Dissimilar Welding Of New High Oxidation Material - THOR 115 With Grade 92

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Abstract

The current development of power industry steels for supercritical boiler components is creating new welding challenges. The use of new combinations of alloying elements to achieve improved mechanical properties, including creep resistance, has an impact on the weldability of joined materials. Each joint must undergo numerous tests, before technologies can be developed to enable the fabrication and installation in boiler plants. Martensitic steels with 9% Cr content intended for steam superheaters are characterised by good creep strength and low resistance to oxidation at temperatures above 600°C. In contrast, steels with 12% Cr content are characterized by much better oxidation resistance, but their strength at elevated temperatures decreases. In this work, it was decided to make dissimilar welded joints made of new generation THOR 115 martensitic steel with Grade 92 steel. The joints were made using two different welding consumables: W Z CrWMoVNb92 and S Ni 6082.The paper presents the results of tests such as tensile test, hardness measurement, impact test and macro and microscopic metallographic studies.

Keywords:
THOR 115, T/P92, welding, power units, martensitic steel, dissimilar joints

1. Introduction

A continuous trend to simultaneously reduce pollutant emissions to atmosphere and reduce the costs of power units construction is related to increasing the efficiency of power units in conventional power plants. An increase in efficiency can be obtained by increasing temperature and steam pressure. Today, obtaining higher parameters of steam boilers is possible only by applying modern steels and alloys able to bear increased operational loads and ensure high resistance at higher temperatures.

Modern martensitic steels such as X10CrWMoVNb9-2 (Grade 92), make it possible to design power plant systems in which the temperature of superheated steam is 625°C. An increase in steam pressure and temperature has a direct effect on the operational conditions of boiler elements 9% Cr martensitic steels are characterised by high creep resistance and moderate oxidation resistance at high temperature. In the past steel grade X20CrMoV12-1 was introduced to assure higher oxidation resistance but difficult fabrication and average creep properties forced the plants to replace it. Another approach was the VM12-SHC (X12CrCoWMoVNb12-2-2) with very good fabrication and oxidation properties but long term creep resistance was lower than estimated at the beginning. The latest introduction to the 9-12% Cr martensitic steel family is Tenaris High Oxidation Resistance steel named THOR™ 115. In this work, it was decided to make dissimilar welded joints made of new generation THOR 115 martensitic steel with Grade 92 steel. The joints were made using two different welding consumables: W Z CrWMoVNb92 and S Ni 6082.The paper presents the results of tests such as tensile test, hardness measurement, impact test and macro and microscopic metallographic studies. [1-4]

2. Subject of investigation

The subject of the investigations was dissimilar weld (ø50,8 x 9,29 mm) made of THOR™ 115 and Grade 92 steel. The chemical composition of both materials is detailed in Table 1. The tubes were welded with GTAW in 5G uphill position in ZELKOT Koszecin.

Table 1. Chemical composition of examined steel acc. to MTR

Contents of chemical elements, %							
THOR™ 115							
C	Si	Mn	Ni	Cr	Mo	N	V
0,09	0,15	0,47	0,15	10,78	0,51	0,042	0,24
Grade 92							
0,10	0,22	0,48	0,16	8,99	0,46	0,05	0,16

The selection of a filler metal for welding depends on the chemical composition of the base metal and operational conditions of joints. Consumables used in welding processes should ensure the chemical composition and properties of the weld as similar as possible to those of the base metal.

Unfortunately there is no dedicated filler available for welding of dissimilar joints of Thor™ 115 and because of that in our research we have used two different filler metals: Grade 92 and Alloy 82.

After welding, according to the pipe manufacturer's recommendations, the welded joints were subjected to stress relief annealing at a temperature of 760°C for a period of 60 minutes. After the post weld heat treatment (PWHT), non-destructive tests were performed (VT, PT and RT). These tests were carried out taking into account the quality level B according to PN-EN ISO 5817. After obtaining positive NDT test results, joints were sampled for destructive testing. The scope of destructive testing included: tensile test, bending test, impact tests, macro- and microscopic metallographic tests, hardness measurements.

