THE EVOLUTION OF TITANIUM IN HPAL
WHO WE ARE

Gary Lantzke, CEO, Callidus Welding Solutions

February 4-5, 2018  Grand Hyatt Hotel  Singapore
HIGH PRESSURE ACID LEACHING

• Started in 1998
• Cheap extraction of Laterite Ore 0.9% - 1.7%
• 98% H₂SO₄, 240°C, 45 bar pressure
### TYPICAL HPAL CONDITIONS

<table>
<thead>
<tr>
<th>Stage</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Stage Pre-Heater</td>
<td>Comes in at 60degC - heated to approx 120degC</td>
</tr>
<tr>
<td>Second Stage Pre-Heater</td>
<td>120degC to 200degC</td>
</tr>
<tr>
<td>Third Stage Pumps</td>
<td>In at 1950kPa / 200degC - pressure increase to 4450kPag</td>
</tr>
<tr>
<td>Third Stage Pre-heater</td>
<td>Slurry contacted with 60bar steam - heated from approx 200degC to 230-240degC</td>
</tr>
<tr>
<td>Autoclave</td>
<td>Addition of acid in the 1st compartment is causes exothermic reaction raising the temp to approx 255degC</td>
</tr>
<tr>
<td></td>
<td>Residence time approx 90min - operating pressure of 4450kPag @ 255degC</td>
</tr>
<tr>
<td>Flash Vessel 1</td>
<td>1950kPag</td>
</tr>
<tr>
<td>Flash Vessel 2</td>
<td>650kPag</td>
</tr>
<tr>
<td>Flash Vessel 3</td>
<td>Atmospheric / 99degC</td>
</tr>
</tbody>
</table>
TITANIUM APPLICATIONS IN HPAL

Gary Lantzke, CEO, Callidus Welding Solutions
February 4-5, 2018  Grand Hyatt Hotel Singapore
SUPER DUPLEX PIPE SPOOL
8” DUPLEX VENT VALVE TRIM

Downstream End Connect

Downstream Side of Ball

Upstream Side of Ball
904 SPRAY NOZZLES
TITANIUM ... THE GOOD AND THE BAD

- Autoclave explosion bonded lining – what works and what doesn’t?
  - Grade 1, 11, 17 and 7.
- Titanium Grade 12 – is it a good choice?
- Corrosion and erosion resistance.
- Weld engineering and material manufacture.
EROSION
EROSION
EROSION

Gary Lantzke, CEO, Callidus Welding Solutions

February 4-5, 2018  Grand Hyatt Hotel  Singapore
WELD ENGINEERING
ENGINEERING AND MATERIALS
ENGINEERING AND MATERIALS

Gary Lantzke, CEO, Callidus Welding Solutions

February 4-5, 2018  Grand Hyatt Hotel  Singapore
EROSION CONTROL
STANDARD SOLUTIONS - Ceramics
STANDARD SOLUTIONS – Thermal Spray Coatings
STANDARD SOLUTIONS – Titanium Nitriding
STANDARD SOLUTIONS – Titanium Nitriding
STANDARD SOLUTIONS – Titanium Nitriding

VALVE TRIMS
STANDARD SOLUTIONS – Titanium Nitriding

<table>
<thead>
<tr>
<th>Chemical Formula</th>
<th>TiN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>300 – 900 HV eq. 30 – 67 Rockwell C</td>
</tr>
<tr>
<td>Fracture Toughness(^{(1)})</td>
<td>35 – 80 Mpa.m(^{1/2})</td>
</tr>
</tbody>
</table>
| Thickness of Converted Material | 1 – 4mm Using Conversion Method  
1 – 6mm Using Build Up Method |
| Converted Compound | 20 to 90% |
| Microstructure    | Dendritic Fine  
Dendritic Coarse  
Rod-like |

\(^{(1)}\) Fracture toughness is measured by the indentation technique. In this application, fracture toughness is an indicative value and used for comparison amongst TiN material.
WHAT’S NEW?
DEVELOPMENTS

- Refined dendritic grain structure.
- Reduced cracked density.
- 3x increase in toughness.
- Introduction of beta stabilisers.
QUESTIONS ?