Design for Reliable Steerable Thrusters by Enhanced Numerical Methods and Full Scale Optimization of Thruster – Hull Interaction Using CFD

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Topics

- Introduction
- Computational Model
- Numerical Calculation
- Experimental Method and Model Test
- Conclusion
Development CFD
Hydrodynamic Optimization
Conservation law of mass
(Continuity equation)

\[
\frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial y} + \frac{\partial u_z}{\partial z} = 0
\]

Conservation law of momentum
(Navier-Stokes equation)

\[
\frac{\partial u_i}{\partial t} + \frac{\partial (u_j u_i)}{\partial x_j} = -\frac{1}{\rho} \frac{\partial p}{\partial x_i} + \nu \left( \frac{\partial^2 u_i}{\partial x_j^2} + \frac{\partial^2 u_j}{\partial x_i^2} \right)
\]
An automatic calculation strategy is developed that includes the following tasks:

- parametrisation of the Thruster geometry
- automatic 3D geometry generation
- automatic mesh generation for CFD calculations
- automatic post processing of CFD results
- embedding the procedure within an optimisation loop
Optimisation run of propeller nozzle
Arrangement of pontoons and thruster
Hydrodynamic Parameter

Total Thrust Ratio $\tau$

$$\tau = \frac{Fh}{Th}$$

$Fh$ - Resulting total horizontal force

$Th$ - Horizontal thrust component of the thruster

Relative Efficiency $\xi$

$$\xi = \frac{\eta_o}{\eta_I}$$

$$\xi(J = 0) = \frac{Fh^2}{\sqrt{\frac{\rho}{2}A_02P_D}}$$

$$\eta_I = \frac{2}{1 + \sqrt{c_{Th} + 1}}$$
Velocity distribution
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Pressure distribution
Stream lines

6°
Stream lines
Stream lines
Stream lines

9°
Stream lines
Vortex generation, inhibiting efficient nozzle inflow at 7° tilt angle

No vortex generation at 8° tilt angle, efficient nozzle flow
Effective thrust due to interaction effects

![Graph showing the relationship between total thrust ratio and tilt angle. The graph illustrates an increasing trend in effective thrust as the tilt angle increases.]
Transverse forces, acting on both pontoons, the maximum force on pontoon 2 is scaled as 100%.
Model test arrangement
Technics of Measurement

VRP
Measuring system for
Azimuthdrives

- Thrust X- and Y-direction
- Torque input
- Thrust propeller
- Torque single blade or
  Torque propeller
- Torque steering gear
Model test arrangement
Model test arrangement
Model test arrangement
Propeller wake at 0° and 8° tilt angle
Pontoon 1

$\alpha = 0^\circ$

$\alpha = 8^\circ$
Propeller wake at $0^\circ$ and $8^\circ$ tilt angle

Pontoon 2

$\alpha = 0^\circ$

$\alpha = 8^\circ$
Tilt Angle and Efficiency

![Graph showing the relationship between Tilt Angle and Efficiency.](image-url)
Transverse forces, acting on pontoon 2; the maximum force on pontoon 2 is scaled as 100%; comparison of full scale CFD calculation and model test data
Conclusion

- Clear influence of the tilt angle on the thrust losses
- CFD is capable to calculate the flow field of a thruster and its interaction with two pontoons
- Strong reduction of the thrust losses for a tilt angle of 8°.
- Simple experimental method has been developed which allows a fast test of the interaction between a thruster and two pontoons.
- The developed methodology offers a fast optimization of offshore platforms and thruster arrangement.
- It is possible to adapt the CFD technology and the experimental method to other platform and thruster designs.
Thank you for your attention!