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

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Contents

- Introduction
- Energy and emission reduction in inland shipping
- Air Chamber Energy Saving (ACES) research

GLOBAL ACTIVITIES DAMEN SHIPYARDS GROUP

▽ Damen Technical Cooperation projects (current and recent)

* Joint venture ** Business cooperation

THE NETHERLANDS

1. Damen Shipyards Gorinchem
2. Damen Marine Services
3. Damen Trading & Chartering
4. Damen Schelde Naval Shipbuilding
5. Damen Schelde Gears
6. Damen Schelde Marine Services
7. Amels
8. Bodewes Binnenvaart Millingen
9. Damen Dredging Equipment
10. Damen Marine Components Netherlands
11. Damen Shiprepair Rotterdam
12. Damen Anchor & Chain Factory
13. Damen Shipyards Bergum
14. Damen Shipyards Hardinxveld
15. Maaskant Shipyards Stellendam
16. Oranjewerf
17. Scheldepoort
18. Spares Services Maritime Europe
19. Van Brink Rotterdam
20. Visser Den Helder

EUROPE

1. Götaverken Cityvarvet
2. Damen Shipyards Gdynia
3. Damen Marine Components Gdansk
4. Damen Shipyards Kozle
5. Brixham Marine Services
6. Damen Shipyards Galati

AFRICA

1. Damen Shipyards Cape Town

MIDDLE EAST

1. Albwardy Marine Engineering*
2. Nakilat Damen Shipyards Qatar*
3. Damen Shipyards Sharjah (FZE)*

AMERICAS

1. Damex*
2. Wilson, Sons**

ASIA PACIFIC

1. Damen Marine Components Suzhou & Damen Trading Suzhou
2. Damen Yichang Shipyard*
3. Damen Shipyards Changde
4. Afai Southern Shipyard**
5. Song Cam Shipyard**
6. Damen Vinashin Shipyard*
7. Song Thu Shipyard**
8. Damen Shipyards Singapore & Spares Services Maritime Asia
9. PT Dumas**

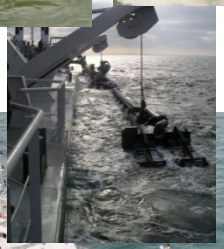
DAMEN SHIPYARDS GROUP

FACTS AND FIGURES 2009

Turnover:	**1.3 billion Euro**
Employees:	
• The Netherlands	2.300
• International	3.300
	5.600
Operating Companies:	
• The Netherlands	17
• Abroad	18
	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
	160

Damen Ships



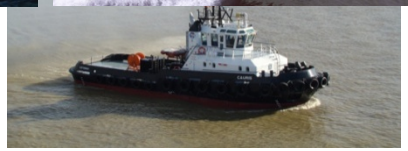
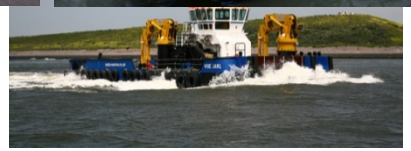










Damen Ships

Energy and emissionreduction inland shipping

Transport over water is energy-efficient!

