Materials and Design 32 (2011) 5120–5126

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

Effect of a post-weld heat treatment on the mechanical and microstructure properties of AA6061 joints welded by the gas metal arc welding cold metal transfer method

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ARTICLE INFO

Article history:
Received 1 February 2011
Accepted 4 June 2011
Available online 16 June 2011

ABSTRACT

This work studies the effect of a post-weld heat treatment (PWHT) on the mechanical and microstructure properties of an AA6061 sample welded using the gas metal arc welding (GMAW) cold metal transfer (CMT) method. The CMT method was used because the method provides spatter-free welding, outstanding gap bridging properties, low heat input and a high degree of process flexibility. The welded samples were divided into as-welded and PWHT samples. The PWHTs used on the samples were solution heat treatment, water quenching and artificial aging. Both welded samples were cut according to the ASTM E8M-04 standard to obtain the tensile strength and the elongation of the joints. The failure pattern of the tensile tested specimens was analysed using scanning electron microscopy (SEM). A Vickers microhardness testing machine was used to measure the hardness across the joints. From the results, the PWHTs were able to enhance the mechanical properties and microstructure characteristics of the AA6061 joints welded by the GMAW CMT method.

1. Introduction

Alloys have become some of the most widely used materials in such industries as the structural and transportation industries because of their good mechanical properties, including corrosion resistance, light weight, high strength, high toughness and recycling capabilities [1]. Alloy 6061 is one of the most widely used alloys in the 6000 series. This standard structure alloy, one of the most versatile of the heat-treatable alloys, is popular for medium- to high-strength requirements and has good toughness characteristics. Applications for the alloy range from transportation components to machinery equipment applications to recreational products and consumer durables. Aluminium alloy 6061 has been used in the automotive industry [2], in marine frames and in pipeline and aircraft applications [3]. This type of aluminium alloy contains magnesium and silicon as its major alloying elements [4]; they increase the strength of the alloy via precipitation hardening [5].

A recent development in welding technology is the cold metal transfer (CMT) process, which is ideally suited to welding aluminium because of the no-spatter welding process and the low thermal input. CMT is a modified metal inert gas (MIG) welding process. The principal innovation is that the motions of the wire have been integrated into the welding process and into the overall control of the process. Every time a short circuit occurs, it interrupts the power supply and controls the retraction of the wire. The wire retraction motion assists droplet detachment during the short circuit; thus, the metal can transfer into the welding pool without the aid of the electromagnetic force. As a result, the heat input and spatter can be decreased significantly [6].

Usually, the microstructure and the mechanical properties of an aluminium alloy will change after the welding because of the melting of the base material during the welding process. This contributes to its lack of strength. To overcome this problem, a heat treatment is performed to the welded part to obtain the desired mechanical properties and to relieve the residual stress on the part [3]. The properties of various aluminium alloys can be altered by specifically designed heat treatments. Heat treatments for aluminium alloys are usually performed by solution heat treatments, followed by water quenching and aging at a certain temperature or by natural aging in air [2].

Many researchers are now focused on finding a material that can replace metal. Metals are excellent building materials because of their high strength, high toughness, high melting temperature and high chemical reactivity; because of this, metal is preferred for construction applications [7]. A good example of a metal is steel. Steel can be defined as an iron–carbon alloy containing 0.02–2.11% carbon. It is the most important category within the ferrous metal group. Applications of steel include construction (bridges, I-beams), transportation (trucks, rails) and consumer

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doi:10.1016/j.matdes.2011.06.007