Active heeling systems improve ice capability

The study included ice model tests where the active heeling system was simulated with a sideways-moving mass that would induce a similar rolling motion to pumping water between tanks.

An active heeling system – a pair of water tanks located on each side of a ship where water is pumped back and forth to induce a forced rolling motion – was once a standard feature for icebreakers. However, these icebreaking auxiliary systems were largely forgotten. Johanna Marie Daniel from the Hamburg University of Technology is currently studying the effectiveness of active heeling systems as part of her Master's degree studies.

Through the 20th century, almost all icebreakers built worldwide were equipped with heeling tanks that could rock the ship back and forth should it become beset in ice. In addition to cracking and breaking the ice around the icebreaker's hull, the relative motion between the shell plating and the surrounding ice helped free the ship by transforming the friction from static to kinetic.

Auxiliary systems forgotten

However, these icebreaking auxiliary systems were largely forgotten following the development of low-friction hull coatings and the adoption of azimuthing propulsion for icebreaking applications.

With the hull-ice friction issue largely solved by better coating and a powerful flushing effect from the propellers, design efforts shifted towards minimising ice resistance using more efficient hull forms. As a result, various systems intended to improve ice-going capability without increasing the vessel's propulsion power were given less attention and became less the focus of systematic research.

An innovation nearly as old as the icebreaker itself, the active heeling system was devised by Admiral Stepan Osipovich Makarov and fitted on the world's first polar icebreaker, Yermak. Photo Source: Tyne & Wear Archives & Museums

Active heeling system in model test

Impact on new hull forms

In November 2019, Johanna Marie Daniel from the Hamburg University of Technology (Technische Universität Hamburg; TUHH) began studying the effectiveness of active heeling systems as part of her Master's degree studies.

The goal of this Aker Arctic-supported research project is to investigate the impact of forced rolling motion on the ice resistance of modern icebreaking bow geometries developed in recent years. One of the latest icebreaker designs developed by Aker Arctic was used to analyse the effect of a heeling system.

In addition to analytical calculations, the study included ice model tests where the active heeling system was simulated with a sideways-moving mass that would induce a similar rolling motion to pumping water between tanks. Tests were done both with and without the heeling system in the same ice conditions to find out the effect of the rolling motion on the vessel's performance.

System parameters such as heeling angle and rolling period were varied to gain further understanding of their impact on the system's effectiveness. The investigated ice conditions represented the most challenging obstacles that an icebreaker can encounter: thick multi-year ice and heavy ridges.

Better ice capability

The model test results already indicate that forced rolling motion can further increase the ice-going capability of an icebreaking vessel with a hull form of the latest design generation.

In addition, it was determined that the power required by a correctly-designed active heeling system can be less than what would be needed for achieving a similar performance gain by simply increasing the vessel's propulsion power.

The model test results were also used to validate the calculation method developed by Ms. Daniel for predicting the ice resistance of a vessel with an active heeling system.

Find out more about this research project in the next issue of Arctic Passion News.