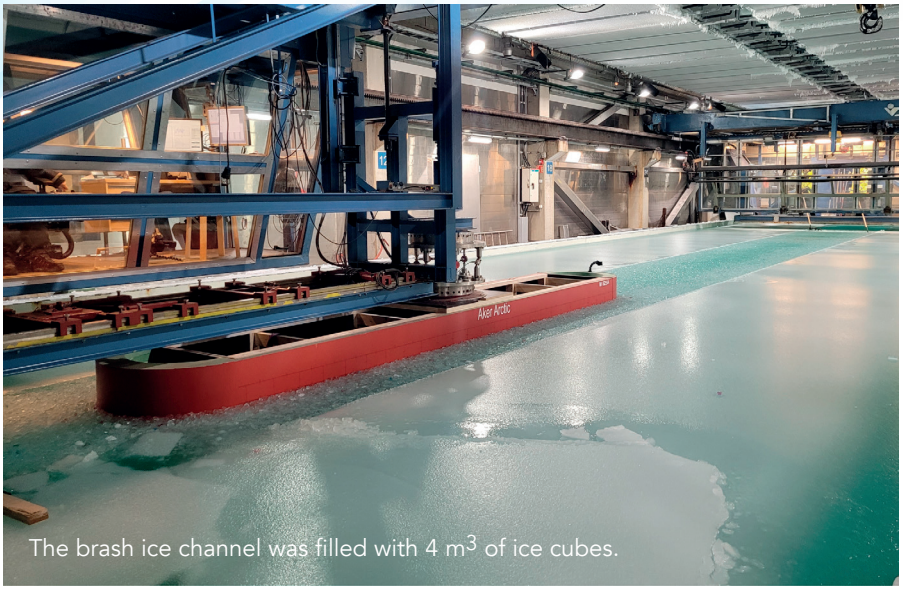
Simulation method explored for brash ice tests



The brash ice channel was filled with 4 m^3 of ice cubes.

To further secure the reliability of ice-model-test-based performance predictions in the future, Aker Arctic works continuously to add understanding to the correlation between full-scale observations and model tests in different conditions. In 2023, we evaluated how a computer-simulated, brash-ice channel test could add value to our processes.

Aker Arctic's state-of the-art ice-model testing procedures provide highly advanced and accurate methods for evaluating a vessel's ice performance prior to construction. The currently applied model ice and model scale testing methods were originally developed for predicting maximum ice conditions for a vessel in level ice.

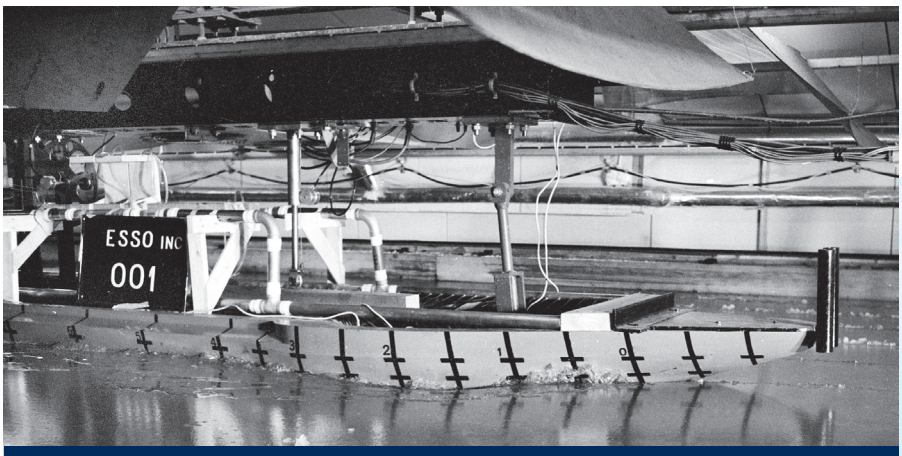
Brash ice channels differ from level ice

Brash ice increases the resistance of a ship, and thus affects the power requirement and fuel consumption of the ship on a voyage. Understanding the interaction between the ship's hull and brash ice in the channel is crucial when attempting to reduce the resistance caused by ice and managing the shipping operation.

Aker Arctic's earlier research on a ship's resistance in an old brash ice channel (Matala and Suominen, 2022) indicated that currently applied methods might be providing conservative predictions of channel resistance for certain types of modern hull shapes. This can result in unnecessary high demands on the ship's minimum engine power or in suboptimal hull shape development.

