TRANSITION ZONES STUDY OF THE HETEROGENOUS WELDED JOINTS

Lucie KREJČÍ, Ivo HLAVATÝ, Xenie ŠEVČÍKOVÁ

VŠB – TU Ostrava, 17. listopadu 15/2172, 708 33 Ostrava, Czech Republic, EU, lucie.krejci@vsb.cz, ivo.hlavaty@vsb.cz, xenie.sevcikova@vsb.cz

Abstract
The production of electric energy and heat belongs to the important branch of industry production in Czech Republic and worldwide as well. Nowadays, coal power plants are still considered as to important sources energy even though exist nuclear plants and further alternative sources. Different temperatures of single plants components need use of different types of heat-resisting materials, which need to be welded. During the welding there are generated heterogeneous weld connections, which need much more attention than the connection of two identical materials. Within these connections from various structural phases, which are caused by properties of one or another basic material. One of suggested connection types, used with new thermal power plants, is heterogeneous weld connection of steel P92 (X10CrWMoVNb9-2) with steel 1.4918 (X6CrNiMo17-13-2), this means weld connection of austenitic steel and martensitic steel.

Keywords: Weld joint, P92, X10CrWMoVNb9-2, 1.4918, X6CrNiMo17-13-2.

1. INTRODUCTION
Some of the proposed types weld joints, which are usually used on new heat power stations, are heterogeneous weld joints steel P92 (X10CrWMoVNb9-2) with steel 1.4918 (X6CrNiMo17-13-2), then weld joints austenitic with martensitic steels. To main requisite feature belongs heat resistant weld joints, which can be in principle effected suit welding, especially in heat effected zones (HAZ). In these regions then is able to happen to failure weld joints at straining at running arrangement.

The quality of weld is strongly dependent on the chemical composition of steels grades used and phases present in them. The welding process alone and subsequent cooling have also the substantial influence. Phase transitions, mainly in low temperature region [1, 2], connected with change of thermophysical and kinetic behaviour of each steel and weld could play important role also. During the welding process diffusion of elements (interstitial and substitution) take place and redistribution of elements in weld and near area around weld takes place also. The important role in the redistribution of elements directly in the weld and in the zones near weld joint depends also on phase transformations taking place. Quality of weld joint could change with regime of heat stress and other factors.

2. EXPERIMENT
The studies were carried out on heterogenous weld joint of martensitic P92 (X10CrWMoVNb9-2) and austenitic 1.4918 (X6CrNiMo17-13-2) steels.

Tube quality P92 - outer diameter 44,5 mm and thickness 10,0 mm.
Tube quality 1.4918 - outer diameter 43,0 mm and thickness 10,0 mm.

Undermentioned values of chemical composition basic materials (tab. 1 and 2) were tested on concrete tubes used for experiment.
Tab. 1 Chemical composition of the P92 (X10CrWMoVNb9-2) steel [wt.%]

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Al-c</th>
<th>Nb</th>
<th>B</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,124</td>
<td>0,50</td>
<td>0,19</td>
<td>0,021</td>
<td>0,0020</td>
<td>0,137</td>
<td>8,90</td>
<td>0,421</td>
<td>0,196</td>
<td>1,72</td>
<td>0,006</td>
<td>0,046</td>
<td>0,0022</td>
<td>0,051</td>
</tr>
</tbody>
</table>

Tab. 2 Chemical composition of the 1.4918 (X6CrNiMo17-13-2) steel [wt.%]

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Al-c</th>
<th>Nb</th>
<th>B</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,059</td>
<td>1,17</td>
<td>0,44</td>
<td>0,035</td>
<td>0,0010</td>
<td>12,2</td>
<td>16,3</td>
<td>2,06</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0,0359</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

On the basis effected examinations before welding can be considered, that both basic material are suitable.

2.1 Option of filler materials and welding parameters

Filler material for welding heterogeneous weld joint was chosen with reference to resulting characteristics weld joint at his practical using. Acts about wire for method 141 with mark Thermanit 617 from firm Böhler [3]. Chemical composition is mentioned in table 3.

Tab. 3 Chemical composition of the wire Thermanit 617 Böhler [wt.%]

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Al-c</th>
<th>Nb</th>
<th>Ti</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,05</td>
<td>0,10</td>
<td>0,10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>zbytek</td>
<td>21,50</td>
<td>9,00</td>
<td>-</td>
<td>-</td>
<td>1,00</td>
<td>0,50</td>
<td>1,00</td>
</tr>
</tbody>
</table>

2.2 Weld joints implementation

Weld joints were welded in position PA with turning. Material P92 was preheated (mine. 220°C) before tacking and own welding. At tacks, first and second run was protected with gas Argon 4.6 on the root side of the weld joints. At welding single runs were thoroughly checked preheating temperature and Interpass temperature. Preheating of the side mediumly - alloyed steel (P92) is necessary always by using preheating min 200°C for martensitic structures [4]. For welding austenitic steel (1.4918) preheating disuses, on the contrary is necessary take control of Interpass temperature. All weld joints after welding cooling in pack.

2.3 Heat treatment

Weld joints dividing is introduced in tab. 4, from which is perceptible and suggested heat processing weld joints subsequently [5]:
Tab. 4 Weld joints and heat treatment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11, 12, 13, 14</td>
<td>P92</td>
<td>1.4918</td>
<td>Thermanit 617</td>
<td>220/260</td>
<td>760°C/2h</td>
</tr>
</tbody>
</table>

Weld joints (tests) No. 11, 12, 13, 14 - PWHT 760°C/2h.*, heat speed 100°C/h., cooling 100°C/h. to 300°C, after welding cooling in pack

2.4 Macrostructure and microstructure examination

Weld joints were prepared for macrostructure and microstructure examination. On macrostructure photo is obviously evident fusion line, heat effected zone and way laying runs. Macrostructures of weld joints are suitable. In light of microstructure examinations single regions are perceptible, that region of weld metal is pouring with character duplex alloys totalled austenite and ferrite. At the same time in matrixs occur numerous coarse element and on limits prime grains eliminated almost continuous layer next phase (fig. 1).

Fig. 1 Macrostructure of test No. 14 with microstructure of given areas

2.5 Measurement of the line chemical composition in heat effected zone

Measurement of continuous line analyses was performed on electron micro - analyzer EDAX Bruker. Chemical line analyses were tested always on the side of martensite basic material P92 (X10CrWMoVNb 9 - 2) in one’s line and on the other side of austenitic material 1.4918 (X6CrNiMo17-13-2) in one’s line (fig. 2). From these analyses is possible make diffusion study for e. g. chromium.
Fig. 2 Chemical line analyses a) 1.4918 side, b) P92 side
3. CONCLUSION

The paper deals with properties study of heat affected zones of heterogeneous weld joints of austenitic steel 1.4918 (X6CrNiMo17-13-2) and martensitic steel P92 (X10CrWMoVNb 9 - 2). The main contribution of the work is comprehensive study of TOO properties of heterogeneous weld joints and their microstructure.

There was set macrostructure, microstructure, basic mechanical properties and measurement of microhardness through HAZ zones in all monitored heterogeneous welds and their HAZ zones. Further, there was performed microstructure study using electron microscope. Information from image analysis and measuring of continuous chemical structure through HAZ zones is very valuable results in the material investigation. This large set of results is contribution for use in practical applications during optimization of welding of heterogeneous weld connections of steel 1.4918 (X6CrNiMo17-13-2) and steel P92 (X10CrWMoVNb 9 - 2) with the method 141.

LITERATURE