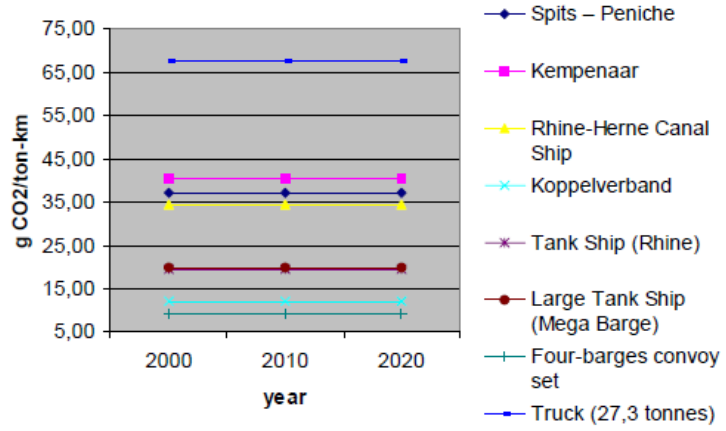


Figure 4: Carbon Dioxide emissions for 2000, 2010 and 2020 for BULK SHIPPING

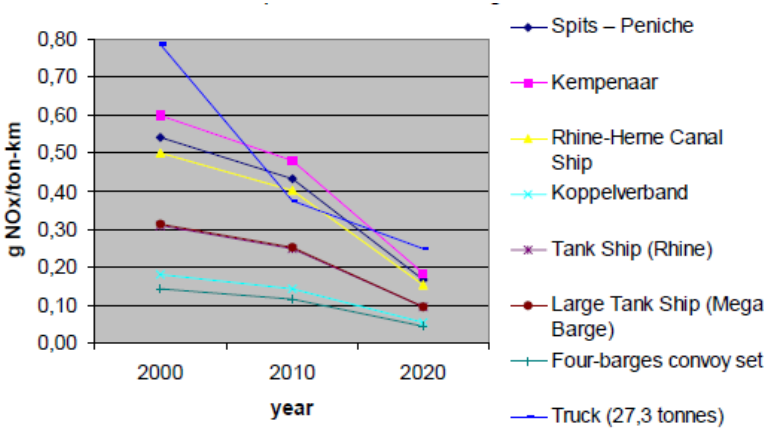


Figure 2: Nitrogen Oxide emissions for 2000, 2010 and 2020 for BULK SHIPPING

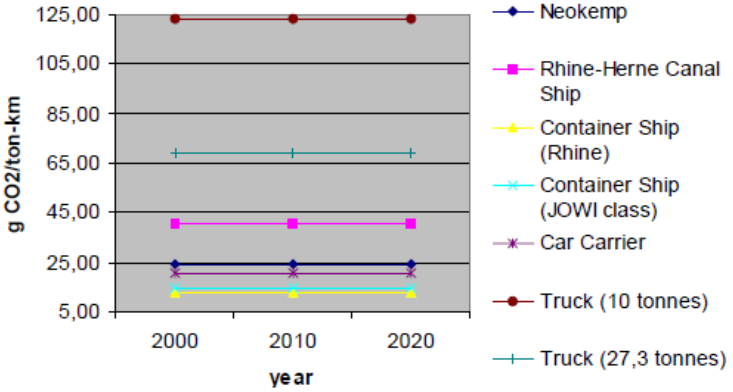


Figure 5: Carbon Dioxide emissions for 2000, 2010 and 2020 for NON-BULK SHIPPING

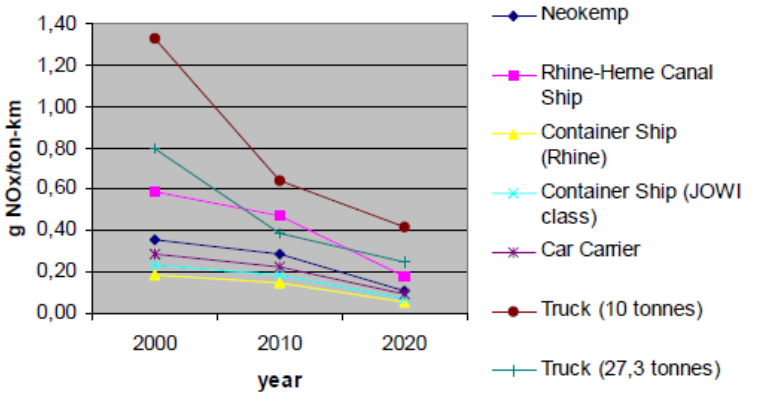


Figure 3: Nitrogen Oxide emissions for 2000, 2010 and 2020 for NON-BULK SHIPPING

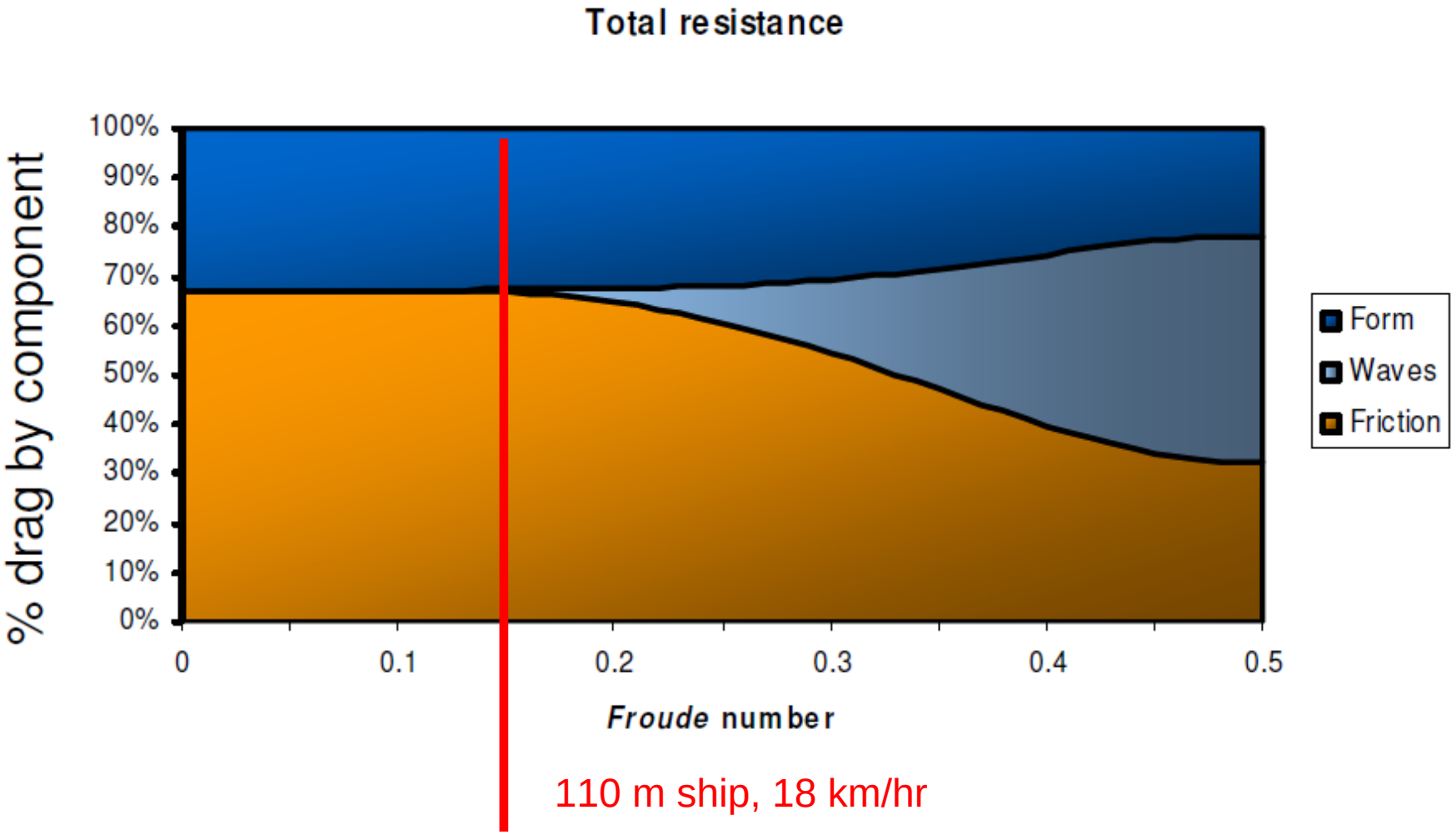
"Binnenvaart Voortdurend Duurzaam" – Royal Haskoning

Energy and emissionreduction inland shipping

Energy and emission reduction; options

