Optimisation of an Air Lubrication System for Geometry and Topology:

A Proposed Solution for Ship Retrofitting

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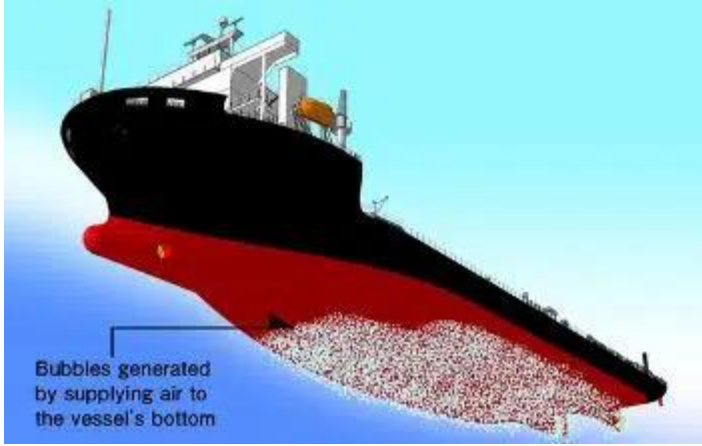
Air Lubrication Systems

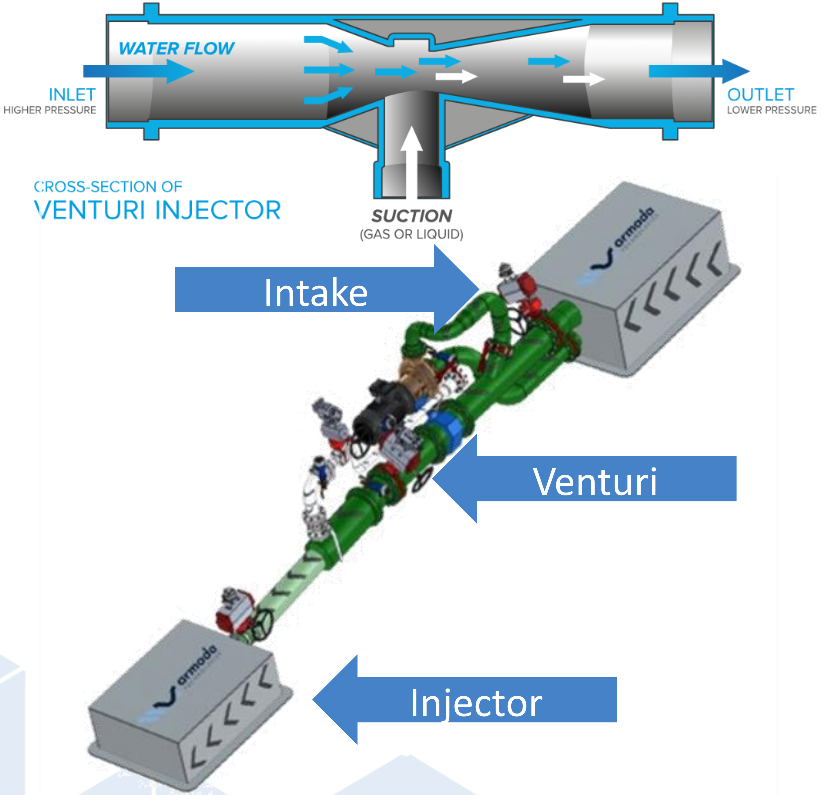
- A significant amount of air has to be pumped underneath the hull.
- Approx. 1bar hydrostatic pressure head per 10m draught.
- Large-scale compressors require space and energy.
- Sufficient GenSet or PTO capacity required.



Generic image from *MarineInsight*!

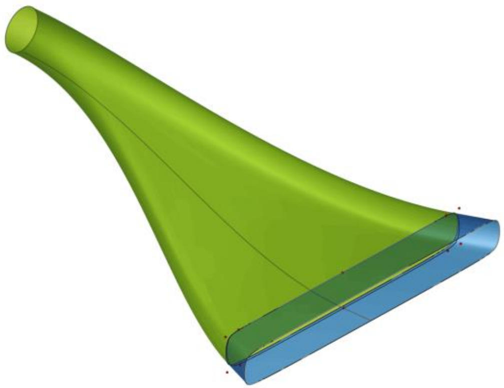
Passive Air Lubrication

- Use dynamic pressure of ship's forward speed as "implicit" PTO.
- Use venturi pumps mounted in double bottom to "suck" air down.
- Water – Air <u>mixture</u> (bubbles) coming out of Venturi.



