50 years of successful model testing in Finland

The history of the ice model testing laboratory is a true success story of Finnish technology. This year, we celebrate 50 years of ice model testing, which began with studying the performance of the newly designed bow for *SS Manhattan,* and continued with ice model tests for icebreakers, oil platforms and Azipod evolution. More recently, model tests in ice have been used in the development of Arctic tankers, LNG fuelled icebreakers, polar research vessels and autonomous vessels.

The first ever ice model test conducted in Finland was a resistance test in level ice of SS Manhattan.

The history of modern icebreaker design and construction in Finland began in the late 1930s with the diesel-electric icebreaker *Sisu.* Until the development of ice model testing, icebreakers were built based on the designers' experience with previous vessels, and the primary way to evaluate the hull form was through full-scale experimental tests.

In the mid-1960s, studies indicated that oil found in the Alaskan North Slope could be feasibly transported to the market through the Northwest Passage. A decision was taken to modify an existing 106,000 DWT tanker, *SS Manhattan,* for the arctic voyage by retrofitting it with a new icebreaking bow. Wärtsilä provided support for the project since the Finnish shipyard had previous experience from building icebreakers both for the subarctic and arctic conditions.

During the retrofit process, the oil company Esso (Humble Oil) suggested to study the performance in ice of the newly designed bow in model-scale in an ice model basin, before making the decision to start the expensive conversion. Esso decided to invest in the construction of the first ice model testing facility in Finland, which was built in an old underground bomb shelter in Helsinki. Wärtsilä shipyard later became the owner.

The first Finnish model test basin

The Wärtsilä Icebreaking Model Basin (WIMB), the first ice model test basin in Finland, was ready for testing at the end of 1969. The technique to create the model ice was adopted from the Arctic and Antarctic Research Institute in Leningrad, USSR. The model tests were conducted by towing the model ships and the data was recorded on paper with an oscillograph.

The first years in the new model testing facility were a time of calibration. Concurrent with the calibration period, the development of new icebreaking hull forms was in full speed and in the 1970s and 1980s, many new icebreaking vessel designs were developed and tested through model tests in ice. The first icebreaking vessels developed and built utilizing the results of ice model tests were the five *Atle/Urho*-class icebreakers, which were built for the Maritime Administrations of Finland and Sweden in 1974-1977.

In the 1980s, operational model tests were often conducted by manoeuvring the model manually. Model of icebreaker Otso, assisting another vessel in heavy brash ice, is steered by her future captain, Atso Uusiaho.

Atle/Urho-class icebreaker Sisu in operation

The first Azipod unit was installed to fairway supply vessel Seili.

The real breakthrough for the Azipod, and the DAS™ concept, occurred with the conversions of the ice-going tankers Uikku (1993) and Lunni (1994).

Comprehensive research centre

The knowledge gained from the WIMB was used to build an improved, modern facility, the Wärtsilä Arctic Research Center (WARC). A new type of model ice was also developed at the same time and the new laboratory was intended to be a comprehensive research centre, in addition to a commercial ice model test basin.

The new facility was inaugurated in February 1983. The timing was excellent; an arctic boom started in the beginning of 1980s and the Northern Sea Route was increasingly attracting interest in the shipping industry. The newly developed fine-grained model ice was also significantly different from all other model ice types used at the time. The ice was made by spraying saline water in the air, and as the freezing droplets fell on the water surface, they created a layer of slush. The slush was then hardened overnight to achieve the appropriate mechanical properties.

One of the key research objectives, was to gain a better understanding of the entire icebreaking process by studying many aspects of ship-interactions. Some key experiments involved bow shapes, the influence of friction using friction panels on the Finnish icebreaker *Otso,* and removable icebreaking bows.

A crisis in the global marine industry led Wärtsilä to pool its marine resources with Valmet, resulting in the establishment of Wärtsilä Marine in 1986. WARC became part of Wärtsilä Marine Arctic Technology, which was a unit within the Helsinki Shipyard. The emphasis on the research continued until the bankruptcy of Wärtsilä Marine near the end of 1989.

Commercial era

In the early 1990s, there was a dramatic slump in the shipbuilding industry in Finland due to the dissolution of the Soviet Union. As a result, the future of the ice laboratory was very uncertain. However, a new shipbuilding company Masa-Yards was established to continue the operations of Wärtsilä Marine. Kvaerner group took over Masa-Yards in 1991 and created Kvaerner Masa-Yards Technology Group. Due to this change in ownership, the research and development work in the ice laboratory decreased dramatically and practically all work in the facility, now called Kvaerner Masa-Yards Arctic Research Centre (MARC), was commercial.