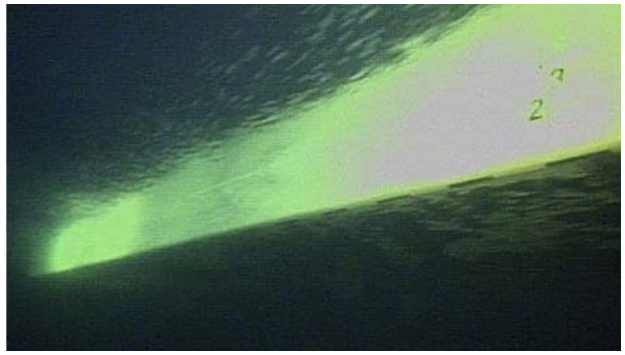
- Reducing Energy Consumption
  - Design for Service approach
  - Resistance reduction **ACES**
- Improving the efficiency of energy conversion
  - Improving engine efficiency and matching engines to Operational Profile
  - Efficient propulsors
  - Fuel Cells
- Pre-, while- and aftertreatment of fuel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

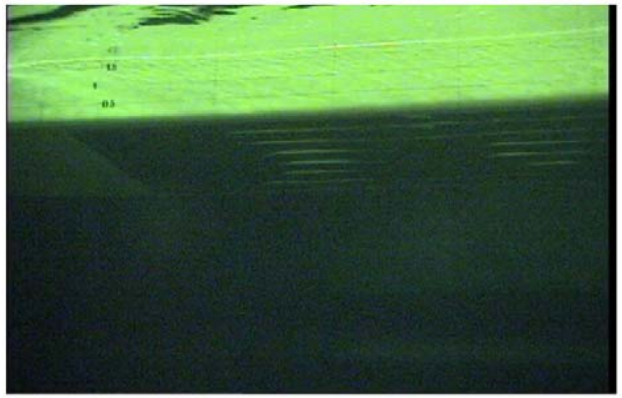
Resistance


Total resistance
% drag by component
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.1
0.2
0.3
0.4
0.5
Froude number
Form
Waves
Friction
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



