Air Lubrication as a means to reduce Cost and CO2 emissions in Inland Shipping

Peter van Terwisga
• Introduction
• Energy and emission reduction in inland shipping
• Air Chamber Energy Saving (ACES) research
Turnover: 1.3 billion Euro

Employees:
- The Netherlands: 2,300
- International: 3,300
- Total: 5,600

Operating Companies:
- The Netherlands: 17
- Abroad: 18
- Total: 35

Annual deliveries:
- Tugs / Workboats: 83
- Offshore Vessels: 7
- High Speed Craft & Ferries: 39
- Dredging & Specials: 8
- Cargo Vessels/Inland & Coastal: 14
- Naval & Yachts: 9
- Total: 160
Damen Ships
Transport over water is energy-efficient!

“Binnenvaart Voortdurend Duurzaam” – Royal Haskoning
Energy and emission reduction; options

- Reducing Energy Consumption
  - Design for Service approach
  - Resistance reduction
- Improving the efficiency of energy conversion
  - Improving engine efficiency and matching engines to Operational Profile
  - Efficient propulsors
  - Fuel Cells
- Pre-, while- and aftertreatment of fuel and emissions
- Alternative fuels (LNG)
- Crew behaviour and operational strategy with a focus on fuel saving.
Resistance

Total resistance

% drag by component

Froude number

110 m ship, 18 km/hr
Reducing frictional resistance

- An (enduring) sleek surface
  - Anti-foulings
  - Maintenance
- Air lubrication
  - By airbubbles
  - By airsheet
  - By air cavity chambers
Project PELS II

PELS Participants

- VNSI
- Stichting BOS
- Atlas Copco
- International yachtpaint.com
- MARIN
- Van der Sluijs Groep
- DAMEN
- SpaarnWater
- MARInvention
• Insight in physics
  – Resistance reduction of two-phase flows and stability thereof
  – Resistance reduction by airfilms and air cavity chambers
  – Scale effects
  – Numerical modeling

• Design knowledge
  – Insight into the design consequences of airlubrication
• Patented Air Chamber Energy Saving System: Costeffective combination of air chamber concept and structural design
PELS II – Desk and Lab studies

<table>
<thead>
<tr>
<th>RESISTANCE TEST No.</th>
<th>9809051</th>
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<tbody>
<tr>
<td>SHIP MODEL No.</td>
<td>8910</td>
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<tr>
<td>DRAUGHT FWD</td>
<td>1.700 m</td>
</tr>
<tr>
<td>DRAUGHT AFT</td>
<td>1.700 m</td>
</tr>
<tr>
<td>SHIP SPEED $V_s$</td>
<td>13.00 KM/H</td>
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</tbody>
</table>

Length between perpendiculars 62.200 m
Breadth moulded 7.740 m
Design draught moulded 1.700 m
Displacement volume moulded 685.0 m³

Figure 2: Diagram of pressure distribution on the ship hull at 12 and 18 inch. The pressure distribution is separately flat between frames 2 and 18 unless the air valves are closed. As the ship speed increases, transverse waves are formed that solidity influences the pressure distribution on the hull.

CFD calculations and modeltests with a number of air chamber configurations: Resistance reductions in excess of 10% predicted for full scale.
• Spring 2009 – full scale reference tests
• Mid 2009 refit of air chambers to ship
• Autumn 2009 Air chamber tests
• Result: Depending on speed and loading condition a power reduction of 15%
• What does this mean for the environment?

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
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<tbody>
<tr>
<td>5000</td>
<td>Dutch inland ships</td>
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<tr>
<td>800</td>
<td>kW average installed power per ship</td>
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<tr>
<td>80.00%</td>
<td>load</td>
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<tr>
<td>180</td>
<td>g/kwh specific fuel consumption</td>
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<tr>
<td>4500</td>
<td>Sailing hours per year</td>
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<tr>
<td>2592000</td>
<td>ton fuel per year</td>
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<tr>
<td>8084448</td>
<td>ton CO2</td>
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<tr>
<td>1212667.2</td>
<td>ton CO2 savings at 15% resistance reduction</td>
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<tr>
<td>700</td>
<td>g/vkm HGV (CE Delft)</td>
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<tr>
<td>1732</td>
<td>mln equivalent Heavy Goods Vehiclekm’s</td>
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What does it mean for the inland shipping operator?

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<td>liter fuel per year</td>
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<td>€/1000 liter</td>
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<td>€/year</td>
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<td>€ fuel cost savings</td>
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</table>
SMOOTH project

- Shallow water effects research – Confirmation of savings
- Prototype air supply system development and validation of power requirement

Conclusion: ACES is ready for market introduction