Materials and Design 32 (2011) 869–876

Contents lists available at ScienceDirect

Materials and Design

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

Effect of tandem submerged arc welding process and parameters of Gleeble simulator thermal cycles on properties of the intercritically reheated heat affected zone

Sadegh Moeinifar *, Amir Hossein Kokabi, Hamid Reza Madaah Hosseini

Department of Materials Science and Engineering, Sharif University of Technology, Azadi Avenue, P.O. Box 11155-9466, Tehran, Iran

ARTICLE INFO

Article history:
Received 16 February 2010
Accepted 5 July 2010
Available online 8 July 2010

Keywords:
D. Welding
E. Fracture
F. Microstructure

ABSTRACT

The effects of real and Gleeble simulated double pass thermal cycles on the properties of the intercritically reheated coarse grained heat affected zones in X80 microalloyed pipeline steel has been investigated. The Gleeble simulated process involved heating the X80 steel specimens to the first peak temperature of 1400 °C and then reheating to the second peak temperature of 800 °C, with different cooling rates. The size and area fraction of martensite/austenite (M/A) constituents were obtained by a combination of field emission scanning electron microscopes and image analysis software. In addition, misorientation was characterized by electron back-scatter diffraction analysis. It is clear that the intercritically thermal cycles have a significant effect on morphology of M/A constituents. The M/A constituent's size, such as mean diameter and length, are important factors influencing Charpy impact properties of thermally simulated intercritically reheated heat affected zones. The simulated thermal cycles of the intercritically reheated region in the high heat input tandem submerged arc welding processes, showed extremely poor Charpy impact absorbed energy. The intercritical reheated thermal cycles with lower heat input value showed higher Charpy impact absorbed energy due to a decrease in the prior-austenite grain and M/A particle size.

1. Introduction

The fracture toughness property is a major factor in the design of oil and gas pipelines [1]. Therefore, recent research focuses on the toughness property of high strength microalloyed steels [2–4]. The strength and toughness of high strength, low-alloy (HSLA) microalloyed steels can be damaged by the thermal cycles during welding, causing fragility in the heat affected zone (HAZ) [5]. For single pass welding, the lowest toughness is expected in the coarse grained heat affected zone (CGHAZ), which is part of the HAZ near the fusion line [6].

Welding processes with high heat input, such as tandem submerged arc welding (TSAW), causes larger prior-austenite grain size in CGHAZ. Recently, research on multi-pass welding has shown that the most degraded part in HAZ is the intercritically coarse grained heat affected zone (IC CGHAZ) [7,8]. This is the region of the CGHAZ that is heated to a temperature between A_{C1} and A_{C3} by the subsequent welding passes [9]. Within the intercritical thermal cycles, transformation of ferrite to austenite occurs particularly where austenite stabilizers, i.e. carbon or manganese, are segregated in the initial microstructure [10].

Although there have been some studies on the microstructure of the IC CGHAZ in HSLA steels, further research must be made on the use of high strength and new HSLA steel grades affected with the high heat input TSAW process [11]. In the present study, high toughness X80 HSLA microalloyed steel was welded with high heat input four-wire TSAW process. However, it is difficult to study IC CGHAZ because the size of this region is very small. Therefore, research on the microstructure and properties via thermal simulated cycles, aim to generate a relatively large region of IC CGHAZ, similar to the four-wire TSAW process. Effects of heat input and cooling rate, during real and thermal simulation process, on the microstructure of reheated IC CGHAZ were not clearly reported. Therefore, in this research, influences of the prior-austenite grain size and cooling rate with different simulated thermal cycles were investigated on the microstructure and mechanical properties of reheated IC CGHAZ.

2. Experimental procedure

The X80 microalloyed HSLA steel was used as a base metal in the hot rolled accelerated-cooled plate. The plate was formed into a cylindrical shape in the two mechanical steps of UOE processes. The chemical composition of X80 microalloyed steel in this investigation is shown in Table 1. The double-V joint preparation used

* Corresponding author. Tel.: +98 9161134176; fax: +98 2166165717.
E-mail address: moeinifar@mehr.sharif.edu (S. Moeinifar).

0261-3069/$ - see front matter
doi:10.1016/j.matdes.2010.07.005