WEAR RESISTANT OPTIONS FOR HIGH PRESSURE ACID LEACHING (HPAL) APPLICATIONS
HIGH PRESSURE ACID LEACHING

- Started in 1998
- Cheap extraction of Laterite Ore 0.9% - 1.7%
- 98% H2SO4, 240°C, 45 bar pressure
TITANIUM APPLICATIONS IN HPAL

Pre Heaters E.B. Ti Internal Equipment Ti 12

Steam Piping Ti 12

Flow Control Valves Ti

Blast Tubes Ti 12 Ceramic Lined

HP Steam

HT

Pre Neut

01TK01AB

Scrubber System

Water

Operation

HPAL Feed Storage Tank

LT

MT

GEHO

ACID

HP Air

Vent to scrubber

01PU03AB

Ti 12 Agi Blades
E.B. Gr. 2 Liner
Weir Walls
Batten Strips
Nozzle Inserts
Inlet & Outlet Piping
Steam Injection piping

Process Slurry Piping Ti 12

CALLIDUS WELDING SOLUTIONS
PERTH, WESTERN AUSTRALIA
**TYPICAL HPAL CONDITIONS**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Condition/Details</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>

Most erosive issues are caused by flashing at points in the process where the pressure drops sufficiently for a portion of the product to form steam (3 phase flow) – the increased volume causes a dramatic rise in the velocity. High velocity flow with entrained solids causes dramatic rates of erosion.
EROSION

Critical Valves
EROSION

Letdown Valves
EROSION
Agitation Blades
EROSION

Piping
STANDARD SOLUTIONS

Ti O2 – A.P.S. Coating
STANDARD SOLUTIONS

Ceramics
TiN - A DEVELOPED SOLUTION
Can the surface of Titanium be contaminated in a controlled way to produce a wear resistant surface while still maintaining the material’s suitability to corrosion service.

YES, it can.
TITANIUM NITRIDE

Applicable onto All titanium grades
Already developed and widely used on commercial pure, low alloy and near alpha titanium grades type Gr. 3, 12, 7, 9.

Method Conversion: the surface of the substrate is converted and result in a flat surface.

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**TITANIUM NITRIDE**

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**Method**

**Build up**: Addition of filler material during the conversion process

![Image of welding process with measurements 2.7mm and 4.3mm]
# TITANIUM NITRIDE - PROPERTIES

<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>
<tr>
<td>Thickness of converted material</td>
<td>1 – 4 mm using conversion method</td>
</tr>
<tr>
<td></td>
<td>1 – 6 mm using build up method</td>
</tr>
<tr>
<td>Converted compound</td>
<td>20 to 90%</td>
</tr>
<tr>
<td>Microstructure</td>
<td>Dendritic fine</td>
</tr>
<tr>
<td></td>
<td>Dendritic coarse</td>
</tr>
<tr>
<td></td>
<td>Rod-like</td>
</tr>
</tbody>
</table>

(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.

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TITANIUM NITRIDE - MICROSTRUCTURE

Rod-like TiN structure usually observed close to the TiN / substrate interface where the TiN concentration drops (top corners are the titanium substrate)

Fine dendritic structure close to the surface (right on the picture) and coarser structure further away from the surface
Hardness profile of two TiN-B (Build up) and two TiN-C (Conversion) samples
TITANIUM NITRIDE – WEAR PROPERTIES

Figure 1: Comparison of hardfaced nonferrous alloys and carbon steel reference materials using ASTM G65 Practice B (source: ASM Handbook Ed 10 Vol 18, p762).
Strainer basket for acidic slurry application (in HPAL process)

Without TiN

With TiN
HOW DO WE DO IT?
CURRENT APPLICATIONS

Agitation Blades
CURRENT APPLICATIONS

Pipes
CURRENT APPLICATIONS

Wear Plates
CURRENT APPLICATIONS

Valve Parts
CURRENT APPLICATIONS

Cone Dispersion
WHERE TO NOW?
WHERE TO NOW?

Optimization of parameters for a flat deposition using build up method.
WHERE TO NOW?

Reduction in relief checking
WHERE TO NOW?

Combination approaches – Vent Plug
WHERE TO NOW?

Combination Approaches - Agitation Blades
WHERE TO NOW?

New markets

OIL AND GAS
AUTOMOTIVE
Questions
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