FATIGUE OF THE HIGH STRENGTH STEEL AND ITS WELD

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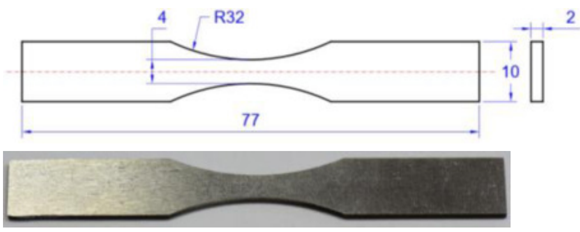
1. General

Despite of the fact that modern materials possess attractive mechanical parameters they are still requiring additional testing especially under cyclic loading in order to get better characterisation of their fatigue phenomenon. This is extremely important from exploitation point of view. Fatigue examinations are conducted by means of specimens of various shapes and dimensions. Their selection depends on technical details of a test, volume of the materials tested and dimensions of the objects in question. Usually, two control signals are applied: stress or strain. A type of control signal depends on the parameters of future exploitation or diagnostic methodology. For example, if strain are taken to assess a state of the structure, then test should be stress controlled.

An importance of the fatigue process for exploitation is still treated as the crucial point [1]. Particularly the fractography and microscopic analysis provides evidence in this matter. Thanks to data from such tests typical features of fatigue zones can be captured, and as a consequence, essential reasons of damage evolution can be indicated. It has to be emphasised that our current knowledge on fatigue features is still limited, particularly for new materials or materials introducing in new structures. Therefore, the aim of this paper focuses on examination of the S700MC steel behaviour and its weld under cyclic loading at various fatigue stages up to fracture.

2. Specimens, material, testing

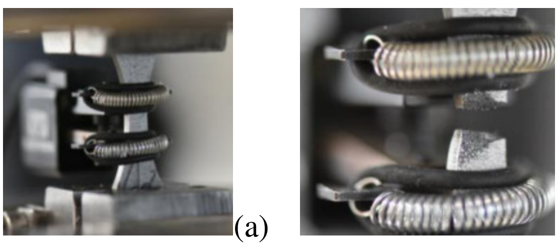
All tests were conducted using 8874 Instron servohydraulic testing machine at room temperature. The geometry of specimens (Fig. 1) was designed according to the requirements of the ASTM standards: E468-90 "Standard Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials". The axial strain was measured using the 2620-603 Instron extensometer on the gauge length of 10 mm, Fig. 2. Stress signals in the form of the sinusoidal function having the amplitude values from 900 to 300 MPa and frequency of 10 Hz at R = 0 were used.



(a)

(b)

Fig. 1. The specimen dimensions (a) and shape after manufacturing (b)



(a) (b)

Fig. 2. The specimen with extensometer (a) and after test (b), respectively

Thin sheets of the S700MC steel were chosen for the tests. The specimens made of parent material and laser welded were selected from the perpendicular direction with respect to rolling. Mechanical parameters of the S700MC were: E = 2.2 GPa, σ_h = 453 MPa, $\sigma_{0.2}$ = 735 MPa, σ_m = 778 MPa. In the case of the weld the proportional limit, yield point and ultimate tensile strength had higher values, i.e.: $\sigma_h = 583$ MPa, $\sigma_{0.2} = 805$ MPa, $\sigma_m = 865$ MPa, respectively. The parent material and weld subjected to cyclic loading were analysed on the basis of variations of the axial strain versus cycle number up to fracture. The relationship between the axial stress and strain was also taken into an account. Finally, the limited fatigue life and fatigue limit of the parent and welded material were determined.

3. Results

The parent material and weld exhibited the ratcheting effect, Figs. 3a, 4a. Before the fracture variations of the mean strain at constant stress amplitude were identified, Fig. 3b. In the case of the cycles close to fracture (Figs. 3c, 4b) the parent material reached larger strain values than the weld, expressing brittle-plastic fracture Figs. 3c, 4b. An influence of the weld on fatigue durability was expressed by fatigue limit variations, particularly for lower stress amplitudes, Fig. 5.

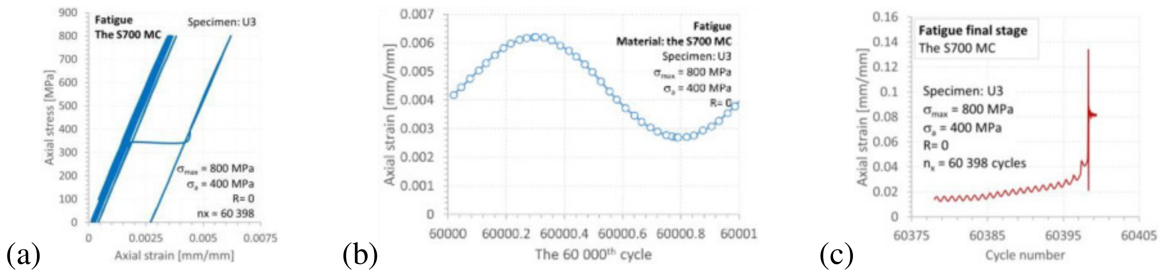
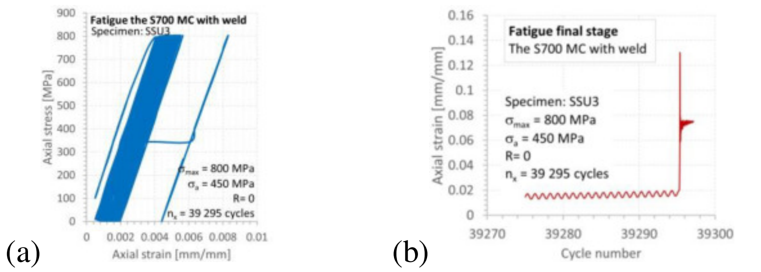


Fig. 3. Stress versus strain (a); strain at the cycles before (b) and during fracture (c)



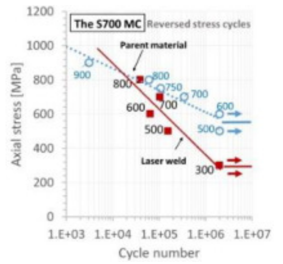


Fig. 4. Stress versus strain (a); $\sigma = f(N)$ (b)

Fig. 5. The Wöhler diagram of the S700MC and its laser weld

4. Summary

The S700MC steel is very sensitive on the welding processes. In comparison to the result obtained for the parent material the fatigue limit of the welded material was reduced even by a factor of 2 for the lowest stress amplitudes taken into account.

5. Acknowledgment

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6. References

[1] *Fatigue and Fracture of Engineering Materials*, Willey, Editors: Y. Hong, R.W. Neu, M. Endo, 42, 9, 2019, 1845-2203.

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