IOT R&D Activities in Supporting the 25th ITTC Ice Committee Work

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Outline

- ITTC ice committee mandate
- Overview of IOT’s R&D activities in supporting the committee mandate
Recommendation from 24th ITTC

• (1) Develop a procedure for testing of podded propellers in ice
• (2) Develop a procedure for ship tank testing in brash ice.
• (3) Review existing testing procedures used to determine loads and responses of offshore structures in ice
IOT’s R&D Activities Related to Committee’s Mandate No. 1

• Develop a procedure for testing podded propellers in ice tank

  – Phase 1: (a) development of pod model and measure of ice impact and milling load on podded propellers–Akinturk and Wang (2004-2007)

  – Phase 2: Simulating vessels driven by podded propulsors – Lau and Akinturk (2008)
Phase 1: Ice Loads on Pods

Partially assembled model showing the measuring system
Pod Assembly

Aft Dyno

Forward Dyno

Blade Dyno Position
Ice-Pod Interaction Experiment

Fully assembled model
Example Run – ice impact load (pre-broken ice)

1 & 2 View from side showing false stern

3 View from below showing propeller breaking ice

4 Propeller hits the ice
Ice Milling Load Experiment

Sample time series data
Numerical Results

• Numerical prediction for the propeller ice milling load was performed (Wang et al, 2006)

• Ice related loads were calculated with the azimuthing angle between 180 and 90 for the tractor mode

• The numerical predictions have a good agreement with experimental results at low advance coefficients (less than 0.4)

Comparisons (Shaft, Ice Related Loads, 150 Deg.)
Phase 2: Ice loads on Poded Propeller During Ship Maneuvering - Overview

- This study investigates the performance of ship model with podded propulsors (APP) in various (realistic) operating conditions: open water and different level ice and pack ice conditions, straight run and various manoeuvres using PMM.
- The model used in this phase was the icebreaker Mackinaw equipped with twin podded propulsors.
- Measurement include steering moment generated by the propulsors, thrust and torque of the propellers, and the force and moments on the hull body.
- Preliminary results on the APP were presented by Akinturk and Lau (2008).
Experimental Set-Up

USCG Mackinaw Model

Planar Motion Mechanism
Example Run
Results

Steering Moment Coefficient

![Graph showing steering moment coefficient (CS) vs. azimuthing angle for Pods A and B. The graph includes data for different opening sizes and initial lengths.]
Results

Pod A - Thrust Coefficient

$K_{TA}$

Azimuthing Angle (Pod A) (degrees)
Results

Pod A - Torque Coefficient

10K_{QA}
Results

Pod A - Unit Thrust Coefficient

$K_{F_XA}$
Results
Pod A - Side Force Coefficient

$K_{F_{Y_A}}$
Results

Pod B - Thrust Coefficient

\[ K_{TB} \]
Ice loads on Podded Propeller – Further Work

• Complete data analysis with different hull velocity and maneuvers, including the loading on the hull
• Conduct additional tests with a second icebreaker (MOERI’s new icebreaker Arion) – also measure pressure distribution on hull
• Develop tools for performance prediction and simulator application
• Develop in-house standards and procedures governing ship testing (propulsion and maneuvering) with APP
IOT’s R&D Activities Related to Committee’s Mandate No. 2 - Brash Ice Test

• Develop a procedure for ship tank testing in brash ice
  – Most test were performed by Arctic and HSVA to provide commercial testing of Baltic ice-going ships
  – First test in IOT

• Collaboration with MOERI to co-develop testing procedure and techniques to test ships in brash ice

• It involved ice tests of the CCGS Terry-Fox transiting in a brash ice channel conducted and analyzed as per IOT's standard for model propulsion in ice.

• The Finnish-Swedish Ice Class Rules (FSICR) class 1A was targeted

• New brash ice production techniques were introduced and the results of ship resistance and propulsion performance were summarized in Lee and Lau et al (2008).
Brash Ice Test – Brash Ice Production

- For the present model tests, the influence of ice piece thickness or number of layers that makes up the brash ice channel was considered.
- Three parent ice sheets with thickness of 46mm, 23mm and 15mm, were used to make brash ice of one, two and three layers, respectively.
Brash Ice Test – Typical Test

- The data shows a good agreement of the towed force between the two- and three-layer constructions (self-propulsion point of 5.4 and 5.3 rps).
- For one layer brash ice, the self-propulsion point was at 5.9 rps possibly due to increased resistance.
- Structure of the brash ice layer is important.
Brash Ice Test – Summary

• We just start modeling brash ice in our tank
• Challenge is still existed in control and characterize the brash ice
• The procedure developed looks reasonable
• Benchmark test methodology and standard development are yet to be done
• The data suggested the importance of using multi-layers to properly model the ship resistance/propulsion in brash ice.
General Summary

- IOT has performed R&D work to develop procedure to test APP and ships in brash ice in an ice tank facility
- Demand for performance revaluation of ships with APP and/or in brash ice increases greatly
- A few other facilities has procedure to perform tests with APP and brash ice; ITTC standards and guidelines are yet to be developed
- Recommendation to follow up work in these areas