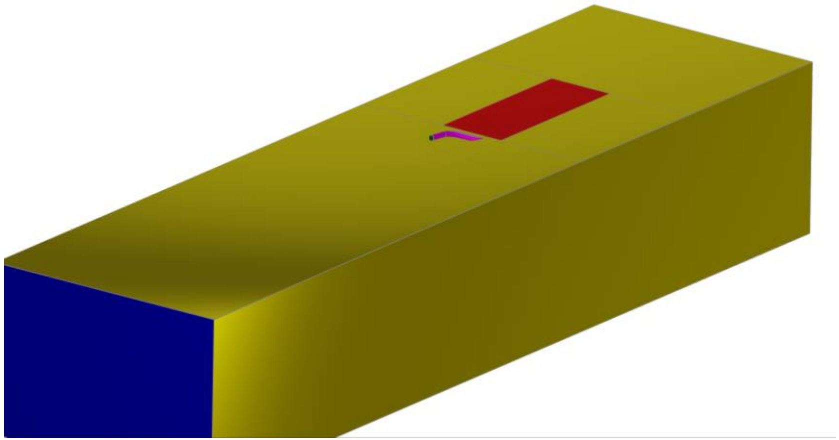
Parametric Geometry Modelling of Intake / Injector

- Fully parametric model in CAESES.
- Modelled beyond the ships bottom – trimmed-off later
- Six parameters used to vary:
  - Opening size and shape
  - Length and height
  - Diffusor angle



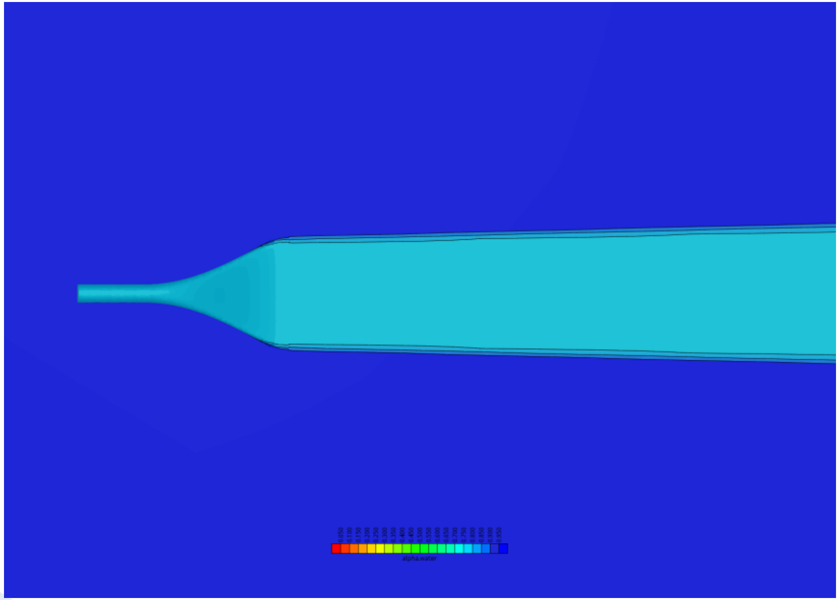
CFD-Setup

- Intake / Injector:
- Domain modelled after HyKat dimensions
- Multiphase flow (VoF-model)
- Air phase fraction according to hydrostatic pressure and ideal gas law
- Viscous force on balance plate (red) evaluated



Optimisation: Intake / Injector

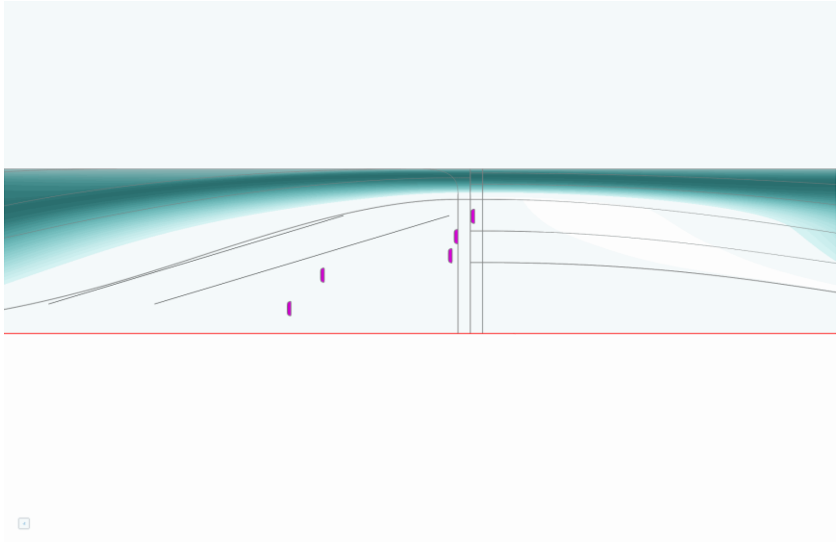
- 35 Variants evaluated in design space exploration (Sobol).
- Qualitatively “unstable“ variants excluded from results pool.
- 5 Further variants evaluated in response surface-based optimisation.



