Thrusters

Dynamics of Propeller Blade and Duct Loading on Ventilated Thrusters in Dynamic Positioning Mode

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Propeller and thruster models

Open thruster

Ducted thruster
Test set-up for ducted thruster tests
Test set-up for open thruster tests

- Electric motor
- Pulse meter
- MC-Lab rig
- 6 component balance
- Measurement blade
Tested parameters

- All tests
  - Different propeller rate of revolutions
  - Speed (negative, zero and positive)
- Constant immersion tests
  - Different immersion ratios
  - Different azimuth angles
- Dynamic azimuthing tests
  - Different immersion ratios
- Dynamic vertical motion tests
  - Different starting immersion ratios
  - Different amplitudes
  - Different periods
Open thruster; funnel centre on water surface
h/R = 2.6 (constant immersion)
Open thruster; shaft immersion ratio at highest position $h/R=-0.15$, amplitude $R=2.15$, period=2s
Continued…

Open thruster; shaft immersion ratio at highest position $h/R=-0.15$, amplitude/$R=2.15$, period=$2s$
Ducted thruster; shaft immersion ratio at highest position $h/R=-0.08$, amplitude/$R=1.8$, period=4s
Open thruster; Relative blade thrust
min. $h/R = -0.15$; amplitude$/R = 2.15$; $T = 2$ s
Open thruster; Low pass filtered blade thrust; min. $h/R=-0.15$; amplitude$/R=2.15$; $T=2$ s
Open thruster; Shaft freq. fluctuations in blade thrust; min. $h/R=-0.15$; amplitude$/R=2.15$; $T=2s$
Ducted thruster; Relative blade thrust
min. $h/R=0.08$; amplitude/$R=1.8$; $T=4$ s

![Graph showing dynamics of propeller blade and duct loadings on ventilated thrusters in dynamic positioning mode.](image-url)
Ducted thruster; Low pass filtered blade thrust; min. h/R=0.08; amplitude/R=1.8; T=4 s
Ducted thruster; Shaft freq. fluctuations in blade thrust; min. \( h/R = 0.08 \); amplitude/\( R = 1.8 \); \( T = 4 \) s

![Graph showing fluctuations in thrust and \( h/R \) over time.](image-url)
Time-averaged ducted thruster loadings under constant immersion
Comparison of time-averaged loadings of ducted & open thrusters under constant immersion

- Total_Thrust / Total_Thrust0 (Ducted prop.)
- FX / FX0 (Ducted prop.)
- FX / FX0 (Open prop.)
- out-of-water factor
Time-averaged ducted thruster loadings under forced heave motion

Graph showing the relationship between h/R at highest position and the out-of-water factor, as well as average loadings for FX/FX0, MX/MX0, Total_Thrust/Total_Thrust0, and Duct_X/Duct_X0.
Time-averaged relative blade thrust of open thruster under forced heave motion

Graph showing the relationship between the out-of-water factor and h/R at the highest position. The graph includes two lines:
- **Average FX/FX0**
- **out-of-water factor**

The x-axis represents h/R at the highest position, ranging from -1 to 2.5, while the y-axis represents the out-of-water factor, ranging from 0.0 to 1.0.
Concluding remarks

- Fluctuations in blade thrust and blade torque are quite significant when a thruster is ventilated.
- Ventilation influences both the dynamic and static loadings.
- More ventilation leads to less available blade thrust, blade torque, duct thrust and consequently total thrust.
- Under ventilated conditions, fluctuations in blade torque are almost identical to fluctuations in blade thrust.
- Loading fluctuations due to ventilation must be taken into account at the design stage.