Materials and Design 32 (2011) 2328–2333

Contents lists available at ScienceDirect

Materials and Design

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

Short Communication

A study on mechanical and microstructure characteristics of the STS304L butt joints using hybrid CO_2 laser-gas metal arc welding

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ARTICLE INFO

Article history:
Received 28 July 2010
Accepted 20 December 2010
Available online 28 December 2010

ABSTRACT

In order to examine mechanical characteristics of the stainless steel (STS304L) hybrid welded butt joints, two-dimensional thermal elasto-plastic analysis has been carried out. To this end, a 2D simulation model has been developed considering hybrid welding features. Based on thermal history data obtained from this heat source model, the residual stress distribution in weld metal (WM), heat affected zone (HAZ) and base metal (BM) characteristics have been calculated and found to be in reasonable agreement with the experimentally measured values. In order to investigate the effect of welding process, thermal elasto-plastic behaviour of the hybrid welded joints was compared with a welded joints obtained by conventional submerged arc welding (SAW) process. The results show that the longitudinal residual stress in the hybrid welded joints is less (13–15%) than that of the SA welded joints. Weld metal formed in both welding processes shows very fine dendritic structure. Due to higher heat input in SAW, the HAZ size of the SA welded joints is more than twice that of the hybrid welded joints. Therefore, from mechanical and metallurgical point of view, it could be confirmed that it makes a good sense to use SAW instead of hybrid CO_2 laser-gas metal arc welding (GMAW) for butt joint of the STS304L thick steel.

1. Introduction

Recently, laser-arc hybrid welding has come to great attention in a large variety of industries from shipbuilding to automobile production because of high welding speed, low distortion, deep penetration and good gap bridging ability. This technique was introduced by Prof. Steen and his co-workers in the late 1970s and combines the best characteristics of both laser welding and arc welding processes, acting simultaneously in the same process zone [1,2]. In particular, laser-arc hybrid welding offers many advantages for heavy industrial applications involving thick-walled materials as it enables full penetration weld of thick plates without the need of multiple passes and at that reduces welding after works such as cutting for adjustment and fairing at the assembly stage. Hybrid welding improves productivity by two to four times as compared to the conventional arc welding [3,4]. Welding process unavoidably involves a stage of residual stress in the welded structure that brings potential problems in terms of dimensional stability and structural integrity. Many analytical and experimental research works on mechanical behaviour of the welded joint have been carried out [5,6].

Although some works have focused on modelling and simulation of hybrid welding, advanced complex welding processes for new materials require for better fundamental understanding of the residual stress. For application of new laser-arc hybrid welding processes it is necessary to examine mechanical behavior of the welded joint in advance in the design stage. This study aims at establishing the possibility of application of laser-arc hybrid welding for austenite stainless steel (STS304L) of 13 mm thickness. For this, 12 kW CO_2 laser is combined with the gas metal arc welding (GMAW) process. Reliability assessment, verification of the welding design and construction criteria for welds formed by hybrid welding are conducted through numerical and microstructure analysis. Using the developed program, two-dimensional heat conduction and thermal elasto-plastic analysis [5] has been carried out in order to clarify and compare mechanical characteristics and formation mechanisms of residual stresses. Moreover, in heavy industries, submerged arc welding (SAW) is commonly used to weld thick plates for austenite stainless steel (STS304L). Therefore, in this paper, a comparison of CO_2 laser-GMA hybrid butt welded joints and SA butt welded joints has been carried out.

2. Research method

2.1. Experimental method and conditions

TRUMPF 12000 TLF turbo continuous wave 12 kW CO_2 laser with 250 m focal length (focus diameter 0.8 m) was coupled with FRONIUS TPS 5000 MIG welding equipment for hybrid welding

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doi:10.1016/j.matdes.2010.12.039