INTRODUCTION of SAIJO FACTORY & Coke Drum Technology

Rio de Janeiro, August 2009
1. SAIJO Factory Profile
2. Experience & Capability
3. Cutting Edge Techniques
4. Research & Development
1. SAIJO Factory Profile

- Location
- History
- Brief Introduction
SAIJO Factory Profile: Location

SAIJO Factory

Location:
- Chiba Works
- Nagoya Works
- Okayama Works
- Tokyo
- Tanashi Works
- Oppama Works
- Kobe Port
- Ehime Works - Niihama Factory
- Ehime Works - Saijo Factory
1973  Established as a manufacturing base for large steel products

1974  Obtained U & U2 Stamps of ASME

1984  Attained 100 unit ASME Stamped Products

1989  Concentrated on Reactors and Coke Drums

1993  Obtained ISO 9001 certificate

1996  Concentrated on Coke Drum Manufacturing

1999  Obtained ISO 14001 certificate

2006  Fabricated 100th Coke Drum

2009  Total Coke Drums Awarded Since 1973 = 176!
To be played the embedded audio-video file of Saijo Factory's Brief Introduction for about 6 minutes.
2. Experience & Capability

- World-wide Delivery
- Coke Drum Weight & Size
- Materials
- Strict Quality Assurance
- Site Assembly
- Field Inspection Services
Experience & Capability: World-wide Delivery

176 Coke Drums Delivered Throughout the World

The Number of Awarded Coke Drums by Region (including under fabrication)

(As of May 2009)
Experience & Capability: Coke Drum Weight & Size

One Drum Weight vs. Built Year

Max. Weight: 560 ton (ID: 9.144 m)
Max. ID: 9.8 m

(30 ft) (32 ft)

176 Drums of Experience
Putting drum weight in chronological order

Drums in North America
Drums in South America
Others

Max. Weight: 1,233 lb

Under fabrication > 20


The first delivery to South America

1985
Experience & Capability : Coke Drum Weight & Size

One Drum Weight vs. Built Year

176 Drums of Experience
Putting drum weight in chronological order

The uniform thickness shell has prevailed since 2002
Fabrication Experiences of Coke Drums for Individual Base Materials

- **3Cr-1Mo-¼V**
  - Total Number: 2
  - Percentage: 1%

- **2¼Cr-1Mo**
  - Total Number: 12
  - Percentage: 7%

- **1Cr-½Mo**
  - Total Number: 29
  - Percentage: 16%

- **1¼Cr-½Mo**
  - Total Number: 121
  - Percentage: 69%

- **C-½Mo**
  - Total Number: 12
  - Percentage: 7%

Total Number: 176
Experience & Capability : Materials

Chronological Fabrication Experiences of Coke Drums for Individual Base Materials

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<td>3Cr-1Mo- ¼V</td>
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<td>2¼Cr-1Mo</td>
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<tr>
<td>1Cr-½Mo</td>
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<tr>
<td>1¼Cr-½Mo</td>
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<td>C-½Mo</td>
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</table>

Total Number: 176
Experience & Capability: Strict Quality Assurance

Skilled Welders

Solid Performance Anywhere

Honing their skills through the training program

ASME Qualified Welders: Over 120
Experience & Capability : Site Assembly

Assembling Experience in South America

Shipping

Fit-up

* Surface Transportation

* Field Welding

* Erection

* Both processes are out of Sumitomo’s scope

Both processes are out of Sumitomo’s scope.
Experience & Capability : Site Assembly

Assembling Experience in South America

The great extent of our capabilities for a site assembly

Ex.-1) Buckling analysis verification taking the reduction in the material properties due to PWHT on site and the field weld groove fit-up condition into consideration

Ex.-2) Applied organization to meet “ASME Field Assembly”
Experience & Capability : Field Inspection Services

In-Service AUT Inspection for Coke Drum

- Dual PA Sector Scan (by using 2 PA Probes) and Dual TOFD Simultaneous Inspection System
- Detection and Accurate Height Sizing by Phased Array for Fatigue Cracks in the Clad Restoration Weld and its Heat Affected Zone

◆ S.H.I. EXAMINATION & INSPECTION, LTD.
A Subsidiary of Sumitomo Heavy Industries, LTD.
Experience & Capability : Field Inspection Services

In-Service AUT Inspection for Coke Drum

TOFD Automatic Ultrasonic Testing for Condition Monitoring of Coke Drums
Simultaneous Acquisition and Analysis for the Flaw Propagation Monitoring by Phased Array and TOFD

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2003 ASME Pressure Vessels & Piping Conference

S.H.I. EXAMINATION & INSPECTION, LTD.
A Subsidiary of Sumitomo Heavy Industries, LTD.
3. Cutting Edge Techniques

- **Integral Skirt Fabrication**
  To bring longer fatigue life by utilizing Sumitomo’s large scale facilities

- **Automatic Devices**
  To achieve high-level productivities and quality

- **Production Process Control**
  To meet short delivery times and customer requests
Machining by the large scale vertical lathe enable us to manufacture the skirt attachment portion up to the coke drum diameter 12m(39ft).

