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REPAIR WELDING OF PRESSURE EQUIPMENT WITH UNACCEPTABLE DEFECTS

REPARATURA ZAVARIVANJEM NA OPREMI POD PRITISKOM SA NEPRIHVATLJIVIM GREŠKAMA

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- NIOVAL 50
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Ključne reči
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- NIOVAL 50
- zavareni spojevi
- reparatura zavarivanjem
- defekt

Abstract

The paper describes non-destructive testing and the repair welding technology for eliminating defects in the pressure equipment of RHE BB (Bajina Bašta) (located in Serbia). The obtained results had justified the proposed technology.

Izvod

U radu je opisana tehnologija ispitivanja bez razaranja i sanacije zavarivanja defekata na opremi pod pritiskom u RHE BB (Bajina Bašta). Dobijeni rezultati su opravdali predloženu tehnologiju.

INTRODUCTION

The maintenance and repair of pressure equipment to meet basic customer requirements involves a range of activities, starting from project phase to exploitation of equipment until reaching a prescribed or expected service life, while at the same time taking into account all aspects: the structure, materials selection, quality of performance, manufacture and testing, operating conditions and monitoring and maintenance of equipment. The user requests that equipment is functioning reliably and maintains integrity during the expected life. In the case of damage as a result of load and working conditions, the performed repair welding and quality maintenance need to be assessed for their impact on integrity and service life. Today, these repairs are very accurate, thanks to modern non-destructive testing devices and precise determination of defects size and position, /1-4/.

Today, the repair welding of pressure equipment is performed to according to relative standards, as it is known that pressure equipment integrity is a very responsible job.

The paper explains a detailed repair welding of a pressure vessel made of NIOVAL 50 in the presence of defects detected by non-destructive testing (NDT), mainly by ultrasonic testing (UT).

PRESSURE VESSELS IN RHE BB

A pressure vessel from the reversible hydropower plant Bajina Bašta is shown in Fig. 1. It was subjected to NDT inspections which are further described.

Figure 1. The pressure vessel 977 at RHE BB.

INSPECTION OF PRESSURE VESSEL 977

Inspection and testing of the pressure vessel, shown in Fig. 1, was performed by NDT methods that have a wide application in all areas of industry, and not only for pressure equipment. Here, visual testing and magnetic particle testing was also applied. These two NDT methods were applied to investigate the presence of surface and subsurface defects. For internal defects, the ultrasonic method was applied. Generally, it is known that ultrasonic testing is mostly used in the testing of pressure equipment, which in this case has proved to be the most reliable technique for detecting defects.

It should be noted that the basic material for inspected vessels is microalloyed steel NIOVAL 50, /1-3/. The vessel 977 pressure (Fig. 1) is p = 78 bar. Geometry of the vessel is: thickness t = 42 mm with mean diameter D = 1958 mm. The vessel 977 was inspected with 100 % ultrasonic testing on two vertical welded joints, and on three circular welded joints.

After the final UT testing of the vessel 977, defects marked 1.6 and 2.5 are found with the following geometry and location:

- defect 1.6: length 20 mm and width/depth 15 mm in the central circular seam, from 27 to 42 mm,
- defect 2.5: length 170 mm and width/depth 14 mm in the central circular seam, from 28 to 42 mm.

The position and size of defects 1.6 and 2.5 are shown in Figs. 2 and 3. Analysis of the effect of these defects on the structural integrity is given in /1/. This problem and its approach have been analysed recently in a number of papers, /5-11/.

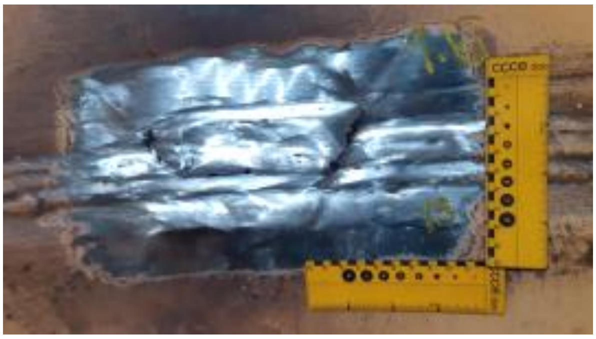

Figure 2. Position and size of defect 1.6 in vessel 977.

Figure 3. Position and size of defect 2.5 in vessel 977.

REPAIR WELDING

The cause for defects often cannot be determined, but they certainly need to be eliminated in some way, typically by repair welding. However, the reparation process itself requires a lot of experience and knowledge of the material in order to be performed properly and not to impair the structural integrity. Prior to repair welding, the workspace must be prepared first, both for safety and technology, as shown in Fig. 4.

