Original article

Institution of MECHANICAL ENGINEERS

Journal of MATERIALS: DESIGN AND APPLICATIONS

Proc IMechE Part L:
J Materials: Design and Applications
0(0) 1–16

DOI: 10.1177/1464420720910442
journals.sagepub.com/home/pil
SAGE

Interactions of the process parameters and mechanical properties of laser butt welds in thin high strength low alloy steel plates

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Abstract

High strength low alloy steels subjected to the thermomechanical control process present excellent strength–toughness combination, high strength/weight ratio, and weldability. Therefore, they are widely used in structural components, such as pressure vessels, oil/gas transportation pipes, lifting equipment, vehicles, shipbuilding and offshore industries, and in the automotive industry where low thickness (0.8–3 mm thickness) is of great importance. Usually, these steels are welded by conventional gas metal arc welding, which creates wide heat-affected zones, large residual stresses, and distortion in the welded parts. Laser welding is nowadays an alternative process to weld high strength low alloy steel parts due to its advantages. The aim of this work is to understand the effect of process parameters on defects, weld bead geometry, microstructure, and mechanical properties, namely hardness and tensile strength. We identify the main laser welding parameters and their influence on the weld bead geometry and defects, for a 3 mm thick high strength low alloy steel welded under a maximum power of 2 kW. A cross section of the weld seam was optimized achieving a good geometry without porosity. The threshold value of the heat input to achieve complete penetration was determined for different focus diameters. The microstructure, size, and hardness of the heat-affected zone and of the fusion zone are strongly influenced by the heat input. The values of the tensile strength achieved in butt welds were close to the base metal by an appropriate selection of the laser welding parameters and the heat input.

Keywords

Laser welding parameters, high strength low alloy steels, welding defects, mechanical properties, heat input

Date received: 9 December 2019; accepted: 11 February 2020

Introduction

The laser welding of high strength low alloy (HSLA) steels is a promising technology since it allows to reduce the weight and to increase the efficiency of the weld, when comparing with other existing techniques. HSLA steels have several applications in diverse areas such as automotive, structural, pipeline, lifting, shipbuilding, among others.[1–3] Due to the improvement of laser technology and to its advantages over conventional welding processes, laser welding is also being used in alloys of aluminum, magnesium, titanium, dissimilar materials[4] and in advanced engineering materials, such as NiTi, being for the latter the most used joining process.[5] The key feature of laser welding is its high-power density, which allows a lower heat input (HI), high cooling rate, and a narrower heat-affected zone (HAZ).[6] Although these characteristics may be conducive to the welding of HSLA steels and other materials, establishing the laser welding parameters that allows achieving sound welds and similar mechanical

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