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ANISOTROPIC FEATURES OF WELDING JOINTS MADE OF HIGH-STRENGTH STEEL

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1. Introduction

High-strength steel belongs to the group of modern structural materials. This is due to excellent values of mechanical parameters such as the yield point (min. 600 MPa) and ultimate tensile strength (min. 1300 MPa), [1], [2] as well as ductility (min. 15%) [1]. As a consequence, it can be often used as a replacement of the conventional structural materials representing less favourable properties, and thus, enabling significant reduction of the components thickness. From the practical point of view, it means their mass reduction even by a factor of 50% [3], [4]. The S700MC steel produced by SSAB is a typical example of that material group, and therefore, it is recommended to various applications in different branches of industry, especially in the case of welding joints. Taking into account the high quality that must be obtained during the welding process, many important aspects should be fixed, like a cooling intervals time ($t_{8/5}$) for the heat affected zone (HAZ) of the welding joint. It should be evaluated within the temperature range from 800°C to 500°C. In the case of S700MC steel, it takes a value in the range from 5 to 25 seconds. A value of this parameter depends on the steel grade. For the S1300MC steel it is equal to 15 seconds. Applying the optimal cooling intervals time, a higher values of mechanical properties can obtained. Such approach is strongly recommended for different welding processes, i.e.: MAG (Metal Active Gas), MMA (Manual Metal Arc), TIG (Tungsten Inner Gas) as well as SAW (Submerged Arc Welding) (SSAB). Among many important issues of mechanical parameters quality of the welding joint materials one can indicate their anisotropic character of either the parent material or weld. A number of the research works in such contest has not been carried out very often as yet. Therefore, in order to fill this gap the S700MC steel was selected as the object of tests.

2. Details of experiment

The S700MC high-strength steel in the form of plate (thickness = 10 mm) with weld was selected for testing, Fig. 1. It is often used for components of the heavy trucks. The welding joint was manufactured by the TEVOR Sp. z o.o. (Poland) at the following parameters: 175 A and 20 V during re-melting, 178 A and 24 V during the joint filling under pulsation of 5.6 – 8.2 m/min, Figs. 1, 2.

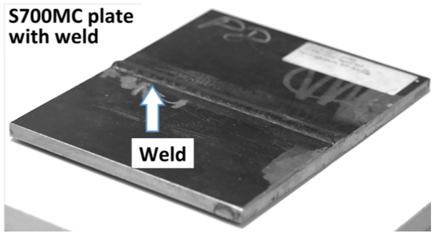

Fig. 1. S700MC high-strength steel plate with weld.

Specimens for the tests were arranged longitudinally and transversally with respect to the weld position. Specimens for the weld testing were cut directly from the welding joint area. Specimens located in parallel to this area were used to test the material of HAZ. All specimens containing the weld area were mechanically processed by removing the face and root, Fig. 3.

(a) face

(b) root

Fig. 2. Weld of the S700MC high-strength.

During tests the specimens were directly mounted in grips of the 8874 Instron servo-hydraulic testing machine. Measurements of the axial strain were captured by means of the uni-axial 2620-601 Instron extensometer of the gauge length and strain capacity equal to 12.5 mm and ± 5 mm, respectively, Fig. 4. All tests were carried out at room temperature under displacement velocity equal to 1mm/min.

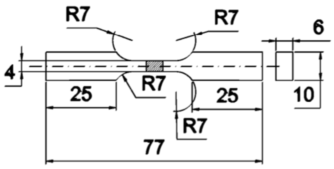

Fig. 3. Mini-specimen for tensile tests.

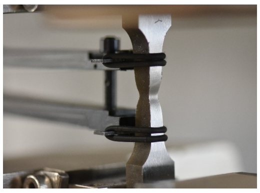

Fig. 4. Mini-specimen of the parent material during tensile test close to fracture.

3. Results

Data collected during tensile tests of the parent material selected from both perpendicular directions taken into account, exhibited similar character up to the fracture, Fig. 5, thus reflecting a lack of anisotropic features of mechanical parameters considered.

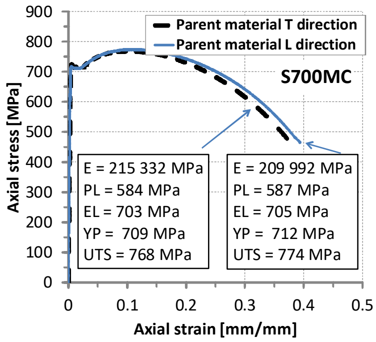

Fig. 5. Tensile characteristics of parent material in both directions, i.e. longitudinal (L) and Transversal (T), E – Young's modulus, PL – proportional limit, EL – elastic limit, YP – yield point, UTS – ultimate tensile strength.

An opposite effect was observed from the results comparison concerning the parent material and weld, Fig. 6. In the case of weld material the physical yield point disappeared. For the transversal direction with respect to the weld position, besides mechanical parameters reduction, the tensile curve is located much lower than that for the parent material specimen of the same orientation. Also a 50% reduction of elongation can be clearly observed, Fig. 6. The results of the HAZ and weld are presented in Fig. 7. One can easily notice, that behaviour of the weld material depends strongly on the specimen orientation. In the case of the same direction of specimen cut the tensile curves are almost the same for the HAZ and weld material. If directions of the specimens representing HAZ and weld materials are perpendicular, than the tensile curves take completely different shape, thus identifying anisotropic character of the mechanical properties of the welding joint material.

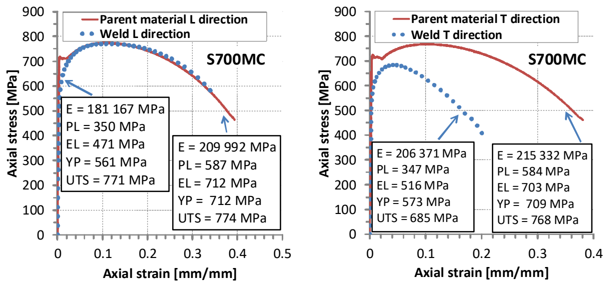

Fig. 6. Tensile characteristics of the parent material and its weld.

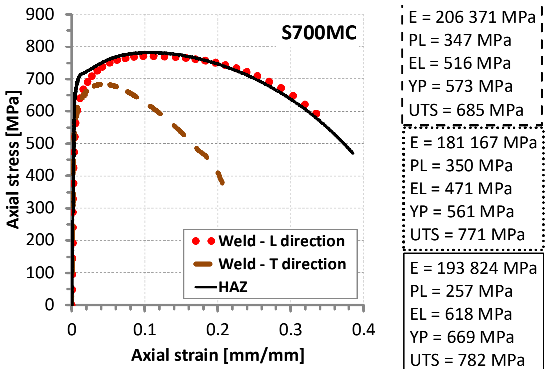

Fig. 7. Tensile characteristics of the weld and HAZ.

4. Conclusions

The results of tensile tests on specimens selected from different directions of the welding joint enable to assess its quality, and more importantly, to indicate anisotropic character of its zones representing parent material, HAZ and weld.

References

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