EXW Titanium Plate

Ultrasonic Inspection of Condenser tubesheets for Nuclear Power Plant
Explosion Welding Process EXW

1. PLAIN MATERIAL INSPECTION
   - Welder
   - Alloy Cladder

2. GRIND MATING SURFACES
   - Grinder

3. ASSEMBLE BACKER, CLADDER AND EXPLOSIVE
   - Explosive Powder
   - Space Between Plates

4. EXPLOSION
   - Detonation Front
   - Metallurgical Weld Line
   - Collision Line

5. FLATTEN AND CUT
   - Rollers

6. TESTING AND INSPECTION

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KEY PROCESSENT ELEMENT

• Input Materials Meet Specifications
• Explosion Bonding Parameters
  ▪ Standoff Distance
  ▪ Explosive Load
  ▪ Explosive Burn Rate
• Final Inspection

KEY

$v_d$ = Detonation Velocity
$v_c$ = Collision Velocity
$v_p$ = Impact Velocity
$\beta$ = Dynamic Angle of Collision
Nobelclad Feasability

- Carbon Steel
  - Pressure Vessel grades
    - A516, 533, 537, etc.
  - CR-Mo & CR-Mo-V steel
  - Structural Steels
  - Pipe grades API 5L / DNV

- Cu Alloys
  - Cu A1 & C1
  - Cu Ni alloys
  - CuBe
  - CuCrZr

- Ni Alloys
  - Alloy 625
  - Alloy 825
  - Alloy 600
  - Alloy 31

- Al Alloys
  - 1xxx
  - 3xxx
  - 5xxx
  - 6xxx

- Reactive Metals
  - Ti grades
    - G1, G2, G7, G11, G17
  - Zr grades
    - G700, G702
  - Tantalum
  - Silver

- Stainless Steel
  - 410S
  - 316L
  - 317L
  - 304L
  - 321
  - 347
  - 904L
  - 2205
  - 2507

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Condenser Tubesheet on Nuclear PP
Condenser Tubesheet

- Titanium Tubes for optimum corrosion resistance and thermal performance
- Titanium Clad Tubesheets
  - As large as 5000 mm x 7000 mm x 50 mm tk
  - Up to 10 000 holes per TS
  - Titanium Gr 1 for TS / Ti Gr 2 for tubes
  - Clad reduces cost by up to 50%
## Condenser Tubesheet reference list

<table>
<thead>
<tr>
<th>CUSTOMER</th>
<th>PROJET</th>
<th>BASE</th>
<th>CLADDING</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
<th>Th.B (mm)</th>
<th>Th.C (mm)</th>
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Equipment

• Automatic UT bench
  • Designing for plate scanning – probe holder self supported with water couplant and filtering system to follow the shape
  • Different transducers support (1 to 8 simultaneous channels)
  • Graphic interface friendly – C scan using color contrast
  • Traceability of the scans– A scan and C scan are automatically recorded for further investigation
  • Dedicated transducers ERD for explosion cladded plates designed through CIVA simulation
Automatic VS Manual Scan

- Overlap under full control
- Probe pressure on the plate constant and identical with the calibration.
- Running speed fully controlled
- Traceability thanks to automatic record of scans
- Faster inspection despite the smaller overlap
Simulation Software

- CIVA simulation software developed specifically for nondestructive testing applications. This high-performance and versatile software is the culmination of more than ten years of development.
  - Design optimal probes for an application
  - Verify inspection parameters
Dual element transducer 4MH

- Improves near surface resolution
- Couples well on rough or curved surfaces
- Reduces noise in coarse grained materials
- Combines penetration capabilities of a lower frequency single element transducer with the near surface resolution capabilities of a higher frequency single element transducer
- Adapt the transducer focal spot to the inspected plate.
Particularity of Ti cladded plates

- $Z_1 = Z_2$
  - Similar impedance
- $Z_1$ and $Z_2$ different
  - Dissimilar impedance
EN 10160 Overview

- EN 10 160 with EN 17405
  - Calibration block – flat bottom Diam 5 (S3, E4)
  - Settings on interface echo
  - Threshold on interface echo first and additionally backwall
  - Overlap set on FTH at – 6db

![Diagram showing backwall reflection and FBH echo]
EN 10160 Civa Simulation

- Different shapes (complexes, simples)
- Different sizes
  - Ø 2 mm & 15 mm
  - Rectangular 1 x 2

All flaws are detected
B 898 Overview

- B 898 & SA 578
  - No calibration block (unless requested)
  - Settings on backwall reflection
  - Threshold on backwall echo
  - Overlap (S1) at min 10% of crystal size
B 898 Civa Simulation

- Same configuration
- Smallest flaws not detected
  - Ø 2 mm
  - Rectangular 1 x 2

3 flaws are not detected