Model Tests for Determination of Ship Resistance in Level Ice under Lateral Pressure

Philipp Hinse
Institute for Mechanic and Ocean Engineering, Technical University Hamburg-Harburg, Germany

Daniela Ehle and Nils Reimer
Hamburg Ship Model Basin (HSVA)
Hamburg, Germany

ABSTRACT

The aim of the research project IRO-2 (Ice Forecast and Route Optimization) is to develop a tool which makes it possible for ships to operate in Arctic conditions in a reliable and save manner. Hereupon a closer look on compressive ice is required which has a significant impact on ship resistance and thereby on the operability of ships in Arctic conditions. Therefore several model tests have been carried out in the large ice model basin of HSVA. Different ships under different ice conditions were tested and the results are presented. Thereby the main objective of the paper is to give an impression of how compressive ice and its parameters have impact on ship resistance.

KEY WORDS: Compressive ice; lateral pressure; added resistance; model tests;

INTRODUCTION

The significant decrease of ice thickness and ice extend in polar regions during the last few years have effect on Arctic shipping. On the one hand the decrease opens new possibilities of routes for ships in this area but on the other hand the risks of ice navigation especially in winter times are given. Due to that a tool is needed which makes it possible for ships to navigate save and fast through ice covered areas. To be able to develop such a route optimization tool one has to know about the ice conditions and of course also about their influence on a vessel. One important impact on ships acting in polar regions is compressive ice. Due to the lateral pressure which is acting on the ship hull the resistance can increase dramatically. For that reason model tests were performed to investigate the most relevant parameters of compressive ice and their influence on ships.

LATERAL PRESSURE

Sea ice mainly consists of land fast ice and compressible ice floes which are surrounded by open water. High forces caused by wind, waves or currents which are acting on these ice fields can move them in several ways. If some kind of abutment occurs the smoothness of running can decrease and the ice is pressed together. Caused by large impressed inertia and continuous interacting forces the ice concentration increases to its maximum and lateral pressure arises.

One effect of compressive ice is the closing channel behind the ship. The closing of a channel can increase up to a third of the open channel directly behind the ship. On the one hand this closing of the channel is a problem of maneuvering ships through compressed ice fields, especially if a ship has to go backwards as it is often required in case of ships breaking through massive ice ridges. But even more the closing of the channel is a reason for added ship resistance. With regard to ice the added resistance is mainly depending on the line load and the drift velocity of the ice beside the ship. The maximum lateral pressure is limited by the magnitude of ice failure. If the compressed ice is treated under high forces the ice fails in several modes and by this ridges can be formed.

MODEL TESTS IN COMPRESSIVE ICE

With the necessity of a reliable prediction method of ship motions model tests represent an adequate solution. In the large ice model basin of HSVA several lateral pressure tests have been performed. The basin itself is 72 m times 10 m in size and has a depth of 2.5 m. To prepare model testing in compressive ice three pressure frames were installed in the ice basin (Fig. 1). Each frame has a length of six meter and was supported by the side tank wall by two 2-way pneumatic cylinders.

Fig. 1: Pressure Frames