TOW TRUCK FRAME MADE OF HIGH STRENGTH STEEL UNDER CYCLIC LOADING

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1. Introduction

Modern materials of high strength are employed for new critical working conditions that are often taking place in many exploited devices and constructions. Among such materials the Strenx Steel plays an important role [1]. The Strenx Steel is recommended for production of special trucks frames. It is manufactured using hot-rolled process. The main advantages of the steel are high elastic limit and ultimate tensile strength usually equal to: 688 MPa and 810 MPa, respectively, Fig. 1.

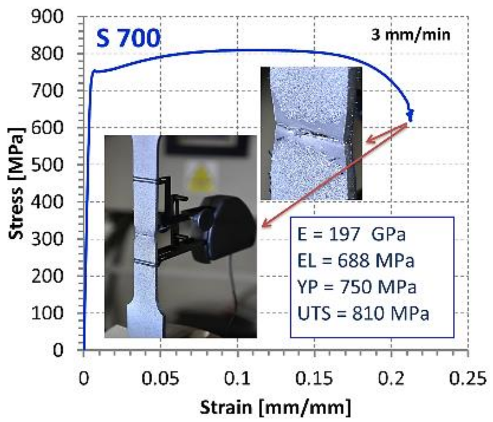


Fig. 1. Tensile curve of the S700 MC steel.

The S700 MC steel can be characterised by the attractive mechanical parameters. A good welding properties are of particular importance. For this type of steel the hardness in the heat affected zone (HAZ) should be lower than that for the parent material, Fig. 2. An importance of HAZ is related to the dominant crack appearance, i.e. the multi-axial stress state components appear in the HAZ, and as a consequence, prevent further crack propagation. Therefore, failure does not take place in the HAZ, but in the parent material or weld [2].

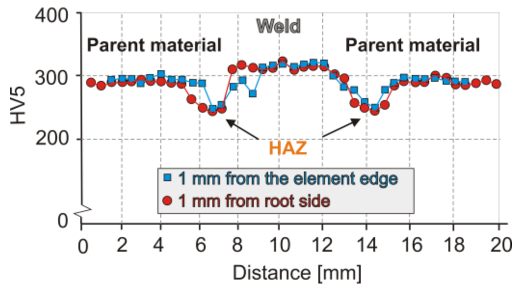
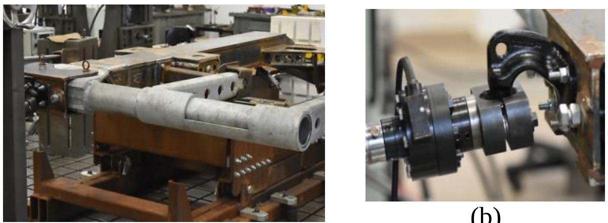


Fig. 2. Vickers hardness disribution for the S700 MC steel after welding, plate thickness 6 mm [2].

The aim of the paper was to examine durability of the special tow truck frame, containing welded joints, (Fig. 3) subjected to cyclic loading.

2. Experimental procedure

All tests were carried out on testing stand equipped with servo-motors, digital controller, anti-vibration platform (9 m×3 m) and coupling grip. A force signal in the form of sinusoid was used to control a piston movement. The tested component was placed on the anti-vibration platform. The loading process was executed by means of the spherical grip connecting the piston to the ball of the coupling device A50-X, Fig. 3a, b.



(a) (b)

Fig. 3. The 3D anti-vibration platform: (a) general view; (b) connection of the servo-motor and coupling device.

The 3D object (3.5 m×2 m×1.5 m), recommended for pulling of damaged vehicles (trucks, lories or cars) due to road accidents was tested. It was mounted to the anti-vibration platform using chassis frame of tow truck by means of screws and clevises, Fig. 3a. Elements of the frame made of the high strength steel (S700 MC) were connected using welding technology.

Parameters of the testing procedure were established on the basis of the 55 Regulation EKG ONZ: amplitude of the force signal - ±18.6 kN, frequency - 4Hz, and limit number of cycles - 2×10^6. A slope of the acting force with respect to the horizontal platform was equal to 15^0. The frame behaviour was evaluated on the basis of force and displacement variations versus time. Also an optical system was applied for damage development inspections.

3. Results

The experiment was carried out up to the frame fracture that has taken place after 573 000 cycles. The crack developed along two paths in the upper and lower parts of the arm. The fatigue fringes were well evidenced at the edge of arm close to the HAZ, Figs. 4, 5.

(a) (b)

Fig. 4. Visualization of the crack in the frame‘s arm (a) general view; (b) magnified view of the upper part.

(a) (b)

Fig. 5. Visualization of the crack in the upper beam: (a) bottom view; (b) fatigue fringes.

On the fracture plane the hardness of the parent material was equal to 285 MPa. It was larger of around 40 MPa than that in the weld section measured. It should be taken into account, that the soft zone was not identified, Fig. 6. Microstructural analysis of the HAZ showed a higher content of sintered carbides in comparison to the parent material. It also revealed their irregular distribution, Fig. 7.

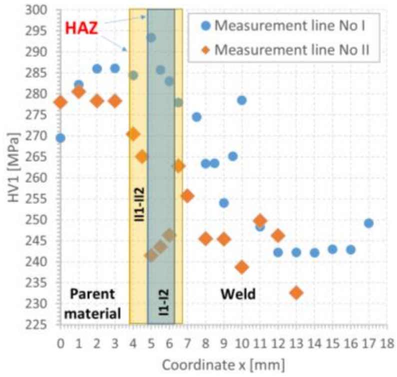


Fig. 6. HV distribution in the fracture plane.

(a)

(b)

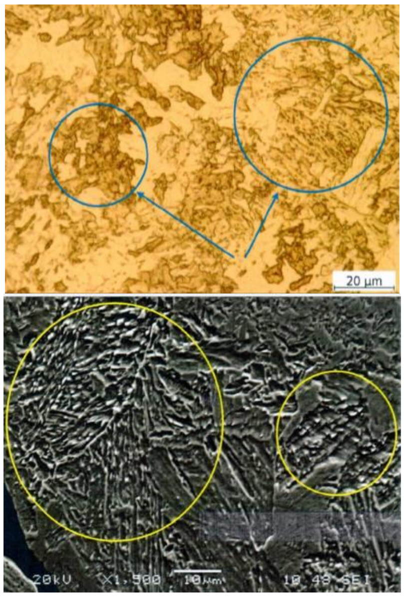


Fig. 7. The HAZ from microscopic observation: (a) LM 500×; (b) SEM 1500×

4. Summary

Welding of the high strength steel requires more advanced technology than the process for typical steels. The soft zones mainly located in HAZ are important features of the welded region. If the soft zone areas have not an adequate mechanical parameters associated with the microstructure, then the fatigue cracks may develop in HAZ.

References

[1] Strenx 700 MC Advanced High Strength steel, SSAB, 2 pages.

[2] Welding of Strenx Advanced High Strength steels, SSAB, 16 pages.