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Collision Model Test Matrix #3

Objective: Assess the sensitivity of damage penetration to striking ship speed and collision angle. Consider zero speed for struck ship and include *DAMAGE* right angle results. Compare results from all models.

Struck Ship: 150k dwt DH Tanker, $V_A = 0$ knt, $T = 16.8$ m, $\Delta = 178867$ MT, baseline design.

Striking Ship: 150k dwt Bulk Carrier; $V_B = 3, 4, 5, 6, 7$ knt; $T=15.96$ m, $\Delta = 174,850$ MT.

Scenario: collision angle = 45, 60, 75, 90, 105, 120, 135 degrees; strike location = 3.5m FMS

Plots: Penetration vs. V_B at each collision angle (7); Penetration vs. collision angle at each V_B - (7) + (5) - 12 plots each model

Models: - *SIMCOL* V2.1; *DAMAGE*; Technical University of Denmark (DTU) / Lutzen; ALPS/SCOL / Paik

Observations: (submit via email to brown@aoe.vt.edu)

- ALPS/SCOL predicts much higher penetration than SIMCOL2.1, *DAMAGE* and DTU, particularly at higher energy. ALPS/SCOL penetration vs. velocity slope larger than other models.
- All models are symmetrical around 90 degree strike with zero struck ship speed.
- High energy ($V_B=6,7$ knt): SIMCOL2.1 shows a substantial decrease in penetration at 90 degrees.
- At high energy with strike directly on the web, SIMCOL2.1 predicts rupture of inner shell before outer shell.

Discussion: (submit via email to brown@aoe.vt.edu)