3. Research results

The tensile test of the welded joints were performed to determine the tensile strength (Rm) and to verify the results obtained due to the required minimum Rm value for the parent material (MR), which is 620 MPa for Thor 115 steel (specified by an ASME Code Case 2890 and VdTÜV WB580). The test was carried out in accordance with the requirements of PN-EN 6892-1 and PN-EN ISO 6892-2. The tests were carried out at room temperature. The obtained test results are summarized in Figure 1.

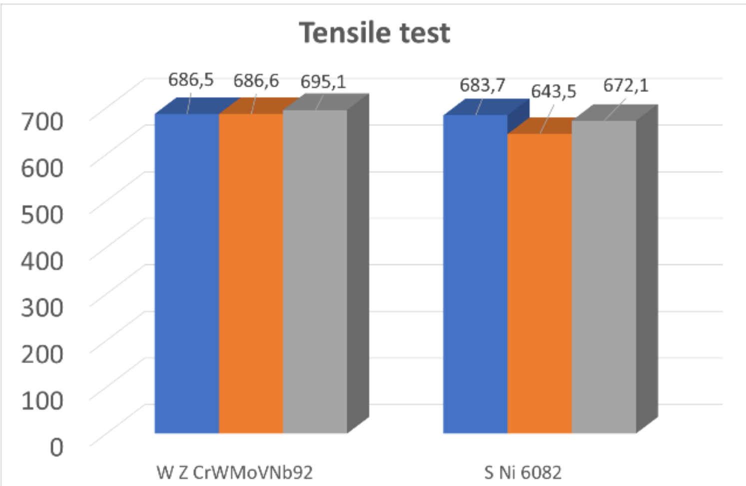


Fig. 1. Tensile strength of THOR®115 and Grade 92 butt welded joints made with different filler metals

Impact test was carried out at ambient temperature +20 ˚C on Charpy V samples, notched in the weld and in the heat affected zone in accordance with the requirements of PN-EN ISO 148-1 and PN-EN ISO 9016. The criterion included in the PN-EN 12952-6 standard specifies the minimum value of the breaking work of samples with a normal cross-section (10×10 mm) in SWC at 24 J at ambient temperature, while the PN-EN 10216-2 standard specifies the minimum value breaking work for MR at level 27 J. The tests were carried out on samples with a reduced cross-section (5×10 mm). The results obtained are summarized in Figure 2.

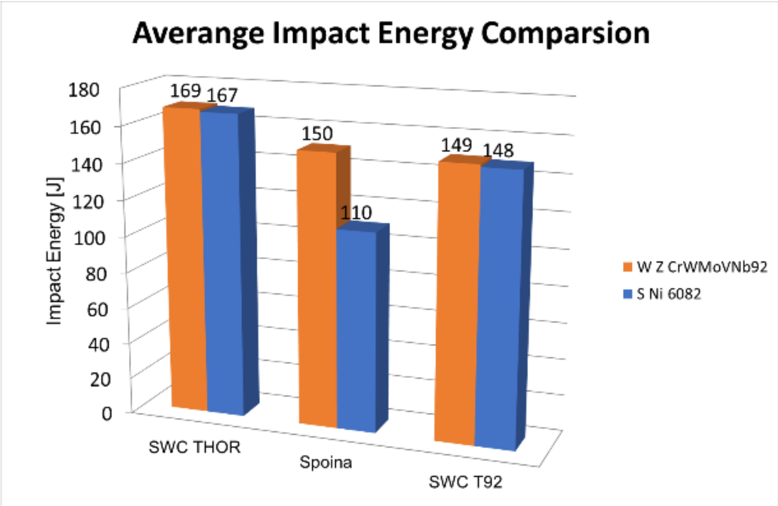


Fig. 2. Impact energy of THOR®115 and Grade 92 butt welded joints butt welded joints made with different filler metals

The bending test were performed in accordance with the requirements of the standards PN-EN ISO 5173. According to the standards, the test criterion is to obtain a bending angle of 180°, without scratches or cracks on the stretched surface of the sample. The results obtained during the tests meet the requirements of the standard.

Hardness measurements were carried out following the requirements of the standards PN-EN ISO 15614-1 and PN-EN 12952-6 PN EN ISO 6507-1 and PN-EN ISO 9015-1. The aforesaid standards define the maximum hardness for martensitic steels at level of 350 HV10. The results of the measurements are presented in figure 3 and 4 .