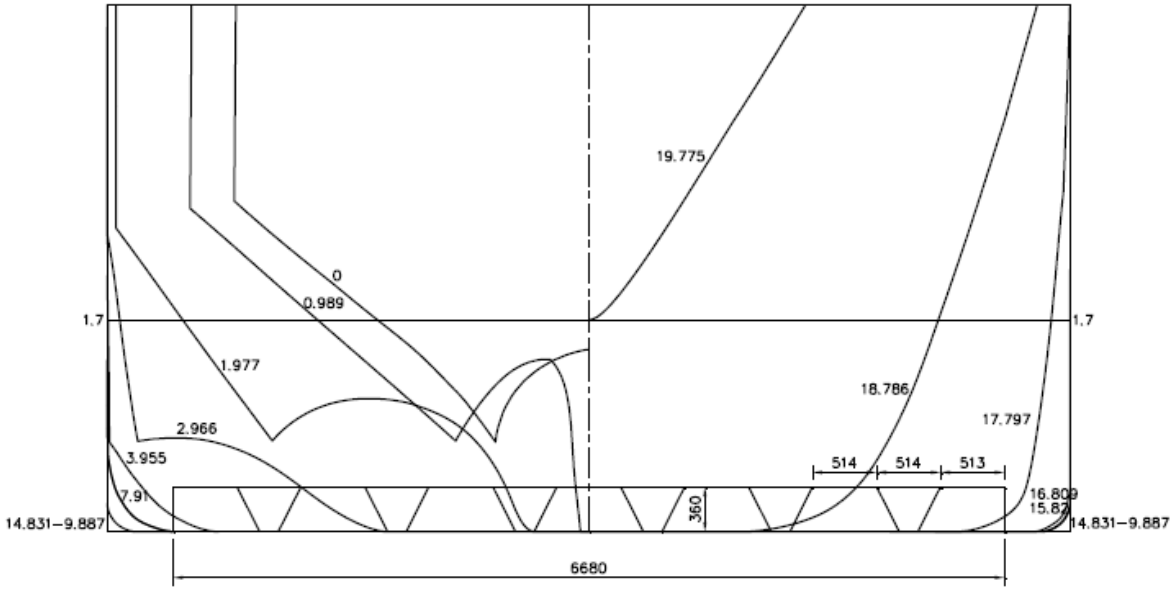


Project PELS II

PELS II: Aims

- 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

PELS II: Project workplan



- Patented Air Chamber Energy Saving System: Costeffective combination of air chamberconcept and structural design

