Germanischer Lloyd –
Design of Double Hull Tankers
Presentation at National Technical University of Athens
May 2005
What do we face in the design?

Practical logistical problems!

- Height to climb 11 km
- Area to survey 300,000 m²
- Length of weld 1,200 km
- Length longitudinals 58 km
- Bottom area 10,700 m²
- 1% pitting = 85,000 pits
Existing Tanker Fleet

27,500 DWT and above

Number of Vessels

DWT (millions)


0 5 10 15 20 25 30 35

0 50 100 150 200 250 300 350

Germanischer Lloyd
World Oil Movements
Oil Tanker Categories

HANDYSIZE TANKER = 20,000 - 30,000 DWT
HANDYMAX TANKER = approx 45,000 DWT
PANAMAX TANKER = approx 79,000 DWT
AFRAMAX TANKER = between 79,000 - 120,000 DWT
SUEZMAX TANKER = between 120,000 - 180,000 DWT
V.L.C.C. TANKER = between 200,000 - 300,000 DWT
U.L.C.C. TANKER = over 300,000 DWT
# Principal Dimensions of Tankers I

<table>
<thead>
<tr>
<th>Ship size (scantling)</th>
<th>Small tankers</th>
<th>Handysize tankers</th>
<th>Handymax tankers</th>
<th>Panamax tankers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dwt</td>
<td>5,000 8,000</td>
<td>10,000</td>
<td>15,000 20,000 25,000</td>
</tr>
<tr>
<td>Scantling draught</td>
<td>m</td>
<td>6.4 7.5</td>
<td>8.0 9.0</td>
<td>9.3 9.6</td>
</tr>
<tr>
<td>Length overall</td>
<td>m</td>
<td>100 116</td>
<td>124 136</td>
<td>155 170</td>
</tr>
<tr>
<td>Length between pp</td>
<td>m</td>
<td>94.5 110</td>
<td>117 127</td>
<td>147 161</td>
</tr>
<tr>
<td>Breadth</td>
<td>m</td>
<td>16.0 18.0</td>
<td>19.0 21.8</td>
<td>24.0 25.5</td>
</tr>
<tr>
<td>Design draught</td>
<td>m</td>
<td>6.0 7.1</td>
<td>7.5 8.4</td>
<td>8.6 8.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship size (scantling)</td>
<td>dwt</td>
<td>30,000 35,000</td>
<td>40,000 47,000</td>
<td>60,000 70,000</td>
</tr>
<tr>
<td>Scantling draught</td>
<td>m</td>
<td>9.9 10.6</td>
<td>11.0 12.4</td>
<td>12.3 14.1</td>
</tr>
<tr>
<td>Length overall</td>
<td>m</td>
<td>176 176</td>
<td>183 183</td>
<td>228.6 228.6</td>
</tr>
<tr>
<td>Length between pp</td>
<td>m</td>
<td>168 168</td>
<td>174 174</td>
<td>219 219</td>
</tr>
<tr>
<td>Breadth</td>
<td>m</td>
<td>28.0 30.0</td>
<td>31.5 32.2</td>
<td>32.2 32.2</td>
</tr>
<tr>
<td>Design draught</td>
<td>m</td>
<td>9.0 9.6</td>
<td>10.0 11.3</td>
<td>11.0 12.6</td>
</tr>
</tbody>
</table>
# Principal Dimensions of Tankers II

<table>
<thead>
<tr>
<th>Ship size (scantling)</th>
<th>dwt</th>
<th>Aframax tankers</th>
<th>Suezmax tankers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>85,000</td>
<td>105,000</td>
</tr>
<tr>
<td>Scantling draught</td>
<td>m</td>
<td>12.1</td>
<td>14.7</td>
</tr>
<tr>
<td>Length overall</td>
<td>m</td>
<td>244</td>
<td>244</td>
</tr>
<tr>
<td>Length between pp</td>
<td>m</td>
<td>233</td>
<td>233</td>
</tr>
<tr>
<td>Breadth</td>
<td>m</td>
<td>42.0</td>
<td>42.0</td>
</tr>
<tr>
<td>Design draught</td>
<td>m</td>
<td>11.0</td>
<td>13.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ship size (scantling)</th>
<th>dwt</th>
<th>VLCC</th>
<th>ULCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>260,000</td>
<td>280,000</td>
</tr>
<tr>
<td>Scantling draught</td>
<td>m</td>
<td>19.1</td>
<td>20.5</td>
</tr>
<tr>
<td>Length overall</td>
<td>m</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>Length between pp</td>
<td>m</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>Breadth</td>
<td>m</td>
<td>58.0</td>
<td>58.0</td>
</tr>
<tr>
<td>Design draught</td>
<td>m</td>
<td>17.7</td>
<td>19.0</td>
</tr>
</tbody>
</table>
Principal Dimension Considerations

• Breadth Limitations (Panama Canal)

• Draft Limitations (Trade Route)

