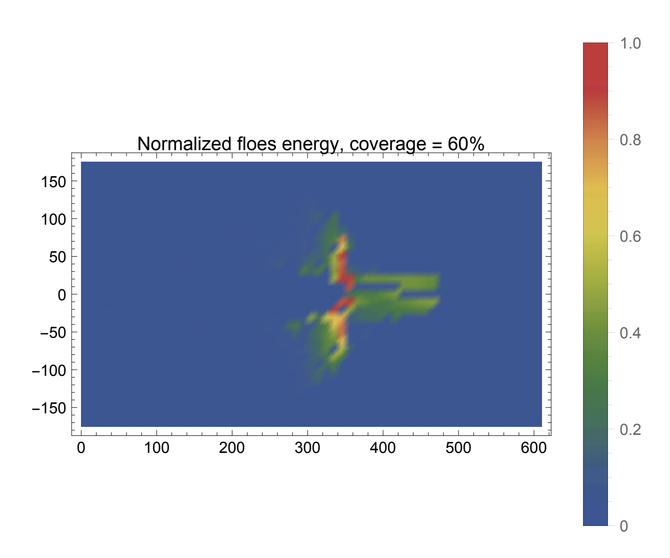
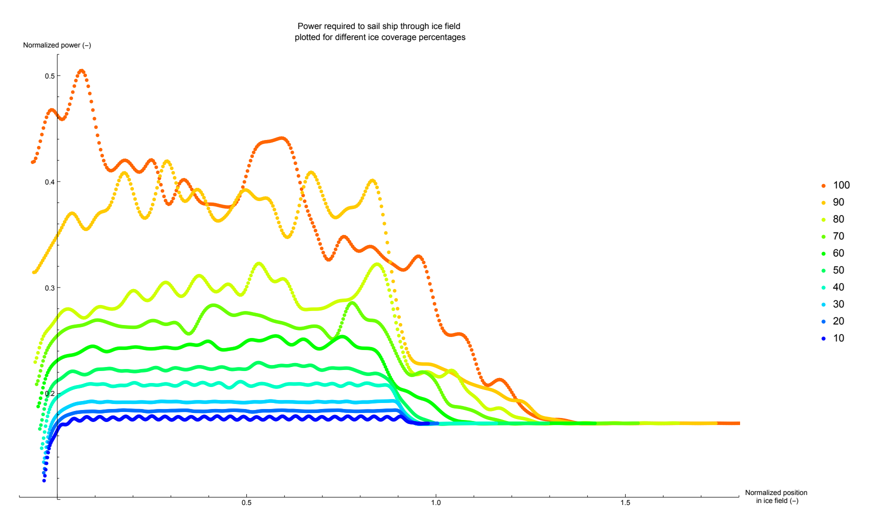
MARIN has experimented with artificial ice in recent model test campaigns to give the industry better insight into working in inhospitable environments.

Artificial ice research provides fresh insight





Over the past few years as the maritime and offshore industry moves into more challenging environments where ice is often prevalent, MARIN has placed increasing importance on researching operations in ice. As part of this on-going ice research, MARIN recently experimented with the use of artificial ice in several test campaigns[1&2].

The main aim is not to obtain an alternative for ice model basin tests but to give insight into the involved processes and to provide validation material for numerical simulations. The advantage of artificial ice over cold model ice is the fact that the properties of the material are constant and known. Moreover, it offers the opportunity to make a comparison between model tests results and simulation results in a relatively straightforward manner because both approaches are based on the use of rigid particles.

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All the model tests were conducted at the MARIN facilities, whereby MARIN experts worked together with Delft University of Technology bachelor students. In the tests a 'pre-broken' artificial ice channel was made, consisting of hundreds of rigid polypropylene (PP) particles in a fishbone pattern. Large PP plates kept the channel together on both sides. A model was towed through the channel, while maintaining constant and equal distance from both plates.

Submersion resistance To get through the channel, the model had to submerge the PP particles, causing a certain resistance, which is referred to as submersion resistance. According to the Lindqvist formulation[3], total ice resistance is a superposition of the submersion resistance and the breaking resistance (which was not present given that the artificial ice was already broken).

With the Lindqvist formulation it was possible to assess whether the measured submersion resistance was close to what it should be. In 2013 this measured resistance was found to be too large and this was probably caused by particles regularly sticking to the hull and being dragged along with the model. Therefore, in 2014 MARIN investigated whether a different coating on the model could reduce the 'stick-slip' behaviour and thus reduce the measured submersion resistance.

After conducting friction tests at TU Delft a coating was selected and the same model test programme was done with a model with the original and the new coating. With each coating, four repeat runs were conducted at three model velocities (0.15, 0.30 and 0.50 m/s). The new coating reduced the submersion resistance by up to 21% depending on the velocity. As a result, the difference between the artificial ice tests and the Lindqvist formulation was below 8% for higher velocities. For the 0.15 m/s runs the difference was still 37%. Artificial ice can therefore not be regarded as a substitute for the refrigerated ice used during model tests in ice tanks.

Despite the difference in measured submersion resistance, artificial ice serves as a very good validation opportunity for simulations that were carried out simultaneously with MARIN's in-house simulation tool XMF, of which aNySIM is one of the modules. With this hydrodynamic tool, ice is simulated as numerous rigid bodies interacting with each other and with a floating structure. By simulating the exact setup of the artificial ice tests in XMF (using artificial ice rather than ice as a material), the flow and friction processes in the simulations can be compared with the tests. Complex ice breaking processes are not present in either the tests or the simulations, which makes the comparison easier.

To facilitate having a large number of rigid bodies in the simulations, XMF's functionality has been extended to integrate a Physics Engine (PE), i.e. a constrained dynamics engine. MARIN has already successfully adopted a third-party PE line module for the lifting of heavy loads. In the simulations with ice particles, the PE accounts for the collision interaction between the vessel and ice.

Confidence going forward The results from the test campaigns and the simulation, combined with the fair comparison found between them, gives MARIN sufficient reason and confidence to proceed with the artificial ice measurements and to perform feasibility studies for Arctic offshore operations.

Following on from the research that has been initiated, MARIN intends to launch the ServICE JIP, an Arctic Joint Industry Project on simulations, focusing on linking the engineering and operational approaches, such that both the technical and operational feasibility of working in ice can be assessed.

The artificial ice particles were placed in the channel by hand

Model towed through the channel of artificial ice particles.

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[1] Bergsma, J.M., Bouhuys, C.M., Schaap, T., Spaargaren, A.F., van der Zalm, M., van der Werff, S.E., 2014, "On the Measurement of Submersion Ice Resistance of Ships Using Artificial Ice", Proceedings of the 24th International Offshore and Polar Engineering Conference, Busan, Korea

[2] S.E. van der Werff, J. Brouwer, G. Hagesteijn, "Ship Resistance Validation Using Artificial Ice", June 2015, Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering

[3] Lindqvist, G., 1989, "A Straightforward Method for Calculation of Ice Resistance of Ships", Proceedings of the 10th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC), Lulea, Sweden, Vol.4, pp 722-736