THRUSTERS SESSION

DP Capabilities of Tilted Thrusters

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DP-CAPABILITY OF TILTED THRUSTERS

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Wartsila FS3510 steerable thruster

Key features

- New Nozzle design WTN.
- Advanced strut design.
- Advanced propeller gearbox design for 90-degree and 82-degree transmission.
- Higher torque on propeller-shaft allows for larger propeller.

- Optimized 4-bladed propeller design (3.9 meter) with minimum tip clearance.
Concept of tilted thrusters

- Jet out of thruster is deflected downwards to minimize interaction with hull.
- Jet deflection is obtained with 8-degree tilted nozzle and propeller.
- Propeller and nozzle are now aligned to give optimum tip clearance.
- Gearbox has 82-degree transmission.
Numerical analysis method

- The results presented are based on numerical flow simulations, also called CFD (Computational Fluid Dynamics).
- With a CFD method the flow field of the actual full scale situation can be calculated.
- Developments in simulations are enormous, due to continuous increasing computing power.
Roadmap for DP-calculations

- Thruster interaction losses
- Thruster 360 degree azimuthing performance
- Thruster open water performance
- Vessel performance with 8 thrusters
Thruster performance

• Unit performance
  – Model scale experiments
  – Validation calculations with CFD on model scale
  – Full scale performance calculations

• Thruster-hull interaction
  – Method development in cooperation with Trust JIP
  – Full scale calculations on actual drill rig

• Thruster-thruster interaction
  – Full scale calculations of straight and tilted units
Thruster performance: comparison with measurements

- Performance on model scale agrees well with measured performance for all advance speeds.
- The flow into the thruster is dependent on the working point, clear differences can be observed between low and high advance speeds.
Thruster-hull interaction along hull

- The 8-degree tilted solution deflects the jet sufficiently downward to minimize the hull-interaction effects.
- Effective mean deflection is 5 degrees for 8-degree geometrical tilt angle.

Straight unit
Interaction of jet with hull due to diverging jet

8-degree tilted unit
No interaction of jet with hull
(hull fouling will not lead to thrust degradation)
Thruster-hull interaction: Drill rig at DP

- The impact of the jet of the conventional unit is diminished when tilted thruster unit is used.
- Thrust-deduction factor $t$ in sideways operation drops from approx. 0.50 for straight to approx. 0.05 for tilted unit.

8-degree tilted unit gives 5 degree effective deflection

Straight unit:
- No deflection of jet
- $t = 0.50$

8-degree tilted unit:
- Clear deflection of jet
- $t = 0.05$
Thruster-thruster interaction

- Thruster-thruster interaction occurs when the jet from the upstream unit is directed into the downstream thruster (see top view):

- This phenomenon depends on:
  - Thruster type (tilt-angle)
  - Distance between two units
  - Steering angle of upstream unit

- All conditions have been analyzed with CFD method based on fully transient approach.
Thruster-thruster interaction

- For the determination of thruster-thruster interaction a numerical model consisting of 2 units has been made, either straight or tilted.
- The streamlines show the jet out of the thrusters in aligned steering angle configuration.
Roadmap for DP-calculations

- Thruster interaction losses
- Thruster 360 degree azimuthing performance
- Thruster open water performance
- Vessel performance with 8 thrusters

DP-capability
Drill-rig example case to determine DP-capability

- Example case of drill-rig with 8 steerable thrusters.
  - First, the performance of a single thruster is evaluated for each steering angle (0-360 degrees).
  - Second, the performance of all 8 units is combined.

- Performance is based on:
  - Thrust losses due to thruster-hull interaction
  - Forbidden zones of operation due to thruster-thruster interaction

Arrows indicate direction of the jet flow out of the thruster. The thrust is generated in opposite direction.
Single thruster performance polar plot

- The effect of **thruster-hull interaction** losses are shown in the polar plot below.
- The white areas indicate losses due to thruster-hull interaction.
Single thruster performance polar plot

- The effect of **thruster-thruster interaction** losses are shown in the polar plot below.
- The white areas indicate forbidden zones due to thruster-thruster interaction losses.
The combined polar plot of the available thrust of one thruster unit is shown below.

The white areas indicate forbidden zones, either due to thruster-thruster interaction losses or due to severe thruster-hull interaction losses.
Comparison straight and tilted thrusters

- A comparison is shown below for the zones of operation (and the forbidden zones) for the straight and tilted thruster units.
- The benefits of the tilted unit are best recognised in the larger blue areas in the region between 0 and 180 degrees for this unit.
Effects of thruster position

- The interaction effects depend on the position of the thruster on the vessel.
- A comparison for available thrust based on two different locations on the hull is presented below.
Overall vessel performance with 8 thrusters

• The overall vessel performance is based on the combined performance of 8 single thrusters over the range from 0 – 360 degrees.
• The steering direction of each thruster has been adopted to avoid operation in a forbidden zone.
Comparison straight and tilted thrusters

- A comparison is shown below for thrust performance of the vessel with 8 thrusters for the straight and tilted thruster units.
- The benefits of the tilted unit are best recognised in the larger blue areas in the regions between 45-135 and 225-315 degrees for this unit.
Comparison straight and tilted thrusters

- The normalized thrust in each direction has been compared for the conventional straight unit and the tilted thruster unit.
- The gain in effective thrust in DP-mode is at minimum 8% and at maximum 35%, depending on the direction of thrust.
Summary of route for DP-capability analysis

- Concept study + detailed design
- Thruster performance
- Thruster interaction losses
- Effective azimuthing thrust
- DP-capability
Conclusions

• The full scale performance of steerable thrusters has been determined with aid of CFD analyses.

• The thruster interaction losses can be reduced dramatically when the jet is deflected sufficiently downwards. This is achieved with an 8-degree tilted unit.

• For a proper DP-capability calculation, both the thruster-unit performance and the thruster-hull interaction factors have to be taken into account accurately.

• The 8-degree tilted units give a significantly improved DP-capability, which is in line with ABS-guidelines.

• The clear benefits of tilted thruster units have to be taken into consideration when vessels are designed.