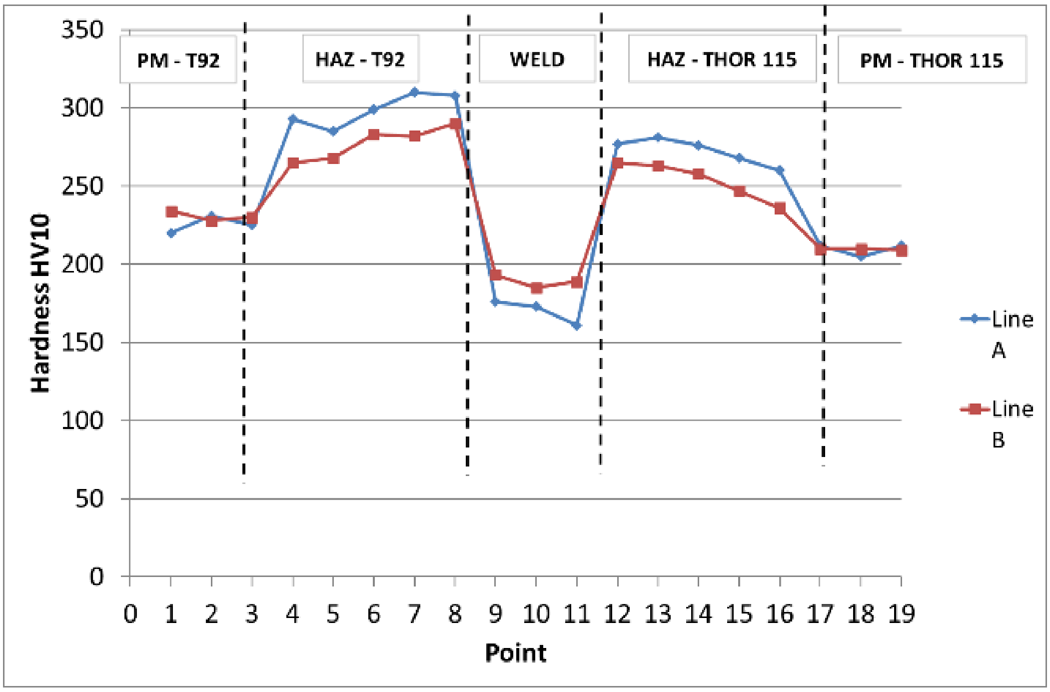


Fig. 3. Results of hardness measurement.
Filler metal: W Z CrWMoVNb92

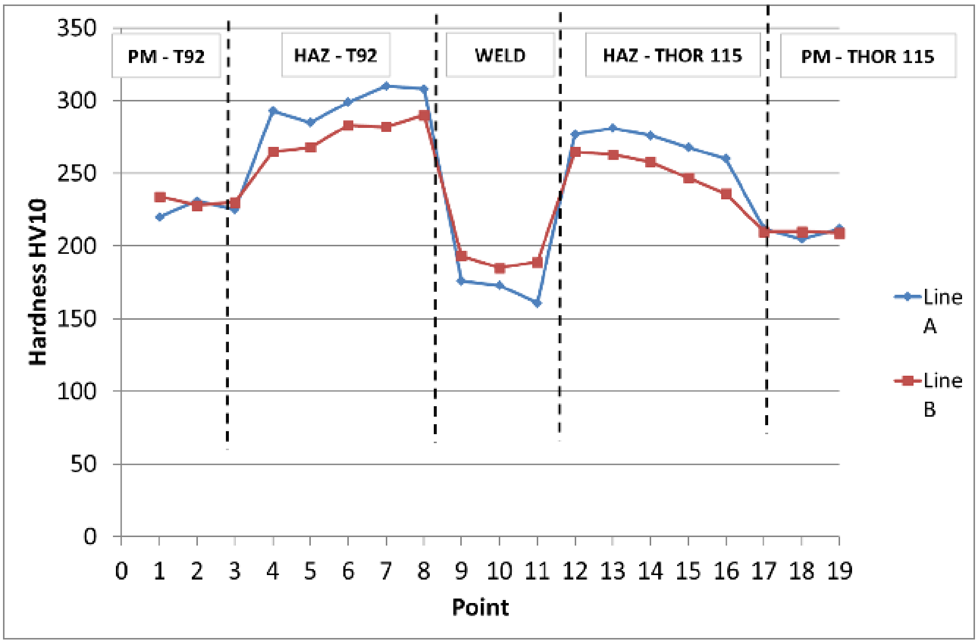


Fig. 4. Results of hardness measurement.
Filler metal: S Ni 6082

Metallographic macroscopic and microscopic tests were carried out following the requirements of the standard PN-EN ISO 17639. A criterion adopted for assessment was the quality level B according to the standard PN-EN ISO 5817. The results of macroscopic tests in the form of a photograph of the macrostructure are shown in figure 5. The results of the microscopic tests did not show any welding imperfections and confirmed the correct microstructure in all zones. The results in the form of photos and descriptions of structures occurring in the characteristic zones are presented in Table 2.

4. Conclusions

On the basis of the aforesaid tests it was possible to come to the following conclusions:

1. Dissimilar welded joints made of Thor™ 115 and Grade 92 steel, welded with GTAW in 5G uphill position are characterised by high quality, which is confirmed by the results of destructive and non-destructive tests.
2. The use of S Ni 6082 filler metal made it possible to obtain very good results of welded joints. The decarburized/hydrocarburized zone is very narrow, which has a favourable influence on the exploitation properties of the joint.

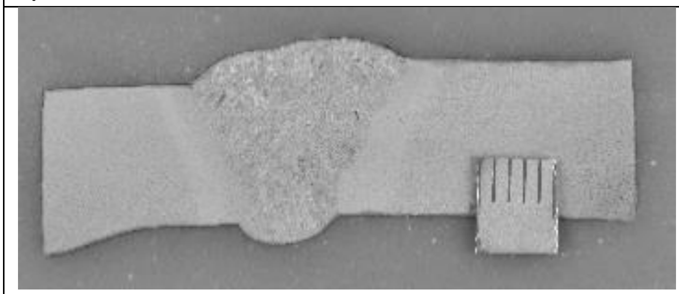
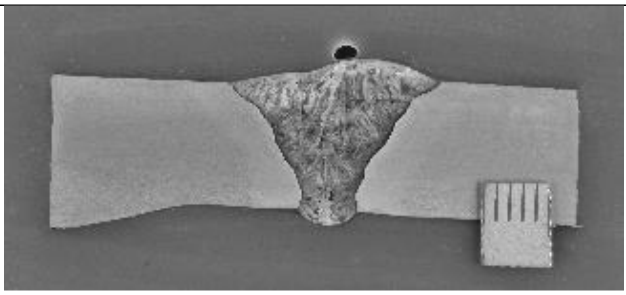
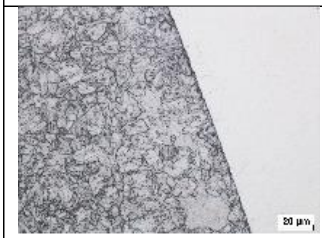
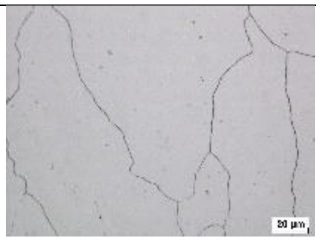
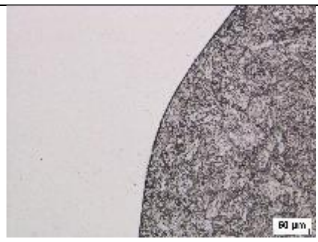
a)	b)
	

Fig. 5. THOR®115 and Grade 92 dissimilar joint welded with a) W Z CrWMoVNb92 and b) S Ni 6082

Table 2. Results of microscopic examination

W Z CrWMoVNb92 filler metal		
 THOR 115 HAZ tempered martensite	 weld tempered martensite	 Grade 92 HAZ tempered martensite
S Ni 6082 filler metal		
 THOR 115 HAZ tempered martensite	 weld austenite	 Grade 92 HAZ tempered martensite

Acknowledgements

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