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WELDED JOINT TENSILE STRENGTH TESTING OF NEW AND USED MATERIAL

Bahrudin Hrnjica, Fadil Islamović, Dženana Gačo
University in Bihac – Faculty of Technical Engineering Bihac
dr. I. Ljubijankica bb, 77000 Bihac
Bosnia and Herzegovina

Zijah Burzić
Military Technical Institute
ul. R. Resanovića 1, 11000 Belgrade
Serbia

ABSTRACT

The repair process of welded steel construction (tank) requires a number of demanding tests that have to determine whether welded joints fulfill all of the required standards. This paper examines testing of butt welded joint constructed of 40 years old exploited material, as well as unused material of the identical composition. Testing procedure involved a number of prerequisite procedures, prior to tensile strength testing itself. Beside the selection of the adequate welding technology, extraction of old steel plates from the tank had to be carried out, and welded to the new material. Initially we prepared the old material for welding, conducted welding procedure, examined the weld using microscopic and macroscopic tests, cut out the samples and tested them for tensile strength. Beside the test results, this paper also covers welding technology used in the process of welding new material with the one that has been exploited for over 40 years.

Keywords: Tensile Strength, Tank, Welded Joint, Welding

1. PREPARATION AND JOINING OF THE PLATES

Repair of the existing steel structures is a very demanding job, and one in a series of such operations is a welding process of new material to the exploited material located on the structure. The paper presents the results of tensile testing during the repair of the large volume tank. In the process of preparations actions were conducted in several directions, such as procurement of new steel plates that need to match the characteristics of the exploited steel on the tank construction, cutting of plates off the existing tank, and procurement of electrodes for welding process. Namely, the entire tank structure is made of steel S235, which conditioned the procurement of new plates which should be of the same type of steel. Procurement of the exploited material was conducted from one of the vertical cylindrical tanks at the terminal in Bihac. The plates were cut to predetermined length in accordance with the plan of the experiment. After the base material was delivered, the first step was to join the plates of old and new steel. The process required a strict criteria and conditions for the process of joining, since these were welded joints of high-level security. Figure 1 shows the position and method of plate processing and the welding process, as well as the weld shape. Upon the completion of the welding process, through series of control activities a certificate has been issued for welded joints, thus enabling further experiment activities. Cutting of test tubes was conducted in a way to optimally use the surface, so that plate rejects be as small as possible, in order to minimize the costs of the experiment. After the test tubes were prepared, the radiographic testing of welded joints was started, followed by the Institute plan and testing implementation.

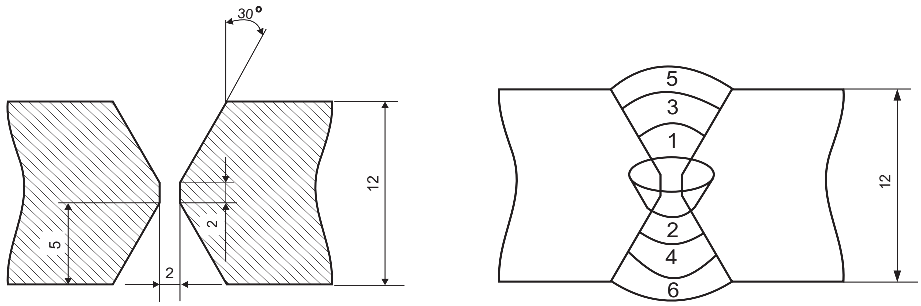


Figure 1. Position and processing of the plates (left), scheme of the welded joint (right)

Preparation of the plate surfaces that are welded consists of bordering the upper and lower side of the plate at an angle of 30◦, while the vertical flat part is 2 mm. The plates are set closer to about 2 mm from each other. The application of the additional material (welding process) is done in phases evenly on both sides, in order to achieve the minimum effect of residual stresses on the structure.
Welding technology, selected for the implementation of this experimental research is REL procedure with EVB 50 electrode with preheating [1]. This procedure has proven to be the best welding technology in experimental research and testing of welded joints. When connecting plates are prepared, prior to welding process they are heated to the temperature of 50 ◦ C, for the purpose of reaching initial temperature of the operating material higher than the surrounding temperature, but also to increase the overall quality of the welded joint. The following tables show the mechanical (Table 1) and chemical (Table 2) properties of the base material (new and exploited), and the additional material used in the process of connecting steel plates.