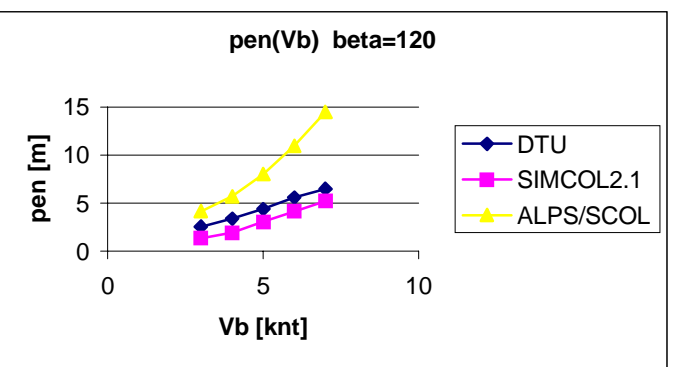
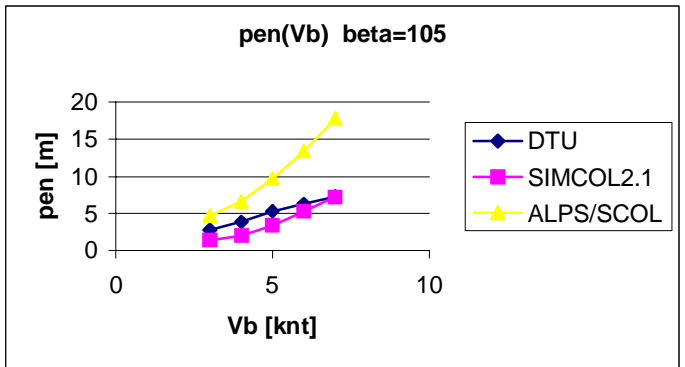
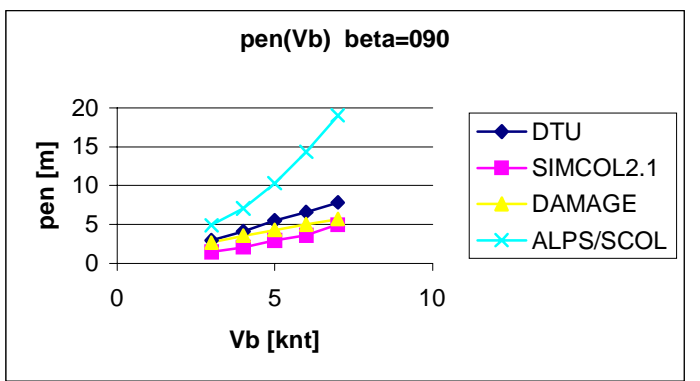
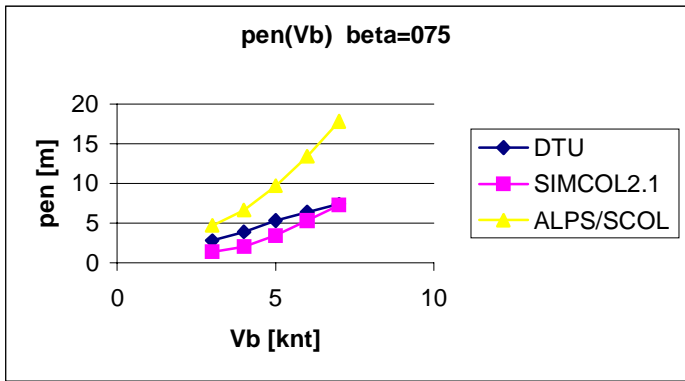
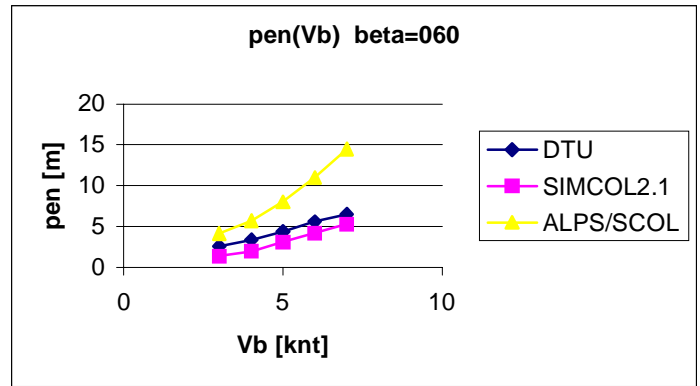
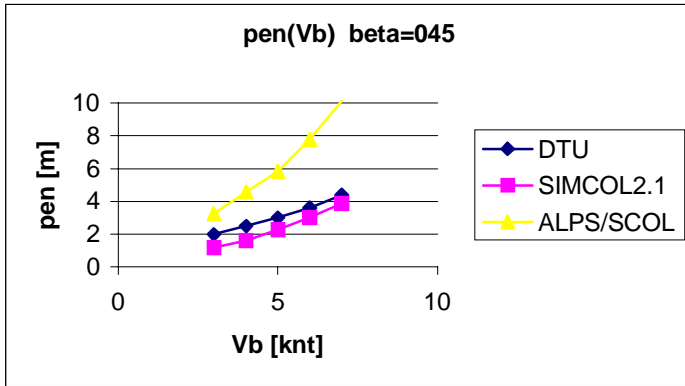
- There is reasonable agreement between SIMCOL2.1 and DTU at lower energy, but trends are quite different at higher energy where SIMCOL predicts a strong minimum at 90 degrees. SIMCOL is again much more sensitive to collision angle.
- At high energy and 90 degrees, SIMCOL2.1 predicts that the web is actually driven through the inner shell causing rupture before the outer shell is ruptured. High bending stress develops at the intersection of web and inner shell. This is a "hard spot" type of failure.

