Full scale CFD simulation of Azipod unit performance at varied steering angles

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ABB Marine and Cranes overview
Global leader in power and automation

Leading supplier of
- Electric power plant & propulsion
- Azipod® propulsors and thrusters
- Drives for offshore oil drilling process
- Automation and electrification for Harbor cranes

Market leader
- Cruise ships
- Ice breakers
- Offshore supply vessels
- LNG carriers
- Oil drilling vessels

Global operations
- Presence in > 20 countries
- Main business centers in Finland, Norway, China and Singapore
Azipod® - The most environmental friendly propulsion system

- Azimuthing electric propulsion and thruster system
- Electric motor inside a submerged pod
- Speed controlled fixed pitch propeller
- Propulsion module can be rotated 360 degrees around its vertical axis
- Azipod® is a registered trade mark of ABB
Introduction

- CFD simulation of Azipod unit
  - Pulling type propeller
  - Full scale RANS with SST (Menter) $k-\omega$ turbulence model
  - Comparison to experiments

Homogeneous inflow to propeller

Direction of travel
Definition of dimensionless parameters

- Advance number $J = \frac{V}{nD}$
  
  Velocity $V$, Propeller rotation speed $n$, Propeller diameter $D$

- Thrust coefficient of the propeller $KT = \frac{T}{\rho n^2 D^4}$
  
  Water density $\rho$, Propeller thrust $T$

- Torque coefficient of the propeller $KQ = \frac{Q}{\rho n^2 D^5}$
  
  Propeller torque $Q$

- Thrust coefficient of the pod unit $KT_{unit} = \frac{T_{unit}}{\rho n^2 D^4}$
  
  Pod unit thrust $T_{unit}$

- Open water efficiency of the propeller $eff = \frac{JKT}{2\pi KQ}$

- Open water efficiency of the pod unit $eff_{unit} = \frac{JKT_{unit}}{2\pi KQ}$
Simulation case 1:
Open water performance of Azipod unit at full scale

- propeller efficiency
- pod unit efficiency
- propeller torque KQ
- propeller thrust KT
- pod unit thrust KT_unit

exp – model test scaled to full scale
MRF – moving reference frame
SM – sliding mesh
Simulation case 1: Open water performance of Azipod unit at full scale
Simulation case 2: Azipod unit performance at varied steering angles at full scale

- Steering angles between ± 90 degrees were simulated using unsteady sliding mesh approach for capturing hydrodynamic loads on propeller and pod surfaces.
- These loads are further utilized in the strength analysis and compared to sea trial measurements.

Flow fields at varied steering angles at random time
Simulation case 2: Azipod unit performance at varied steering angles at full scale

Pressure and suction sides of propeller blades at a steering angle
Average pressure per one propeller revolution
Conclusions

- Open water performance of Azipod unit is performed at full scale and compared to experiments.
- Full scale simulations at varied steering angles:
  - Hydrodynamic loads are further utilized in the strength analysis.
  - Comparison to sea trial experiments.
- Unsteady sliding mesh approach is very time-consuming for daily work:
  - Alternative approaches for describing propeller rotation are needed.
  - MRF, virtual disk model, coupled CFD-BEM for propeller–pod behavior.
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