Materials and Design 32 (2011) 3854–3864

Contents lists available at ScienceDirect

Materials and Design

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

Microstructure and mechanical properties of resistance upset butt welded 304 austenitic stainless steel joints

M. Sharifitabar [a], A. Halvaee [b,*], S. Khorshahian [a]

[a] Metallurgy and Materials Engineering Division, Sistan & Baluchestan University, Zahedan, Iran
[b] School of Metallurgy and Materials Engineering, University College of Engineering, University of Tehran, P.O. Box: 11365-4563, Tehran, Iran

ARTICLE INFO

Article history:
Received 26 October 2010
Accepted 3 March 2011
Available online 10 March 2011

Keywords:
A. Ferrous metals and alloys
D. Welding
E. Mechanical
F. Microstructure

ABSTRACT

Resistance upset welding (UW) is a widely used process for joining metal parts. In this process, current, time and upset pressure are three parameters that affect the quality of welded products. In the present research, resistance upset butt welding of 304 austenitic stainless steel and effect of welding power and upset pressure on microstructure, tensile strength and fatigue life of the joint were investigated. Microstructure of welds were studied using scanning electron microscopy (SEM). X-ray diffraction (XRD) analysis was used to distinguish the phase(s) that formed at the joint interface and in heat affected zone (HAZ). Energy dispersive spectroscopy (EDS) linked to the SEM was used to determine chemical composition of phases formed at the joint interface. Fatigue tests were performed using a pull–push fatigue test machine and the fatigue properties were analyzed drawing stress-number of cycles to failure (*S*–*N*) curves. Also tensile strength tests were performed. Finally tensile and fatigue fracture surfaces were studied by SEM. Results showed that there were three different microstructural zones at different distances from the joint interface and delta ferrite phase has formed in these regions. There was no precipitation of chromium carbide at the joint interface and in the HAZ. Tensile and fatigue strengths of the joint decreased with welding power. Increasing of upset pressure has also considerable influence on tensile strength of the joint. Fractography of fractured samples showed that formation of hot spots at high welding powers is the most important factor in decreasing tensile and fatigue strengths.

1. Introduction

Resistance upset welding is a solid-state welding process which involves the interaction of electrical, thermal, mechanical and metallurgical phenomena. In this process, the joining surfaces are kept at a forced contact; followed by a high electric current passing through the workpieces. Due to the contact resistance and Joule heating, a vast amount of heat is generated at the faying surfaces. Before, during and after applying the electric current, force is applied to maintain the electric current continuity and to provide the pressure necessary to form the weld zone. The metal at the joint is heated to a temperature where recrystallization can rapidly occur across the heated surfaces. In this process, similar to other resistance welding processes, there is no requirement to any extraneous material such as filler material or shielding gas [1]. In this welding process there are two types of resistances namely contact resistance and bulk resistance. At the earlier stages of the welding, contact resistance plays the main role but gradually it decreases and the role of bulk resistance becomes more important [2,3]. Kanne expressed that in comparison with fusion welding processes, the chemical composition and metallurgical properties are not significantly changed leading to better mechanical properties. Simplicity, welding speed, capability of remote control and independence of welding quality from the operator skill are the other advantages of this process [4]. Miyazaki et al., Kang, Kanne and Sharifitabar and Halvaee stated that resistance upset welding is a suitable welding process for applications such as sealing of atomic waste containers, welding of automotive parts and joining of stainless steels, low carbon steels, super alloys, aluminum alloys and parts made of dissimilar materials [4–7]. The general configuration of parts and equipments in upset welding is shown in Fig. 1.

Stainless steels play an important role in the modern world. Austenitic stainless steels represent more than 2/3 of the total stainless steel production. These stainless steels are preferred more than other stainless steel types due to their good weldability [8]. But there are some negative metallurgical changes during welding of these steels which should be considered. They are [9,10]: (a) formation of delta ferrite phase, (b) formation of sigma phase, (c) stress corrosion cracking, (d) precipitation of chromium carbide at grain boundaries and (e) formation of hot cracks.

Nikitin et al. and Nikitin and Bses stated that fatigue behavior of austenitic stainless steel welds is strongly affected by stress ampli-

* Corresponding author. Tel.: +98 2161114104; fax: +98 2188006076.
E-mail address: halvaee@ut.ac.ir (A. Halvaee).

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.03.007