Welders N.V.

The impact of Titanium characteristics on design, fabrication and marketing of pressure equipment

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Contents

- Welders N.V. Presentation
- Refresher of Titanium salient features
- Titanium equipment main applications in processing industries
- Impact of Titanium unique properties on the fabrication of pressure equipment
- Welding of pressure vessels
- Heat exchanger tube to tubesheet joints
- Case studies
- Titanium cost advantage
- Conclusion
Introduction Welders N.V.
Introduction to Welders N.V.

- Fighting corrosion since 1948
- Construction of process equipment in high alloys and exotics
- ISO 9001:2015 certified and international codes compliant
- Global player: references in over 100 countries
- Industry wide recognition
- Associated in development of welding processes for new alloys with material producers
Typical examples from our production range
Hydroliser column in Duplex Stainless Steel
Cycle Gas Cooler in Hyper Duplex SAF 2507
Heat exchanger in 2RE10
H2S Reactor in Stainless Steel 310S

Pol Rixhon, Sales Director
Liquid separator in Alloy 825
Heavy ends column in Alloy G30

Pol Rixhon, Sales Director
Heat exchanger in Zr 702 / 316L
Formic Acid Column in Zr 702
16” Pipe spool and Injection Quill Assembly in Alloy 625
# Mechanical & Physical Properties of various alloys

<table>
<thead>
<tr>
<th>Property</th>
<th>Titanium Gr.2</th>
<th>90-10 CuNi</th>
<th>70-30 Cu-Ni</th>
<th>316 Stainless</th>
<th>Mild steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (min) MPa</td>
<td>345</td>
<td>275</td>
<td>360</td>
<td>515</td>
<td>300</td>
</tr>
<tr>
<td>Yield strength (min) MPa</td>
<td>275</td>
<td>105</td>
<td>125</td>
<td>240</td>
<td>170</td>
</tr>
<tr>
<td>Elongation (min)</td>
<td>20%</td>
<td>30%</td>
<td>15%</td>
<td>50%</td>
<td>45%</td>
</tr>
<tr>
<td>Elastic Modulus (10^6 psi)</td>
<td>16</td>
<td>18</td>
<td>22</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>Thermal expansion coeff. μm/m°C</td>
<td>9,2</td>
<td>17</td>
<td>16,2</td>
<td>16</td>
<td>11,5</td>
</tr>
<tr>
<td>Thermal conductivity w/m°C</td>
<td>21,8</td>
<td>50</td>
<td>29,6</td>
<td>16,2</td>
<td>40</td>
</tr>
<tr>
<td>Density g/cc</td>
<td>4,51</td>
<td>8,90</td>
<td>8,94</td>
<td>8,0</td>
<td>7,85</td>
</tr>
</tbody>
</table>
## Titanium grades mostly used in CPI

<table>
<thead>
<tr>
<th>Grade</th>
<th>Major alloying elements</th>
<th>Main feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20% Fe – 0.18% O</td>
<td>Low strength - corrosion resistant - good formability</td>
</tr>
<tr>
<td>2</td>
<td>0.30% Fe – 0.25% O</td>
<td>Most common - pure metal</td>
</tr>
<tr>
<td>3</td>
<td>0.50% Fe – 0.40% O</td>
<td>Higher strength</td>
</tr>
<tr>
<td>7</td>
<td>Gr.2 + 0.20% Pd</td>
<td>Improved resistance to reducing acids</td>
</tr>
<tr>
<td>11</td>
<td>Gr.1 + 0.20% Pd</td>
<td>Similar to grade 7</td>
</tr>
<tr>
<td>12</td>
<td>0.40% Mo; 0.9% Ni</td>
<td>Improved resistance to crevice corrosion &amp; erosion</td>
</tr>
<tr>
<td>16</td>
<td>Gr.2 + 0.05% Pd</td>
<td>Improved corrosion resistance to Gr.2</td>
</tr>
</tbody>
</table>
Applications in Hydrocarbon and Downstream Industries

- Oil and Gas
- Seawater cooling
- CPI
Applications in Process Industries

**Refineries:**
Immunity to corrosion from cooling waters and refinery process stream corrodents

**Marine environment**
Off-shore platforms FPSO seawater upto 260°C

**General chemical processing:**
Oxidizing acids: Nitric & chromic acids
Nitrate fertilizers
NACL KCL salt
Chloride solutions
Chlorine chemicals
Most Alkalies
Caustic soda & soda ash
Mildly reducing acids

**Organic synthetics & petrochemicals:**
Urea, PTA, Vinyl Acetate, Ethylene Glycol, Acetic Acid

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Pol Rixhon, Sales Director
Typical Heat Exchanger Refinery Applications

Condensing

Vacuum dryer, Depropanizer, Deethanizer Overhead, Dryer Regenerator

Cooling

Depropanizer bottom, Desalter Effluent Rundown, Butane, Alkalyte, Stabilizer Bottom Trim, LPG Product, Gasoline Trim, Lean Oil, Recycle water
Titanium salient properties in relation to alternative alloys

- Lower density
- High strength
- Smooth hard surface
- Lower modulus of elasticity
- High thermal conductivity and lower thermal expansion
- Noble metal
- Weldability: to reactive metals only and sensitive to contamination
Pol Rixhon, Sales Director

Planning and initiating the production process

- Checking the incoming materials and consumables conformity and ensuring the Titanium material surface cleanliness (Acetone)
- Determining the appropriate welding process (selecting the weld joint configuration) developing the WPS/PQR procedures and specifying the filler material grade
- Ensuring a proper environment and facilities: welding space, power supply, welding equipment, gas supply.
- Checking the shear, forming and other machines suitable conditions
Welding of Pressure Vessels

**Recommended welding processes:**

- Plasma upto 13mm maximum. All passes in automatic mode; great care in performing tack welds is needed
- **TIG:**
  - Automatic (root pass always in manual mode)
  - Manual by means of solid welding rods

**Bevels shape**

- I: Plasma only (filler material from 6mm onwards)
- V: Medium thickness
- X: thick material with accessibility: economical

**Protection**

- Need for auxiliary inert gas shielding to avoid contamination by air
Welding of Pressure Vessels

Protection Types:

- Gas torch: with greatest possible gas lens for molten weld puddle
- First trailing shield: with inert gas / argon on weld deposit and HAZ behind the torch
- Secondary trailing shield for protection of back side (backing gas)
- Recommended practice: HAZ and weld must be shielded to temperature lower than 300°C on root and cap side

(*) From 8mm weld thickness no backing gas required.

