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Effect of Cut Quality on Hybrid Laser Arc Welding of Thick Section Steels

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Abstract

From an industrial point of view, in a laser cutting-welding production chain, it is of great importance to know the influence of the attainable laser cut quality on the subsequent hybrid laser arc welding process. Many studies have been carried out in the literature to obtain lower surface roughness values on the laser cut edge. However, in practice, the cost and reliability of the cutting process is crucial and it does not always comply with obtaining the highest surface quality. In this study, a number of experiments on 25 mm steel plates were carried out to evaluate the influence of cut surface quality on the final quality of the subsequent hybrid laser welded joints. The different cut surfaces were obtained by different industrial cutting methods including laser cutting, abrasive water cutting, plasma cutting, and milling. It was found that the mentioned cutting methods could be used as preparation processes for the subsequent hybrid laser arc welding. However, cut quality could determine the choice of process parameters of the following hybrid laser arc welding.

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Keywords: Laser cutting; Hybrid Laser Arc Welding; Cut quality; Weld quality

1. Introduction

Manufacturing of large steel constructions demands the ability of processing thick section steels. By taking the advantages of high power laser cutting and hybrid laser arc welding (HLAW) it is possible to process thick section

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steels with thickness of above 25 mm. Recent studies on laser welding (Farrokhi et al., 2015) and cutting (Goppold et al., 2014) of steels with lower thicknesses show that the unique characteristics of solid-state lasers can result in high quality products. However, some crucial challenges appear when it comes to processing of thick section steels. For instance, in addition to the well-anticipated defects, such as, concavity, undercut, and root humping, HLAW has been found to have higher tendency to form porosity in the root side with increasing plate thickness (Dilthey et al., 2005). It is difficult to avoid solidification cracks when welding 40 mm thick double-sided steel joints (Nielsen, 2014). In the case of laser cutting the striations and dross attachments, which are left on the sides and bottom of the kerf respectively, are known as the main quality challenges of thick section laser cutting (Wandera et al., 2011).

A great deal of research has been conducted to find technical means to overcome the mentioned challenges and to obtain lower cut surface roughness values (Goppold et al., 2014); (Wandera et al., 2011). Striation-free cuts of thin steel sheets by using fiber lasers with modified process parameters have been reported in some studies (Powell et al., 2011); (Sobih et al., 2007). However, from an industrial point of view, in a laser cutting-welding production chain, it is of great importance to know the influence of the attainable laser cut edge quality on the subsequent HLAW operation. In practice, the cost and reliability of the cutting process is crucial and it does not always comply with obtaining a fully perpendicular cut with a low surface roughness on the edge. Recent studies about reduced pressure laser welding of 40 mm thick low alloyed steel shows that the combination of increased edge surface roughness and a pre-set air gap increases the weld penetration in the butt joint configuration (Sokolov et al., 2015). In addition, the significance of the edge surface roughness on the laser absorption at power levels of above 10 kW has been reported by another study (Sokolov et al., 2012). Therefore, one can argue that influence of cut quality and surface roughness must be taken into consideration when laser welding thick section steel, as the processing of higher thicknesses requires the laser power levels above 10 kW. However, despite the importance of the subject, only a few studies are available about the influence of cut surface quality on the following HLAW of thick section steels.

The aim of this study is to investigate the effect of different cut surface qualities of 25 mm thick section steels on the final quality of the subsequent hybrid laser arc welded joints and the welding procedure. A number of experiments were carried out to obtain the different cut surface qualities by milling and the common industrial cutting methods including laser cutting (LC), plasma cutting (PC), and abrasive water cutting (WC). The cut samples were prepared for butt joint configuration and welded by a high power solid-state laser. The final quality of the welded joints was compared between laser cut samples and samples cut with alternative industrial choices. Figure 1 shows the structure of study.

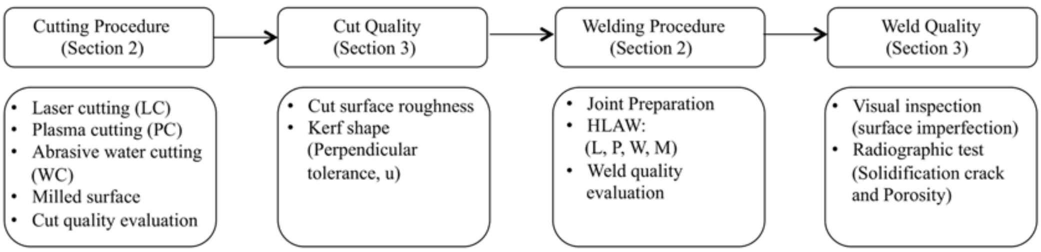

Fig. 1. Structure of study.

2. Experimental Procedure

2.1. Cutting Procedure

The laser used for the cutting was an IPG Photonics YLS- 3000SM fiber laser providing a 3 kW single mode, continuous wave laser beam with a wavelength of 1076 nm. The laser was guided through an optical fiber to a High Yag cutting head (focal length: 470mm) and cutting was performed with Nitrogen as the assist gas. S355 Mild steel plates with a thickness of 25 mm and 120 mm x 100 mm dimensions were considered for this study. The chemical

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