Suez Canal

Malacca Straits
A new type of VLCC is Born

MALACCA-MAX

$T=20.5m$  Cargo same as a large VLCC
Double vs Single Hull Tankers

• *We have come a long way!*
Double vs Single Hull Tankers

• Increased Strength Requirements
• Increased Stability Requirements
• Increased Cargo Temperature
• Increased Ballast Surface
Structural Design Considerations
Structural Design Considerations

• Longitudinal Strength (Global Bending/Shear)

• Transverse Strength (Primary Support Members)

• Buckling (In combination with above)

• Fatigue (Long Term Effect)

• Ultimate Strength (Extreme Load/Plasticity)
Longitudinal Strength (Beam Model)

- Minimum Section Modulus (IACS Requirement)
- Static and Wave induced Bending and Shear
- Sagging and Hogging
- Sagging dominates in Full Load
- Hogging dominates in Ballast Load
Transverse Strength (Local Loads)

Internal Tank Pressure
Roll, Pitch & Acceleration

External Pressure
Static & Wave

Germanischer Lloyd
Typical Midship Section of a VLCC
More Mid-ship Sections

Product tanker design

Aframax tanker design

VLCC design
How to do it?  Cavalry To the Rescue!

Poseidon ND 3.5
Interactive dimensioning of ship structures.

Germanischer Lloyd
Operating 24/7
POSEIDON ND

Computer Supported Tanker Scantling Assessment

• Rule Based Structural Design
• First Principle Structural Design
• Support of Plan Approval Procedure
• Condition Assessment
Midship Section of a Suezmax Tanker Created by
POSEIDON-Plating
It is not over yet!

2\textsuperscript{nd} Stage of Analysis $\rightarrow$ FEA
Model of a Suezmax Tanker without Deck and Shell Plating
FE Model 319,000 dwt VLCC

GERMANISCHER LLOYD
SAMHO 319000 DWT VLCC, FE-MODEL VLCC
POSEIDONND 2.724 Fl

File: C:\PROJECTS \SAMHO \VLCCModel\New\FE-Model\319000DWT_VLCC_Fl_Model.pst
Date: 08.04.2002, Time: 10:25

Germanischer Lloyd
The bad and the ugly: Sloshing and Slamming
Sloshing
Critical for:
$L_{tank} > 0.1L$ and/or $B_{tank} > 0.5B$
Slamming
Critical at Low Draft Fwd-High Speed
Fatigue Assessment

Critical Areas

- Stress Concentration
- Misalignment
- Insert Type Collar Plate under Bracket Toes (typical)
- No scallop
Fatigue Input (In addition to Stresses)

Wave Scatter

North Atlantic
Material Tolerance (S-N curves)
Detailed Stress Analysis (Zooming)
In Conclusion of Fatigue 101

• Miner Damage Accumulation Model
• North Atlantic Wave Input
• Weibull Stress Distribution
• Proper S-N curves (depend on approach)
• Satisfy Target Life (>20 years)

BUT.............
The Fatigue Doctor: Good Details

Fatigue Crack Initiation of Longitudinals

Soft Toe Brackets
Soft Heel

Filler Plate
Improve Fatigue Strength
Soft Heel
Filler Plate
Soft Toe Brackets

Web Plate
Flat Bar
Longitudinal
Shell Plating
Design Proper Structural Details!

Quiz: Find what is missing below

Bracket Toe Details of the Primary Members

Deep Penetration Welding

Insert Type Collar Plates
LAST BUT NOT LEAST
Operational Considerations in Design
Ship Acoustics

- Noise prediction
- Optimisation of engine foundations
- Optimisation of structure-borne noise insulation index
- Noise measurements
Vibrations

- Local Vibration Analysis
- Mast Vibration Analysis
- Shaft Vibration Analysis
- Vibration Level Prediction
- Analysis of coupled machinery/foundation vibrations
- Vibration measurement

<table>
<thead>
<tr>
<th>Overall frequency-weighted r.m.s-values from 1 to 80 Hz</th>
<th>Area Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Passenger Cabins for instance</td>
</tr>
<tr>
<td>mm/s</td>
<td>mm/s</td>
</tr>
<tr>
<td>Values above which adverse comments are possible</td>
<td>143</td>
</tr>
<tr>
<td>Values below which adverse comments are not probable</td>
<td>71.5</td>
</tr>
</tbody>
</table>

Note: The zone between upper and lower values reflects the shipboard vibration environment commonly experienced and accepted.
The Big Enemy: Corrosion!

Under-Deck Vapor Spaces - Flaky Corrosion, 0.1 mm /Year

Dry and Wet (due to Temperature at Day and Night)

Sea Water

Inner Bottom Pitting: 1.5 – 2.5 mm /Year
Coatings do not last forever!
Protection of Cargo Oil Tanks

- Pitting corrosion caused by sulphur components in combination with water
- Formation of hydrochloric acid
- Sulphur reducing bacteria
- Susceptible areas to be protected by coatings
Where to Protect?
Do not Forget: Eco-friendliness
THANK YOU FOR YOUR ATTENTION!