Simulation results compared to model tests

To tackle the problems of current model testing methods of predicting brash ice resistance, research trainee Juhan Voutilainen studied how a model test in a brash ice channel could be replicated using numerical simulation. As part of his master's thesis, he applied coupled computational fluid dynamics (CFD) and discrete element method



The first ice model tests were performed more than 50 years ago in Finland. Accurate performance predictions are now of the utmost importance for efficient winter navigation, both on economic and environmental grounds.

According to Matala, optimizing the whole system benefits all stakeholders. Keeping transportation costs reasonable is important both for the industry and for the citizens. Moreover, by using less fuel, both money and the environment are saved.

Reflecting on her contribution, Matala says: "I am honoured to have contributed to a solution that not only ensures the reliability of Aker Arctic's predictions in this new scenario but also serves the needs of the authorities to secure the safe and sustainable winter navigation system." ■

(DEM) approaches in order to model ship-to-ice interaction.

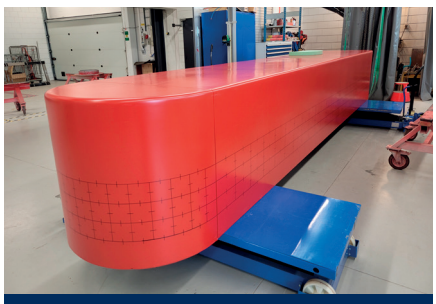
When modelling the interaction between a hull and brash ice correctly, it is necessary to understand the physics behind the phenomenon.

"The forces experienced by the hull can be split into hydrodynamical and contact forces," Voutilainen explains. "It was therefore relevant to be able to model both fluid flow and the movement of the particles."

The results of the achieved simulations, conducted with a commercial Simcenter Star-CCM+ 2206.0001 software with an existing CFD-DEM solver, were compared to experimental results. The experiments were performed with cylinder-shaped solid fresh-water ice blocks of unscaled strength to avoid an overestimation of the resistance occurring in brash ice model tests using model ice with scaled-down strength.

"Important aspects of the study were the comparison and selection of DEM-models, the selection of ice parameters, and finding reasonable simplifications to keep the computational cost under control," Voutilainen says.

The simulations were conducted at several speeds with a simple ship-like geometry without propulsion to keep the focus on the interaction between ship and brash ice, and to make the comparison with experimental results easier.



The model used was 6 metres long, which corresponds to a 120-metre-long real vessel, of an extremely simplified form, without propulsion.

Potential tool to support model tests

Voutilainen believes the studied CFD-DEM method proved itself as a potential tool for modelling a ship in a brash ice channel.

"Especially for simple cases, with Froude numbers exceeding 0.13, the potential is obvious, and the method could be used alongside traditional model tests. With some additional work, the simulation model could also be expanded to lower velocities," he clarifies.

Parameters confirmed

Aker Arctic's senior research engineer Riikka Matala has investigated brash ice channels over many years, both in full-scale tests and model tests, using the corresponding ship model in the basin. (See previous articles in Arctic Passion News issue 16/2018 and issue 19/2019.)

She is excited about the results of Voutilainen's research.

"Maybe the most important lesson for us was the confirmation that we had correctly understood the parameters which dominate the test results in a brash ice channel, when the brash ice consists of solid ice cubes," Matala highlights.

The crucial ice parameters were concluded to be brash ice porosity, shape and size of individual ice pieces, and both static and kinetic friction of ice-ice and ice-model contacts.

"It turned out that one significant improvement we achieved in this work, compared to our earlier attempts with simulations, related to the physical friction measurements we achieved for the ice type used in the tests," Matala says.

Both static and kinetic friction coefficients were measured for ice-ice contact and in ice-model contact. The measurement results from the friction measurements were directly utilized in the simulation.

Accurate predictions require research

"In addition to our customer projects, we constantly conduct research work to ensure that our methods are of highest standards and accurately predict real-life situations which vessels face after delivery," Matala says.

According to Matala, it would be interesting to repeat the same model test and simulation correlation study on a different bow shape, and later to add hulls with propulsion, to learn more about the possibilities of simulation.

"All research related to ships transiting old brash ice channels is especially interesting, as it is the determining operational condition for granting ice class according to the Finnish-Swedish ice class rules," she adds.

Chief Inspector Ville Häyrynen from the Finnish Transport and Communications Agency comments:

"The core aim of the Finnish-Swedish ice class rules is to allow ships safe and efficient winter operation in Finnish and Swedish ports. These rules are the result of gathering real-world, research and model test data over a relatively long period of time. Further understanding of a ship's resistance in an old brash ice channel could allow for more accurate requirements for the engine power of a ship in the rules. This in turn would make winter navigation more economical in the future, as the rule required minimum engine power would more closely match the actual operational requirements." ■