Methodology for Investigation of Ice Breaking Performance

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ABSTRACT

Understanding the influence of the ship hull design on the ship-ice interaction is essential for its assessment in an early design stage. Within the research project ProEis an investigation is carried out which is based on a holistic consideration of the ice breaking process. This paper aims to present an improved testing procedure to enable the development of a numerical simulation procedure that predicts the two-way coupled hydrodynamic interaction of the vessel with the turbulent nonlinear flow as well as the collision of the pre-broken ice and the ship hull and a companion tool which determines the bow ice-breaking pattern. Analysis results of the influence of different bow shape (parameters) on the breaking pattern are given followed by a first evaluation of the ice flow along the ship hull.

KEY WORDS: Ice breaking; Level ice; Simulation procedure; Ice model testing; Ships in ice; Breaking pattern; Numerical ice tank

INTRODUCTION

The performance of ice breaking ships is usually defined by their ability to proceed in uniform level ice, where good performance means low ice resistance, high propulsion efficiency and guaranteed continuity in ice breaking. The ice floes reaching the propeller are affecting the ship’s propulsive efficiency and the physical ice impact on the propeller exerts loads on the propeller and on the propulsion train. Both aspects are strongly dependent on the ship hull design, besides the ice properties and the ship’s speed. Understanding the influence of the ship hull design on the ship-ice interaction is essential for its assessment in an early design stage.

The German national funded research project ProEis focuses on the aforementioned aspects. It is divided into four work packages with the following main focus: Influence of the ship hull shape on the propeller-ice interaction; Influence of the propeller-ice interaction on the propulsive efficiency; Loads on the propeller induced by propeller-ice interaction; Ice trials for validation. This paper only focuses on work package one. An investigation is carried out which is based on a holistic consideration of the ice breaking process comprising an analysis of the ice breaking at the bow and the flow of broken ice pieces along the ship’s hull. A numerical simulation procedure that predicts the two-way coupled hydrodynamic interaction of the vessel with the turbulent nonlinear flow as well as the collision of the pre-broken ice and the ship hull is developed at the Hamburg University of Technology (TUHH) in close collaboration with HSVA. By means of the simulation the amount of ice floes reaching the propeller plane can be determined. Since the tool does not simulate ice breaking, HSVA is developing a companion tool which determines the ice-breaking pattern in the bow region and serves as input to the simulations.

Both tools are either derived from model test results gained at HSVA or use such data for validation purposes. Since the available body of experimental data is insufficient, an improved testing procedure is applied to ice model tests that are carried out in HSVA’s Large Ice Model Basin within ProEis.

This paper presents the improved testing procedure followed by the analysis results, which serve as input for the numerical tools developed within the project. In particular the influence of different bow shapes and bow geometry parameters on the breaking pattern and a first evaluation of the ice flow along the ship hull are presented. Finally, a brief description of both numerical tools is given.

MODEL TESTS

Model test results available to date are seemingly not sufficient for development of the numerical tools. Therefore, an improved testing procedure is applied to ice model tests that are carried out in HSVA’s Large Ice Model Basin within ProEis. For this purpose, new testing equipment has to be designed, i.e. an underwater video carriage.

For the tests a set of six common ice breaking vessels is chosen. They have a length between 70 and 90 m, a breadth between 18 and 23 m and a draught between 6.5 and 9 m. All of them are equipped with a forward skeg for installation of bow thrusters.

Model Test Execution – Towed Propulsion Tests

All tests of work package one are carried out as towed propulsion tests in level ice and pre-sawn ice. During a towed propulsion test (Figure 1) the ship model is towed at constant speed values and the propeller