Azipod development

In late 1980s, Wärtsilä, ABB and the Finnish Maritime Administration started the development of a new azimuthing podded propulsion unit, the Azipod. The first prototype was installed onboard the ice-going fairway supply vessel *Seili.* After the validation of the model during the full-scale tests of *Seili,* the development of a high ice class Azipod continued with the Tarmo II project.

In 1992, a team dedicated to developing the commercial Azipod was established within the ice laboratory. This allowed designers access to the model test basin to perform extensive model tests for the new Azipods. The main principles of the Azipod design are still based on the ice model and open water tests from the 1990s.

The invention of the Azipod created many new possibilities in icebreaking practices. One of the most significant concepts was the Double Acting Ship (DAS™), where a ship is designed to advance ahead in open water and thin ice, and to use the stern to proceed in heavy ice conditions. The real breakthrough for the Azipod, and the DAS™ concept, occurred with the conversions of the ice-going tankers *Uikku* (1993) and *Lunni* (1994).

In 2004, Aker Finnyards, owner of the Rauma shipyard, took over Kvaerner's shipbuilding industry. In 2006, the company changed its name to Aker Yards. Up until the early 2000s, the ice model testing and the related consulting was an integral part of the different shipbuilding companies. However, following the turbulent shipyard ownership changes, a decision was made to establish a new independent company focusing on design of ice breaking vessels. A brand-new state of art testing facility was built to support the design development process.

Next generation testing facility

The new technology company, Aker Arctic Technology Inc, was founded in January 2005. The site for the construction of the next generation ice model testing facility was chosen next to Vuosaari Harbour in Helsinki and the new facility was inaugurated in February 2006. At this point the company employed about 20 persons, consisting of 12 employees from the old facility and a group of ship design engineers from the former design department of the Helsinki Shipyard. Over the years, as the business of arctic shipping expanded, the number of personnel steadily increased to be approximately 50 people in 2018.

While the 1990s saw only 35-70 test days per year, the opening of the new facility coincided with a boom in the shipbuilding market. The oil exploration activities around the world increased and so did demand for Aker Arctic's services. During the peak years, the number of ice model test days exceeded 100 per year. The new Arctic exploration activities changed the requirements for the supporting icebreakers, ultimately leading to many new developments in vessel design.

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The current ice model test basin is unique in several respects. One of the outstanding features includes the glass bottom of the test basin, allowing designers to view and record the tests from below. Additionally, there are observation windows on both sides from which the amount of ice gathering under the model can be seen.

Computer controlled ship model approaching docking on quay represents the future trend in model testing.

The customers have ranged from the world's biggest oil companies to shipyards and shipowners. To meet the market demand, new test types were developed:

- fixed offshore structures,
- floaters,
- drill ships,
- artificial islands,
- harbour ice melting system,
- new ice management methods, and
- friction tests.

Future of model testing

Aker Arctic is constantly striving to improve its model testing services to give customers the best possible designs of ice going vessels and structures. The quality is ensured by the continuous study of model ice properties and behaviour in many different ice conditions such as level ice, brash ice and ice ridges. New model testing techniques have also been developed to reflect the trends in modern shipping.

Aker Arctic has developed a model propulsion system that is capable of full computer control of the model. In addition to standard model testing, the propulsion system can be used with dynamic positioning, autopilot and other external control systems. This system also serves as part of a testing platform for autonomous vessels, which are actively being developed in the maritime industry. Aker Arctic's propulsion system allows testing of full-scale control systems in a challenging, but controllable and safe model-scale environment.

Model tests are also used to support the development of Aker Arctic's simulator. The data collected from model tests in ice is used in the simulator's database to more accurately portray the ship's response in ice. One aim for the future of the simulator is to estimate the effects of different hull features on the ship's ice resistance. The optimization of the hull form could then be started before the model tests.

Read the full history at www.akerarctic.fi/publications.

Polaris, built in 2016, is the most powerful icebreaker ever to fly the Finnish flag and the first icebreaker in the world to feature environmentally friendly dual-fuel engines capable of using both low-sulphur marine diesel oil (LSMDO) and liquefied natural gas (LNG). It has excellent manoeuvrability due to the two Azipod units in stern and one in bow.

Aker Arctic has been leading the development of Arctic LNG carriers over the years resulting in Yamalmax icebreaking LNG carriers. The vessels are based on the DAS™ concept and capable of operating independently without icebreaker escort along the Northern Sea Route. The hull form has been extensively tested in Aker Arctic's ice model test laboratory. The first Yamalmax carrier, Christophe de Margerie, was delivered in 2016.