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Measurement of strain during tension test of welded joint using multi-camera 3D correlation system

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Abstract

This work concerns experimental research on the determination of deformation during uniaxial tension test of samples made of laser-arc hybrid welded joints. Steel sheet made of S355 steel with thickness 5mm is butt-welded without gap using hybrid welding technique involving GMAW method with Yb:YAG laser beam. Samples used to the tension test are made from welded joints and base material. Universal strength machine Zwick&Roel Z100 is used with extensometer Multisens in all performed tension tests. The machine works with Dantec Q-400 Istra multi-camera 3D correlation system. System of three cameras mounted on a beam line is used for accurate measurement of the spatial deformations. Presented results of the research include strain fields measured for the entire tension cycle at the frequency 40 Hz.

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Keywords: hybrid welding; optical corelation system; tension test; strain;

1. Introduction

Thermal impact on the material in many technological processes significantly affects mechanical and structural properties of the entire construction [1-6]. In the case of welding processes, coupled physical phenomena have a direct impact on the quality of welded joint [7-9]. The material in the weld and adjacent region is heated to various temperatures resulting in a variety of structures that occur in the joint and heat affected zone (HAZ), having different mechanical properties in comparison to base material. Theoretical and experimental analysis of mechanical behaviour of welded joint is still one of the fundamental industrial problems [10]. In the welding process using a

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laser beam a high welding speeds are obtained with a good quality of welds and a narrow thermal influence zone which is helpful in increasing the quality and mechanical properties of the joint as well as the production efficiency [11]. One of the modern welding technologies (recently under particular investigation) is laser-arc hybrid welding, which combines laser beam welding with classical electric arc welding cooperating in a single process. This method has many advantages in comparison to welding process with electric arc or laser beam heat sources used separately [12]. Advantages of laser-arc hybrid welding process include higher welding stability, higher melting efficiency, easier input of additional material to the welding pool and a lower input power under the same welding penetration. The investigations about laser-arc hybrid welded steel have been reported widely and applied successfully in a wide range of the industry. These studies include analytical and numerical modeling of thermomechanical phenomena occurring in the process [13-16] and experimental research on plasma formation, liquid material flow through the welding pool, microstructure composition as well as the analysis of welding deformations and mechanical properties of welded joints, performed in both destructive and nondestructive tests [17-19].

One of usually performed tests on welded joints is the classical tension test. The standard for this type of testing is the norm PN-EN ISO 6892-1. This test allows the determination of basic mechanical properties of welded joints. However, the development in new measurement systems, such as 3D multicamera correlation system allows the analysis of deformations at the surface area of tensed sample in control area determined for cameras used in the experiment. The knowledge about strain distribution in the joint combined with the analysis of the microstructure of welded joint is essential in determining the material properties in separate joint zones, like the weld, HAZ and transition zone. Moreover, the results of such studies are an excellent base for verification of developed theoretical models.

Considering above facts, the main objective of this study are experimental studies on strain during tension of samples welded by laser-arc hybrid technology using GMAW method and Yb:YAG laser beam. Dantec Q-400 Istra multi-camera 3D correlation system is used to measure the distribution of strains during performed tests made on the base material (S355 steel) and welded joint. Presented results include tension diagrams as well as a comparison of strain fields measured for the entire tension cycle.

2. Experimental set-up

2.1. Hybrid welding

Laser beam emitted by D70 Trumpf laser head with maximum power up to 12 kW is used with electric arc in GMAW method (Fig. 1). Laser head is equipped with collimator lens having a focal length f_c=200 mm, and a focusing lens with a focal length f=400 mm. The diameter of the beam is set by changing the optical fiber supplying the laser beam to the head. Optical fiber is used in the research having a diameter 0.4mm *dLLK*. For used optical system double magnification is achieved giving laser focus diameter d=0.8 mm. Samples are welded in the system with leading laser beam in the tandem as well as in inversed system with leading arc. Laser beam power is set to Q=3 kW, arc voltage U=19V and current I=190A in the welding experiment.

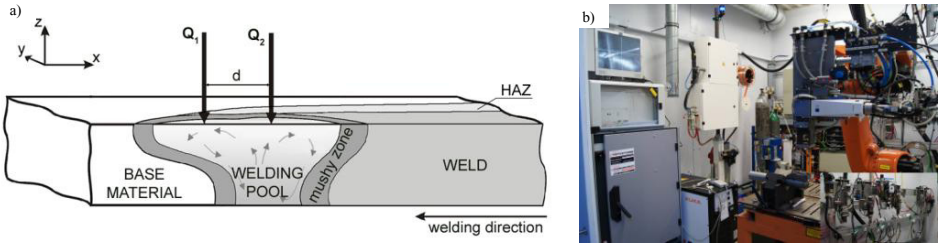

Fig. 1. Hybrid welding process: a) scheme of considered system, b) robotic laser welding station TruDisk 12002.