Table 1. Mechanical properties of new (OM-N), exploited (OM-S) and additional material (EVB 50) in the welding process

Sample	Yield Stress $\sigma_{p0,2}$ [MPa]	Tensile Strength $\sigma_{p0,2}$ [MPa]	Strain A [%]	Impact Energy E_v [J]
OM-S	239	385	25,0	min. 27
OM-N	247	398	24,0	min. 27
EVB 50	450	500-550	26-30	min. 50

Table 2. Chemical properties of new (OM-N), exploited (OM-S) and additional material (EVB 50) in the welding process

Sample	% mas.					
	C	Si	Mn	P	S	N
OM – S	0,17	0,32	0,94	0,052	0,049	0,011
OM – N	0,16	0,23	1,12	0,028	0,021	0,009
EVB 50	0,08	0,63	0,11	0,012	0,014	0,017

The composition of the additional material of the EVB 50 electrode was selected based on previous research, where it was shown to be the best technology in the welding process [1, 2].

2. MACROSCOPIC AND MICROSCOPIC EXAMINATION OF THE WELDED JOINT

Macroscopic and microscopic examinations are the methods of metallographic examination, and are conducted with the purpose to determine the elementary structure of the tested material. As in this concrete case it is welded joint examination that is being considered, these tests enable the determination of the quality of the conducted welded joint in terms of defined eligibility criteria contained in the standard EN 288-3. This examination, in addition to the quality assessment of the applied welding technology, is also determining the boundaries of the individual structures of the welded joint. Macroscopic and microscopic examinations were conducted on both sides of the welded joint, on both, old and new material. By visual and radiographic examination welded samples were characterized as acceptable.

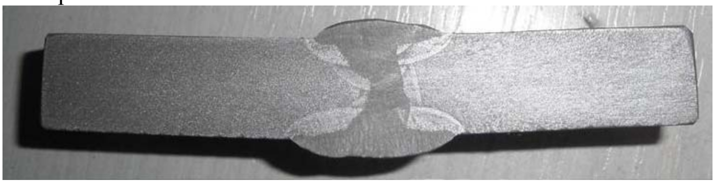
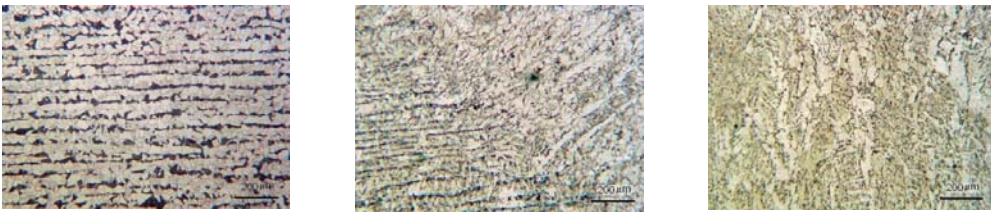


Figure 2. Macroscopic view of the welded joint

The above Figure 2 clearly shows the parts of the welded joint: base metal-BM, heat affected zone-HAZ and weld metal-WM, within which groove fill zone is expressed. Macrostructure of the examined samples of welded joints in the upper Figure indicates that the welding procedure and selected welding technology have been satisfied completely and that the review of the macrostructure is satisfactory [3].



a) BM *b) HAZ* *c) WM*

Figure 3. Microscopic display of the welded joint elements

Micro images in Figure 3 show that the base material of steel S235 JR has an equal ferrite-pearlite structure. Ferrite has the shape of polygonal crystals, while pearlite resembles a compact dark micro constituent. HAZ and WM also have expressed ferrite-pearlite structure, which is shown in the above Figure under b) or under c), respectively.

3. TENSILE TESTING

Standard EN 895 Part I – Butt welded joints in metal materials – Transverse tensile test stipulates the tensile testing of welded joint of new and exploited steel S235 JR at room temperature, including the shape and dimensions of the test tubes, as well as the testing procedure. Test tubes that were cut and used for tensile testing are shown in Figure 4. Table 3 shows the results of tensile testing of welded joint of old and new material [3].