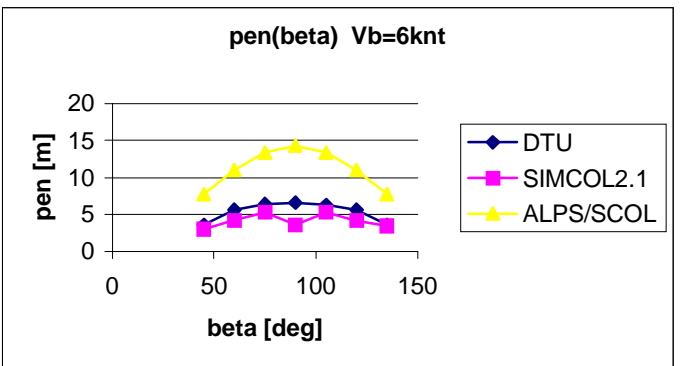
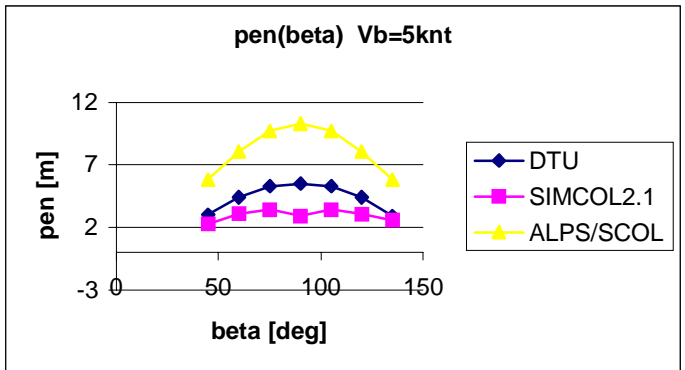
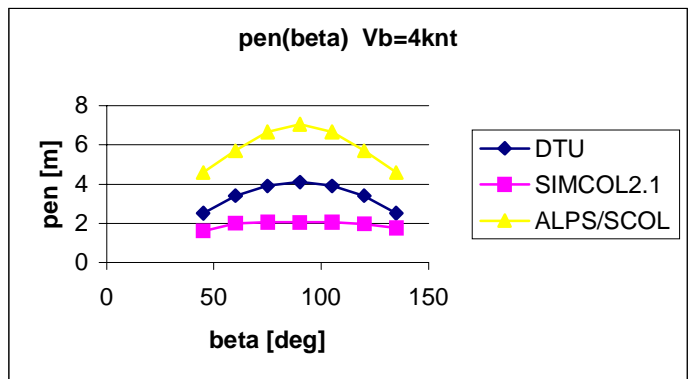
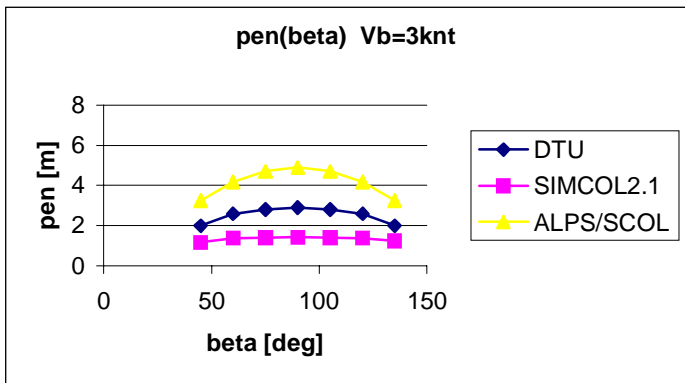
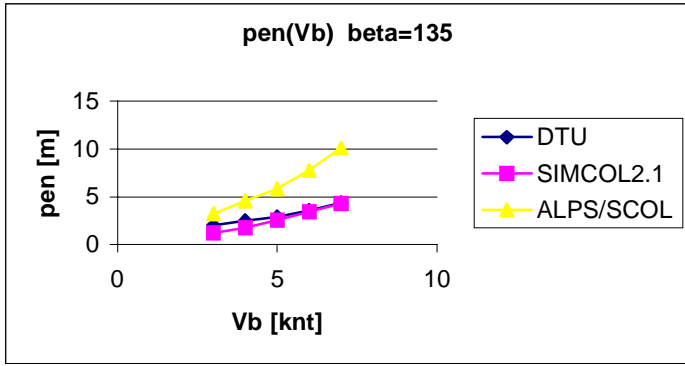
- At high energy SIMCOL2.1 predicts maximum penetration at 60 and 120 degrees due to substantially reduced membrane resistance as discussed in Matrix 1, and less web crushing as the penetration bypasses the web due to the angle. At larger angles (45 and 135 degrees) more energy is absorbed in longitudinal deformation and less in penetration.