Figure 4. Working environment before repair welding.

We start the repair by digging out defects 1.6 and 2.5 and creating grooves for welding. Welding grooves for defects 1.6 and 2.5 are shown in Figs. 5 and 6.

Figure 5. Welding groove after the removal of defect 1.6.

Figure 6. Welding groove after the removal of defect 2.5.

When selecting an electrode, the tendency is that the electrode usually has approximately the same chemical composition as the base material. It must also have appropriate mechanical properties in relation to the base material and service conditions. The use of electrodes that release a lot of hydrogen during welding, such as cellulose coated, acid and rutile coated electrodes, can cause cracks. For this reason, only basic electrodes with low hydrogen content are used for welding NIOVAL 50 steels, such as EVB 65 - the basic electrode manufactured by 'Jesenice', of diameters 2.5 and 3.25 mm.

Electrodes are dried at 300-350 °C for approx. 2 hours. Before the start of welding, the base material is preheated to a temperature of 200 °C. Preheating is performed with a gas flame on the outside surface of the vessel, Fig. 7, using equipment shown in Fig. 8. During preheating, the temperature is measured from the inside with a contact thermometer shown in Fig. 9. Prior to the welding itself, performed by the device in Fig. 10, the welder created a pair of test passes as shown in Fig. 11.


Figure 7. The preheating procedure.


Figure 8. Preheating equipment.


Figure 9. The contact thermometer.


Figure 10. Welding device.


Figure 11. Welded test passes.

After creating the groove, the preheating procedure and the welded test passes, the welding process is carried out according to defined procedure (WPS), using the shielded manual arc welding (SMAW) technique. Figures 12 and 13 show the weld repaired inner and outer zone of the vessel.

Figure 12. The inner surface after the repair - vessel 977.

Figure 13. The outer surface after the repair - vessel 977.

After a successful welding process, an NDT re-inspection has followed, including visual, magnetic particle and ultrasonic testing, as already described according to appropriate standards. All this is performed to ensure the defects are successfully repaired. It should be noted that UT testing is performed after the welding process and after a vessel pre-test in working conditions.

During the welding process, the welder removed the slag after each pass and measured the intermediate temperature with a contact thermometer. The intermediate temperature was maintained at 180 °C throughout the process, Fig. 14.

Figure 14. Interpass temperature measurement.

Upon the completion of welding, heating took place at a temperature of about 180 °C for 1 h. Reheating is performed on the outside of the vessel, using the apparatus for preheating. The temperature was controlled by a contact thermometer on the inside of the vessel near the welded joint. After reheating, the welded joint is protected from drafts and immersed in asbestos cloth to slow down the cooling as much as possible, as shown in Figs. 15 and 16.

Figure 15. Asbestos cloth on the inner side of vessel.

Figure 16. Asbestos cloth on the outer side of the vessel.

NDT INSPECTION AFTER REPAIR

As already mentioned, inspection is performed by magnetic, visual and ultrasonic methods before and after the repair welding. Only some details of the NDT inspection of vessel 977 after repair are presented here. Figures 17-20 show details of the NDT tests of vessel 977 at defect zones 1.6 and 2.5. It should be noted that after the repair welding, NDT has shown that defects 1.6 and 2.5 were successfully removed.

Figure 17. Defect zone 1.6.

Figure 18. Ultrasonic inspection of vessel 977 - defect 1.6.

Figure 18. Magnetic particle tests on the outside wall of vessel after the repair welding of defect 2.5.

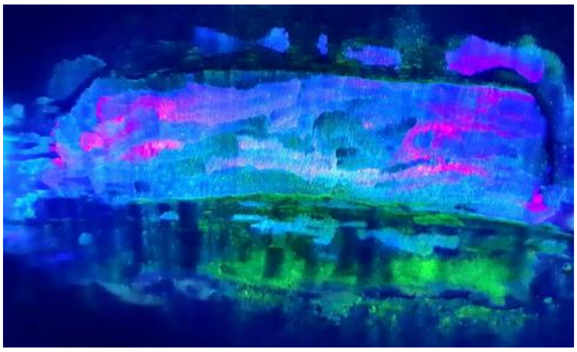

Figure 19. Magnetic particle tests on the inside wall of the vessel after repair welding of defect 2.5.

CONCLUSIONS

Defects 1.6 and 2.5 in vessel 977 have been successfully removed by repair welding, which was verified by NDT inspection after the weld repair process.

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