Parametric Geometry Modelling

Arrangement:

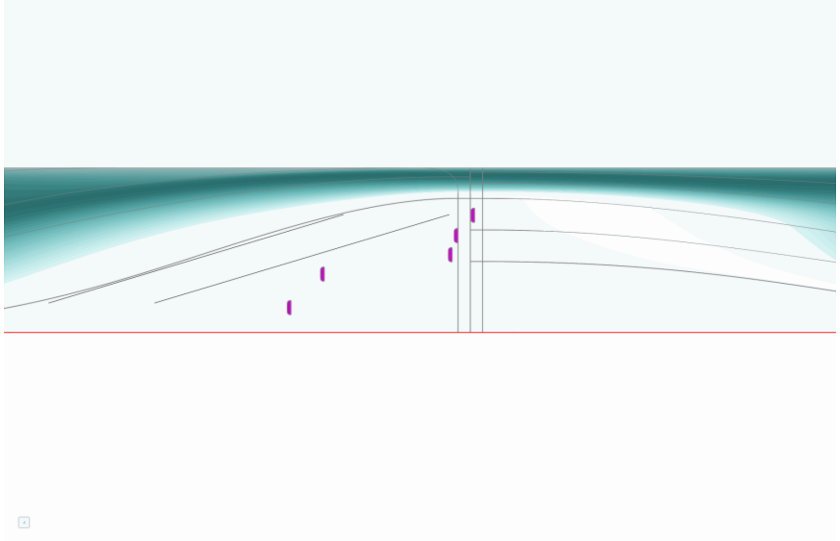
- Only injectors modelled as for towing tank model.
- Fixed geos for hull and injectors.
- Five systems per side.
- Limited to flat-of-bottom region.



Parametric Geometry Modelling

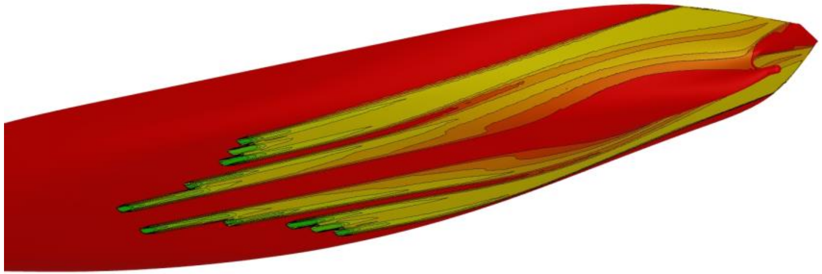
Arrangement:

- Relative locations formulated as parameters to avoid interference.
  + Avoids using constraints in optimization.
  – Introduces cross-correlation between parameters.



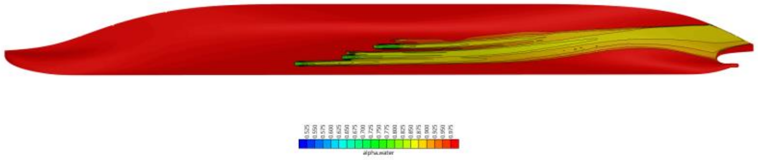
CFD-Setup

- Arrangement
- Double-body-setup
- Multiphase flow (VoF-model)
- Air phase fraction according to hydrostatic pressure and ideal gas law
- Viscous force and volume fraction on hull evaluated



Optimisation: Arrangement

- 70 Variants evaluated in design space exploration (Sobol).
- Unplausible outliers excluded from results pool.
- 13 Further variants evaluated in response surface-based optimisation.



Conclusions

- A Passive Air Lubrication System has been developed and optimised.
- Numerical methods have deciding role in evaluation and optimisation process.
- Experimental tests support promising CFD results.
- As always, the proof is in the pudding (in vivo installation). TBC.

Acknowledgement

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Thank you for your attention!

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