Tafel polarization curve. Optical metallography (OM) and scanning electron microscopy together with energy dispersive spectroscopy (SEM-EDS) were used to determine morphology and semi-quantitative analysis of the welded zone. FSW resulted in equiaxed grains of about 1–2 μm, while GTAW caused dendritic structure of the welded region. Resistance to corrosion was greater for the FSW grains than the GTAW structure. In both cases, susceptibility to corrosion attack was greater in the welded region than the base metal section. T6 heat treatment resulted in shifting of the corrosion potential towards bigger positive values. This effect was stronger in the welded regions than the base metal section.

1. Introduction

Diverse applications of aluminum alloys in automobile and aerospace industries dictate significance of choosing their assortment based on welding behavior plus selection of most suitable welding-method. Aluminum alloys of 2xxx, 6xxx and 7xxx series have been considered for substantial use in these industries [1]. This ensues from their desirable strength to weight ratio, excellent formability, appropriate weldability and acceptable corrosion resistance [2]. Depending on the specific application, corrosion behavior is a significant factor of a welded joint [3].

Heat treatable aluminum alloys have been subject of specific investigations for their welding behavior [4]. A weak region usually forms near the welded zone which decreases the strength of the joint [5]. Recrystallization, precipitation [6] and grain growth [7] can also cause more weakening of this region. Extensive research has been conducted in the past either to eliminate or to strengthen this region with optimization [7], change of methods [8], pre-heat treatment [9] and post-heat treatment [10]. Since post heating is generally time-consuming and expensive, other processes ensuring formation of stronger weld regions with smaller grain size and higher formability are adored. Friction stir welding is an alternative method which ostensibly presents a better microstructure and ideal mechanical properties [11].

Corrosion resistance of the welded materials at the various regions formed during welding are not the same. Previous studies show that the welded zones of the most joints are susceptible to corrosion [12]. Numerous parameters such as porosity, crack, residual stress, wrongly selected filler and incorrect design of the edges, would cause little resistance to the corrosion [13]. Elimination of such melting defects can, on the other hand, substantially increase corrosion resistance [14]. Many of these defects are avoided by using friction stir welding which is a solid-state process. For this reason, many investigators have considered FSW as a means of improving corrosion behavior [15].

This paper reports on the most recent findings obtained by friction stir welding of 6061 aluminum alloy as compared to the conventional gas tungsten arc welding method. Microstructure and corrosion properties of both welds are compared. The findings show that the friction stir welding can result in desirable properties close to the base alloy.

2. Experimental procedures

Wrought 6061-T6 aluminum sheets having 13 mm thickness defined by code B0209-04 ASTM standard [16] were welded together by FSW and GTAW methods. Aluminum 4043 alloy was used as the metallic filler in the latter. Chemical compositions of both alloys are given in Table 1.

The sheets were 25 cm long and 5 cm wide. Shoulder diameter, pin diameter and pin height of the tools used for the FSW process was 20, 7 and 7 mm, respectively. H13 steel was chosen as the tool material [17]. After final machining, 1 h austenitization at 1050 °C, quenching to the room temperature under air and 20 min tempering at 450 °C were conducted on the samples. This heat treatment

* Corresponding author. Tel.: +98 2166165215; fax: +98 2166005717.
E-mail address: sadrnezh@sharif.edu (S.K. Sadrnezhaad).

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