**Advantage**

- To make a large inside radius $R = 38\text{mm}(1.5\text{”) - 50\text{mm}(2\text{”)})$}
- No circumferential welds joint at highest stress point of skirt to head
“Stress Intensity Range” can be reduced to about **80%** level by enlarging the inside radius from 13mm to 38mm.

The fatigue life can be extended to about **2 times** by enlarging the inside radius.
## Fabrication Experience of the Integral Skirt

Applicable Max. ID = 12,000 mm (39’)

<table>
<thead>
<tr>
<th>Built Year</th>
<th>Drums</th>
<th>Drum ID</th>
<th>Inside Radius of the Skirt Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>2</td>
<td>7,620 mm (25’)</td>
<td>20 mm (0.8”)</td>
</tr>
<tr>
<td>2002</td>
<td>6</td>
<td>8,484 mm (27.8’)</td>
<td>35 mm (1-3/8”)</td>
</tr>
<tr>
<td>2006</td>
<td>2</td>
<td>6,400 mm (21’)</td>
<td>30 mm (1-1/8”)</td>
</tr>
<tr>
<td>2007</td>
<td>3</td>
<td>6,100 mm (20’)</td>
<td>25 mm (1”)</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
<td>7,620 mm (25’)</td>
<td>30 mm (1-1/8”)</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
<td>6,400 mm (21’)</td>
<td>30 mm (1-1/8”)</td>
</tr>
<tr>
<td>(2010)</td>
<td>2</td>
<td>6,096 mm (20’)</td>
<td>35 mm (1-3/8”)</td>
</tr>
</tbody>
</table>

Σ19

Original Rectangular Material
Typical Requirements for Surface Finish of Welds

- Ground smooth & flush both outside and inside the shell.
- Grinding indication direction below top T.L. to be arranged parallel with the vertical axis of the Vessel.
- Roughness of weld surface to meet some specific value (Ex. Max. 125μin Ra).

Sumitomo has been developing grinding machines to satisfy the customer requirements for the surface finish of welds.
Cutting Edge Techniques: Production Process Control

Director 6 System

Comprehensive Project Planning & Scheduling

Project Schedule

Weekly Schedule

Time & Resource Scheduling across multiple projects

Major Machine & Critical Path

Feed back & Rescheduling

Progress Data

Production Innovation

Insure conformance to delivery

Reduce Lead time

More Product

Work Processes

Progress Daily Check Board at each area in the shop
4. Research & Development

■ Skirt Attachment Examination
  To establish innovative skirt structures by the experiment

■ Improvement in Welding Material
  (Strength Matching of Welding Metal)
  To help shell to less bulge by controlling the weld metal strength
R&D : Skirt Attachment Examination

Static Loading Test and Thermal Test

FEA Modeling

Static loading test

Thermal test

- **Actual** strength measurement based upon various experiments (Static, Thermal and Fatigue)
- **More Accurate** FEA Study verified by the experimental data

Thermocouple & high temperature strain gauge
R&D: Skirt Attachment Examination

Materials

- 1¼Cr-½Mo

Test Condition

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Strain control; under zero mean strain Waveform; triangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>RT, 500°C (932°F)</td>
</tr>
<tr>
<td>Strain rate (S⁻¹)</td>
<td>10⁻³</td>
</tr>
</tbody>
</table>

High-Frequency Heating System

Fatigue Test

Displacement Meter

Waveform

Thermocouple

Test Specimen

High-Frequency Work Coil

Displacement Meter Chip

R.T. Test

500°C (932°F) Test
R&D : Skirt Attachment Examination

Static loading test verification of FEA

Setting for fatigue curve

 Tested at room temperature
Strain Rate : $10^{-3}$

Manson-Coffin Equation

$\Delta \varepsilon_t = \Delta \varepsilon_p + \Delta \varepsilon_e = C_p \cdot N_f - K_p + C_e \cdot N_f - K_e$

Test Condition

- Waveform: triangular
- Strain control; under zero mean strain
- Strain rate ($S^{-1}$): $10^{-3}$

Compression Load 16 kN

Strain (%)

Distance from the edge of test piece (mm)

0 100 200 300 400 500 600

0 200 400 600 800 1000 1200 1400 1600

Graph showing strain vs. distance from the edge of the test piece.
R&D : Improvement in Welding Material

Developed welding materials for 1¼Cr-½Mo to lower the yield strength of the weld metal

Ts of Weld Metal after Improvement
Ys of Weld Metal after Improvement

Decrease the weld metal yield strength to be within a close percentage of the base metal yield strength

Target Zone 460±40MPa (66.7±5.8ksi)

Ts of Base Metal
Ys of Base Metal

Gap=13%
Questions Welcomed
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Thank You!