Slamming analysis using Fluid-Structure-Interaction

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Slamming

High local pressure at impact

Magnitude depends on
• Relative velocity
• Geometry
• Air pockets

Figure 8.8. Artist’s impression of bow slamming causing global elastic vibrations (whipping) of the ship’s hull. (Artist: Bjarne Stenberg)
Model description

• Steel plate with stiffeners
• Hit from below by a block of water
• Impact velocity 4, 5, 6 and 7 m/s
• Max deformation
• Permanent deformation
• Pressure
Software: StarCCM and Abacus

StarCCM+
- URANS, k-e, wall law
- Two-phase, VOF, air and water
- Compressible
- Air: Ideal gas law
- Water: Tait’s equation \( \rho = \rho_0 \left( \frac{p+B}{p_0+B} \right)^{1/A} \), A=7.15, B=3.047e8

Abaqus
- Nonlinear
- Dynamic
- Quasi-static
Interaction set-up

Interaction: in each time step
- Compute solution in fluid domain
- Apply pressure load on structure
- Compute plate deflection
- Update fluid domain according to plate deflection
- Update mesh (mesh morphing)

- Time step 0.001 s
- 2nd order time stepping
Computational models

Geometry and mesh for the fluid domain

FE-model of plate and stiffeners

Initial conditions of the volume fraction for water
Volume fraction of air and water

0.05 s

0.10 s

0.15 s

0.20 s
Force and deformation

Deformation
- 0.085 s
- 0.113 s
## Permanent and max deformation

<table>
<thead>
<tr>
<th>Velocity</th>
<th>StarCCM+/Abaqus Max def.</th>
<th>StarCCM+/Abaqus Permanen t def.</th>
<th>LS-Dyna Max def.</th>
<th>LS-Dyna Permanen t def.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 m/s</td>
<td>26 mm</td>
<td>15 mm</td>
<td>25 mm</td>
<td>14 mm</td>
</tr>
<tr>
<td>5 m/s</td>
<td>44 mm</td>
<td>34 mm</td>
<td>43 mm</td>
<td>34 mm</td>
</tr>
<tr>
<td>6 m/s</td>
<td>76 mm</td>
<td>62 mm</td>
<td>76 mm</td>
<td>59 mm</td>
</tr>
<tr>
<td>7 m/s</td>
<td>112 mm</td>
<td>95 mm</td>
<td>113 mm</td>
<td>87 mm</td>
</tr>
</tbody>
</table>
Slamming – Influence of deadrise angle

Vol. fraction
Water

Pressure

$\text{t=1.258s}$

$\text{t=1.489s}$
Slamming – Influence of deadrise angle

$t = 1.489 \text{s}$

Density
water

Density
air

Deformation

Density
water
Summary

- The FSI model behaves as expected in general
- Good agreement to LS-Dyna results
- Further refinement in space and time necessary to resolve the physics
- A more accurate solution procedure is needed for the structure for eigenmodes and eigenfrequency
- Study influence of bottom deadrise angle