Longer trailer recommended for Plasma and TIG automatic

Interpass temperature: ca. 100°C particularly for small parts
X-shape weld Joints
## Surface Treatment

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickling</td>
<td>For very dirty plate surfaces at room temperature</td>
</tr>
<tr>
<td>PWHT</td>
<td>Not generally required, except for U-bent area</td>
</tr>
</tbody>
</table>
## Inspection of weld beads

<table>
<thead>
<tr>
<th>In process</th>
<th>By the welding operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Coloring</td>
</tr>
<tr>
<td></td>
<td>• PT (Cracks)</td>
</tr>
<tr>
<td></td>
<td>• RX (volumetric control)</td>
</tr>
<tr>
<td></td>
<td>• US (not for coarse grains)</td>
</tr>
<tr>
<td>Complete equipment</td>
<td>• Hydrostatic testing</td>
</tr>
</tbody>
</table>
### Tube to tubesheet joints

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roller expansion</td>
<td>2% - 5% tube thinning</td>
</tr>
<tr>
<td>Automatic orbital welding</td>
<td>Closed head (torch and argon)</td>
</tr>
<tr>
<td>proceduress</td>
<td>Need for methodical purging prior to start welding</td>
</tr>
<tr>
<td>Bevel</td>
<td>Depending on tube thickness and operating conditions</td>
</tr>
<tr>
<td>Caution</td>
<td>Cleaning tube hole and tube end to eliminate oil</td>
</tr>
<tr>
<td>Clad Titanium tubesheet</td>
<td>Seal weld and 2 grooves (no filler metal)</td>
</tr>
<tr>
<td>Solid Titanium tubesheet</td>
<td>Strength weld: leak path consideration; moderate coastal expansion</td>
</tr>
<tr>
<td>Testing</td>
<td>Helium test (shell side)</td>
</tr>
<tr>
<td></td>
<td>Soap test</td>
</tr>
<tr>
<td></td>
<td>Hydrotest: starting with shell side</td>
</tr>
<tr>
<td>Protection</td>
<td>Nitrogen in the shell, prior to packing</td>
</tr>
</tbody>
</table>

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**Pol Rixhon, Sales Director**
Orbital welding
TUBE - TUBESHEET CONNECTION
1. TUBES SLIGHTLY ROLLED BEFORE WELDING
2. STRAIGHT WELDING
   - WELD SEAM IN 2 LAYERS
     - FIRST LAYER WITHOUT FILLER METAL
     - SECOND LAYER WITH FILLER METAL
   - START-UP OF SECOND SEAM IN FRONT OF FIRST ONE

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Substituting Titanium parts for other materials in tube bundles replacement

- Check the compatibility of other parts (shell, channels)
- Perform a thermal rating analysis, considering:
  - Titanium tubes thermal conductivity
  - Possibility to increase the flow velocity
  - Titanium strength
- Relative position of materials concerned in the galvanic series
- Common findings:
  - Often selection of thinner tubes
  - Use of Titanium clad tubesheets
  - Installation of additional baffles
  - Rarely need for cathodic protection system
Figure 11. Galvanic series valid for natural seawater (1 m/sec) at 10 and 40°C after 4 months (10°C) and 1 month (40°C) exposure. After Valen et al [37].
Case Study 1

Application
Vertical brine cooler in Na2 SO4 plant in North Africa
Cooling of feed brine by mother liquor

Problem
Severe damage to CuNi tubes due to erosion – corrosion, the clogging leading to numerous unplanned stoppages

Solution
Installing a new heat exchanger in solid Titanium Gr.2

Main details
- Code: ASME VIII Div.1 and TEMA B
- Tubes: 1465 off x 10000mm
dia. 38mm x 1,2mm (instead of original thickness of 1,6mm
0,6µ Ra Finish
- Tubesheet: 50mm thick
- Shell: 10mm thick, diameter 2180mm
- Weight: 17 tonnes empty; 56 tonnes in operation
Brine Cooler in Titanium Gr.2
Case study 2

- Application: seawater cooled heat exchangers in a Singapore refinery
- General corrosion of tube side due to seawater
- Replacement of 19 tube bundles fitted with Aluminum brass tubes (19,05mm x 1,65mm) by Ti gr.2 tubes (1,25mm thick) and Titanium clad tubesheet
- Particularity: floating heads design
- Testing of equipment: at site during shutdown
Titanium tube bundles for Refinery Shutdown
Sample of our Titanium reference list
Heat exchanger with Titanium Gr.2 Finned tubes
2 Tube bundles in Titanium Gr.2
Stacked heat exchangers in Titanium Gr.2
Tube bundle in Titanium Gr.2/Gr.3
Anolyte tank in Titanium Gr.2
Heat exchanger in Titanium Gr.2
Crude Oil Heater in Titanium Gr.12
Tower for Chlorine Absorption in Titanium Gr.2
Reactor in Titanium Gr.2