Conclusions: (submit via email to brown@aoe.vt.edu)

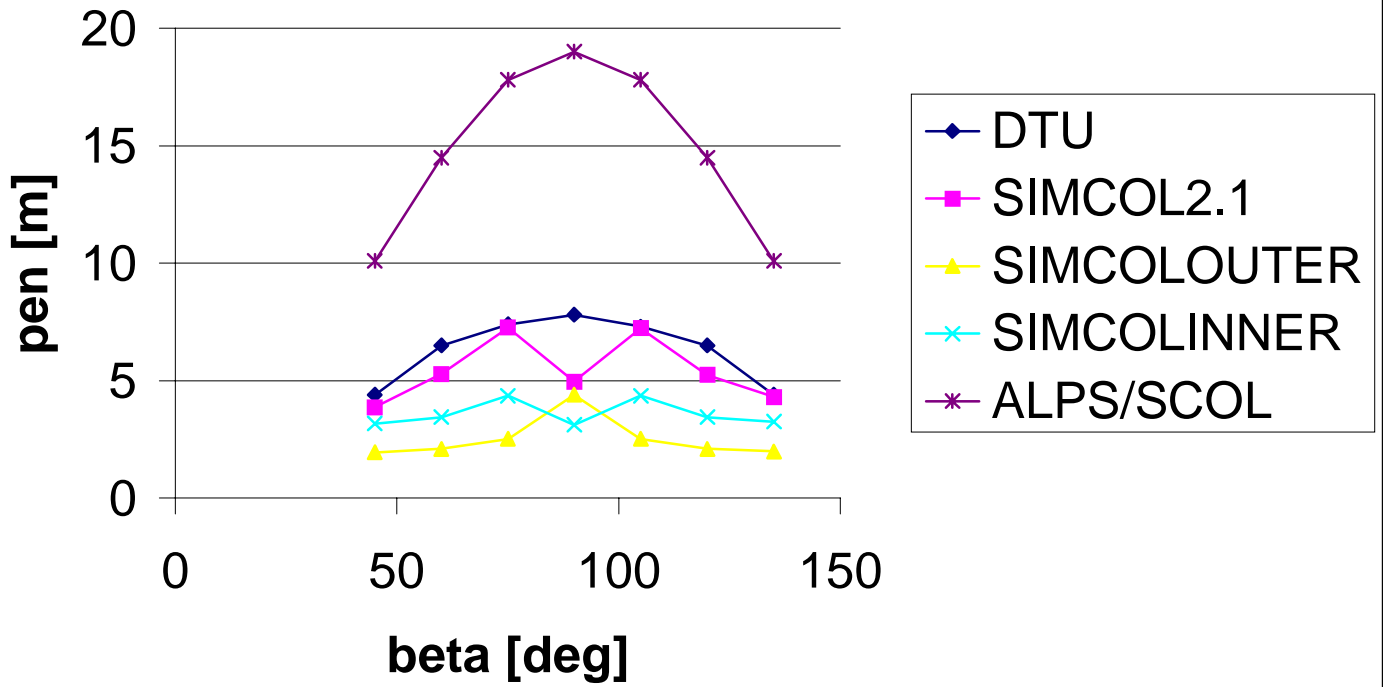
- The hard spot failure predicted by SIMCOL2.1 should be verified experimentally.
- Maximum penetration at other than 90 degrees with zero struck ship speed should also be verified experimentally.

Results:





pen(beta) Vb=7knt



Longitudinal extent of damage (SIMCOL 2.1):