PELS II – Desk and Lab studies

RESISTANCE TEST No. : 9809051
SHIP MODEL No. : 8910

DRAUGHT FWD : 1.700 m
DRAUGHT AFT : 1.700 m

SHIP SPEED V_s : 13.00 KM/H

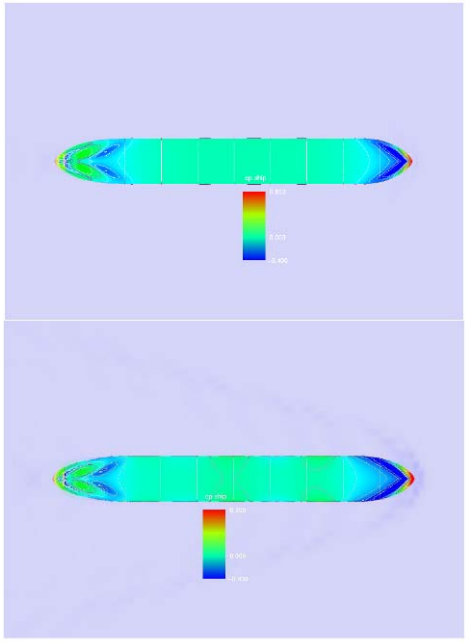
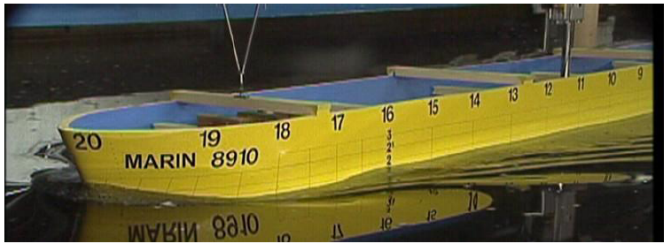
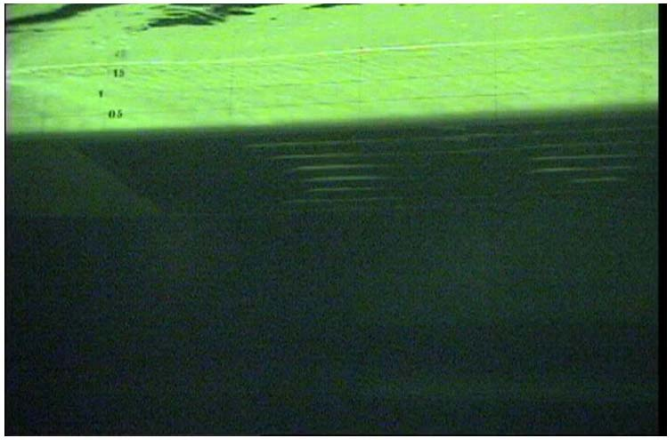


Figure 2 Dimensionless pressure distribution on the ship hull at 13 and 19 km/h. The pressure distribution is reasonably flat between frames 4 and 16¼ where the air cavities are situated. As the ship speed increases, transverse waves are formed that visibly influences the pressure distribution on the hull.



WAVE PROFILES



13 km

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

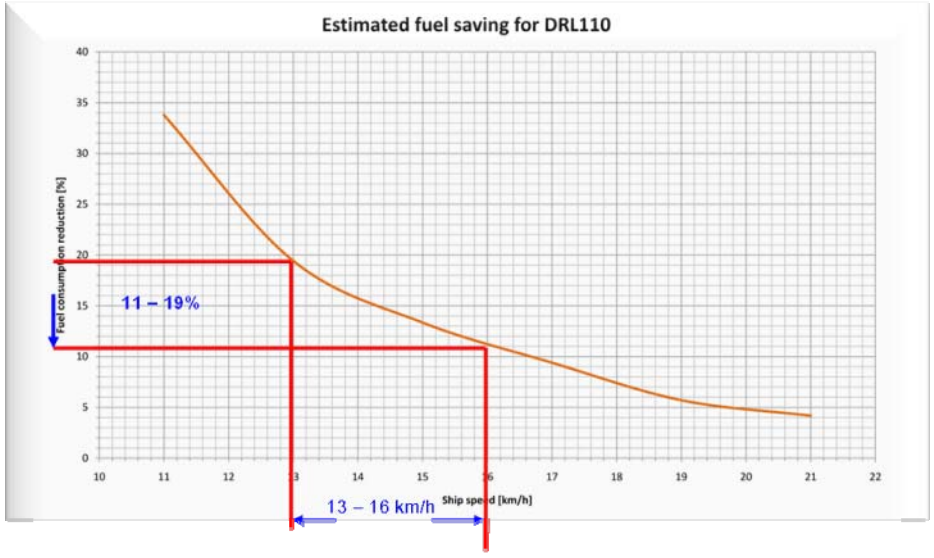
CFD calculations and modeltests with a number of air chamber configurations: Resistance reductions in excess of 10% predicted for full scale

PELS II: Full Scale Testing

- Spring 2009 – full scale reference tests
- Mid 2009 refit of air chambers to ship
- Autumn 2009 Air chamber tests

PELS II: Projectuitvoering

- Result: Depending on speed and loading condition a power reduction of 15%



PELS II: Effects

- What does this mean for the environment?

5000	Dutch inland ships
800	kW average installed power per ship
80.00%	load
180	g/kwh specific fuel consumption
4500	Sailing hours per year
2592000	ton fuel per year
8084448	ton CO2
1212667.2	ton CO2 savings at 15% resistance reduction
700	g/vkm HGV (CE Delft)
1732	mln equivalent Heavy Goods Vehiclekm's

PELS II: Effects

- What does it mean for the inland shipping operator ?

800	kW average installed power per ship
80.00%	load
180	g/kwh specific fuel consumption
4500	Average sailing hours per year
612748.8	liter fuel per year
450	€/ 1000 liter
275737	€/year
41361	€ fuel cost savings

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