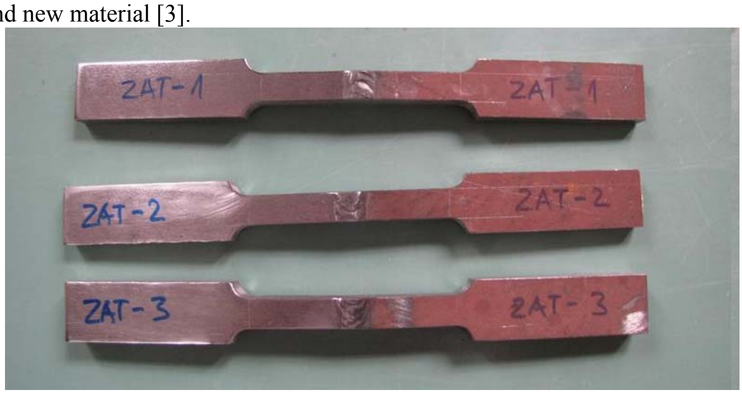


Figure 4. Tensile testing test tubes

Tensile testing of welded joint test was conducted at room temperature, with accuracy of ± 0.001 mm. Number of tested test tubes was three. The results showed consistency of measurements and that measured sizes were approximately the same in each observed test tube.

Table 3. Results of the welded joint examination

Sample	Yield stress $\sigma_{p0,2}$ [MPa]	Tensile Strength $\sigma_{p0,2}$ [MPa]	Strain A [%]	Fracture location
ZAT – 1	272	369	28,7	OM-S
ZAT – 2	273	366	26,8	OM-S
ZAT – 3	275	377	28,8	OM-S

Tension curve obtained on the test machine is shown in Figure 5 [3].

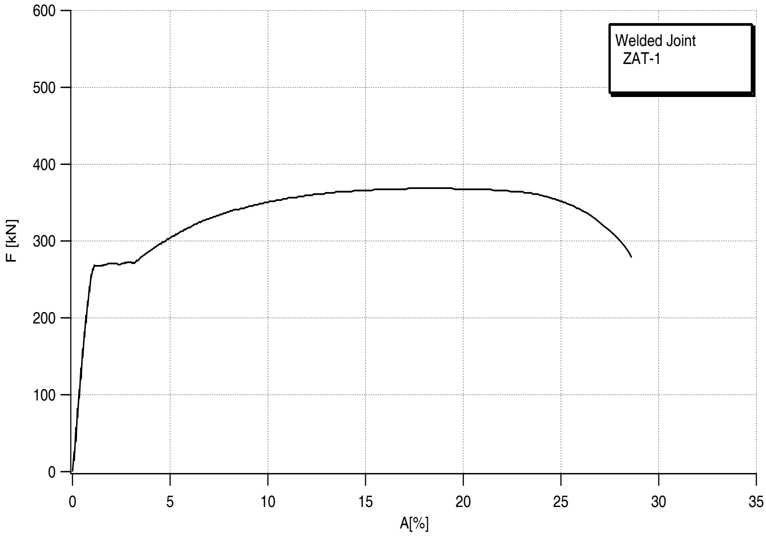


Figure 5. Tension curve

4. CONCLUSION

Testing has shown that the obtained results are within the limits prescribed by the standards for a given material. The very nature of the curves corresponds to the ductile material with approximate values of participation of homogeneous and inhomogeneous strain. The loss of occurrence of the phenomenon of the upper and lower yield strength of welded joint test tubes is a consequence of strain of three different materials. Considering the fact that welded joint consists of weld metal WM, heat affected zone HAZ and parts of base metals BM-S and BM-N, each constituent phase represents a different material, which due to approximately similar elasticity modules strain in the same manner.

5. REFERENCES

[1] Islamovic F.: Doctoral dissertation, Faculty of Mechanical Engineering, Tuzla, 2006.
[2] Gaco Dz.: Doctoral dissertation, Faculty of Mechanical Engineering, Belgrade, 2007.
[3] Hrnjica B.: Master’s thesis, Faculty of Technical Engineeering, Bihac, 2012.