Ships Breaking through Sea Ice Ridges

Daniela Ehle
Hamburg Ship Model Basin (HSVA), Ice & Offshore
Hamburg, Germany

ABSTRACT

Within the research project IRO-2 (Ice Forecast and Route Optimization) the process of ships breaking through first-year sea ice ridges was analyzed. To understand the process of a ship breaking through ridges, six ridge ramming model tests with systematically varied keel depths were performed in HSVA’s large ice model basin. Based on the model test results a general method to predict the ship’s average transit velocity in first year sea ice ridges was established. The method serves as a pre-condition for developing an efficient route optimization tool for ice covered seas and will be embedded in this tool.

KEY WORDS: sea ice ridge, breaking, routing tool, model tests, resistance, Arctic navigation, prediction method

INTRODUCTION

Ice-breaking ships operating in first year sea ice ridges were investigated as a part of the research project IRO-2 (Ice Forecast and Route Optimization). Based on model test results the behavior of the ice resistance and the ship’s transit velocity during the process of breaking through sea ice ridges in Arctic regions was determined. The relevant ship and ridge parameters of the ridge breaking process were defined as the method’s input quantities. Finally the calculated values were compared to the measured ones.

IRO

Due to decreasing ice thickness and ice extent, the time period the Northern Sea Route (NSR) can successfully be navigated has significantly increased. Together with different economic incentives the navigation of Arctic routes has attracted considerable international attention. With respect to this challenging environment even the strongest nuclear icebreakers could lose their optimal maneuverability leading to passive drifting with the sea ice.

Due to dangers like this ice forecast and navigational simulation should be combined by developing a service for nautical staff, an efficient route optimization tool, which provides support for the navigation in ice covered seas.

SEA ICE RIDGES

Sea ice ridges are one of the most difficult obstacles for the navigation in ice. Depending on their age and formation process, sea ice ridges can be found in many different sizes, strengths and shapes.

A sea ice ridge is a line or a wall of broken ice forced up by pressure (Fig. 1). This pressure results from a combination of different environmental factors, mainly from wind and water induced stresses.

Fig. 1: Sea Ice Ridge (Salvesen, 1990)

BREAKING THROUGH SEA ICE RIDGES

Ships can break through sea ice ridges either continuously (Fig. 2) or by ramming (Fig. 3). In both figures the velocity v, acceleration a and total resistance $R_{IT}$ are presented as a function of distance. Thereby distance means the position of the midship frame. The blue lines represent the ridge profile.

At the beginning of test run 3010 the ship accelerates by means of the thrust the ship produces. Due to acceleration of the ship the resistance increases until it is in balance with the thrust. With encountering the ridge, the resistance increases significantly so that its velocity decreases. The ship can maintain progress with a very low velocity of