Aker Arctic
The Ice Technology Partner

Arctic Passion News

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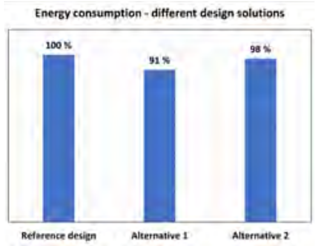

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A team of Aker Arctic experts travelled onboard *Le Commandant Charcot*, the world's first icebreaking hybrid-electric expedition cruise ship, for full-scale ice tests in June 2021. *Le Commandant Charcot* features a modern Polar Class 2 icebreaking hull and can sail ahead and astern, even in severe ice conditions, using Aker Arctic's Double Acting Ship (DAS™) principle. The vessel's performance is comparable to existing polar icebreakers, but with lower ice resistance ensuring better fuel economy. Photo by Nicolas Dubreuil, Ponant.

Read more about the ice trials and Ponant's first experiences in ice on page 4.

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Contact details

AKER ARCTIC TECHNOLOGY INC
Merenkulkijankatu 6, FI-00980 HELSINKI
Tel.: +358 10 323 6300
www.akerarctic.fi

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September	Webinar: Aspects for polar cruise vessel design
September	21 – 24.9. Neva, St. Petersburg, Russia
October	Webinar: Testing of ice-going ships. Ice model tests and full scale trials.
November	10 – 11.11. Åland Maritime Day, Mariehamn, Finland
December	7 – 10.12. Marintec China, Shanghai, China

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Arctic Passion News 2 / 2021

Dear Reader,

Pandemic has hit the cruise and shipbuilding industry hard, but many new exploration cruise ships have still been under construction during this difficult time. The industry is now slowly reactivating, and it will be interesting to see how it evolves in the coming years.

One of these new exploration cruise ships is particularly unique. The famous cruise operator Ponant has taken delivery of the world's first icebreaking cruise vessel. Recently, this vessel made a historical test voyage to the North Pole. The voyage demonstrated the operational and technical capability that can be achieved today. We could actually say that the top has been reached.

Although other icebreakers have, of course, sailed to the pole earlier, Ponant's *Le Commandant Charcot* is the first commercial vessel to do so. She opens up a completely new era in exploration cruises to the Arctic. All parties involved in the ship's realization, from its design, building and operation, can be proud.

The Arctic region is a sensitive area with a fragile nature, and must be respected accordingly. Thanks to continual technical development, lessening the environmental impact can be achieved. This is, of course, beneficial and necessary for the Arctic, Antarctic and all other oceans, as well as the climate in general.

Indeed, it presents a considerable technical challenge for all maritime players. We have learned more about new fuels and minimising emissions while finding optimal solutions for the icebreaking ships we design.

An important decision regarding polar icebreakers was recently made in Canada. The Government of Canada announced that the long-awaited construction of the Canadian Coast Guard's new polar icebreaker will begin. Surprisingly, the announcement stated that two such icebreakers are to be built by two different Canadian shipyards. Earlier, the design for the polar icebreaker was created by STX Canada Marine supported by Aker Arctic.

Sincerely yours,

Reko-Antti Suojanen
Managing Director

Energy-efficient Baltic Sea icebreaker concept chosen

Ice-covered Baltic Sea between Sweden and Finland, March 2021. Photo taken from icebreaker *Ymer* by Dan Broström.

Fossil-free fuel options, battery solutions and a 32-metre-wide icebreaking capability make this the world's most modern assistance icebreaker.

The Swedish Maritime Administration and the Finnish Transport Infrastructure Agency, partnering in this joint project to design new energy-efficient assistance icebreakers for the Baltic Sea, have chosen to proceed with an icebreaker design incorporating three azimuthing propulsion units. The propulsion design is similar to the Finnish icebreaker *Polaris*, also an Aker Arctic design, with one azimuthing propulsion unit in the bow and two in the aft.

"The icebreaking capabilities, the manoeuvrability and life-cycle costs showed that this was the best concept for the future," says project manager Dan Broström from the Swedish Maritime Administration.

Three different propulsion concepts were initially evaluated, along with a fourth reference vessel: a 32-metre-beam icebreaker with similar propulsion to the *Atle/Urho* class icebreakers, which are planned for replacement. All test results and life-cycle costs were compared to the reference vessel.

Multi-fuel vessel design

Using fossil-free fuel in the icebreaker has been one important design criteria, as well as a major challenge. Sweden has a target of fossil-free shipping by 2030 and the demand is that the new icebreaker is ready for this.

"The icebreaker will have a life-span of 50 years, which is a very long time," Broström continues. "Today, we don't know what all the future fuel options could be, and it is therefore difficult to decide which fuel to use. Aker Arctic has successfully dealt with this problem by designing an innovative concept which is prepared for several alternatives, giving us the possibility to decide at a later stage."

Today, we don't know all the future fuel options. Aker Arctic has designed an innovative concept prepared for several fuel alternatives.

The concept designs were evaluated in ice model tests at Aker Arctic. Photos by Catarina Stewen.

The current alternatives are hydrotreated vegetable oil (HVO), a fossil-free diesel fuel; liquid biogas (LBG), made from waste products in food production, replacing liquefied natural gas (LNG); and fossil-free bio-methanol. All of these are already available, but costs, infra-structure, production capacity and logistics are still big question marks. Experts currently estimate that the aviation industry might swallow most of the production of HVO, leaving scarce amounts for other industries.

Batteries for quick energy

Battery-driven vessels have slowly been introduced on the market, but this is the first full-size icebreaker design with battery packs or supercapacitors augmenting the main engines.

Although this part of the development is still in its initial phase, Broström is convinced that using an electric hybrid installation in the new icebreaker will provide many benefits, when, for instance, additional energy is needed quickly or in situations where it is not necessary to start an additional main engine.

"It will be exciting to see how much fuel we can save using batteries," he says. "They may also be employed in harbours to avoid emissions."

Wide channel with narrow hull

Future commercial vessels entering the Baltic Sea will be longer and wider, and therefore the most important requirement overall is that the new icebreaker must be capable of breaking channels of up to 32 metres wide.

Finland and Sweden have a long tradition of successful cooperation, both in icebreaking and icebreaker acquisitions. In the picture Swedish icebreakers *Atle, Ymer, Frej* and *Ale*. Photo by Maria Asén, courtesy of Swedish Maritime Administration.

At the same time, the aim is to build an icebreaker with a narrower hull, as the construction price will be lower and fuel will be saved in operations.

"We want to be able to break a channel width on demand, ranging from the icebreaker's beam and up to 32 metres. This has required much innovative thinking in order to provide the solutions," Broström says.

In the chosen concept, the thrusters can be angled outboard to achieve a water flush effect to widen the channel.
"In this way, the width can be chosen effectively and flexibly," underlines Helena Orädd from the Finnish Transport Infrastructure Agency, project manager for Finland in the project.

Lifetime costs evaluated

In big projects spanning long periods of time, life cycle costs (LCC) are important to consider and thoroughly analyse.

"In this case, where we are looking at 50 years of service, low acquisition costs combined with high maintenance costs could result in extremely high lifetime costs," Broström explains. "Conversely, high acquisition costs but low maintenance costs might turn out to be the cheapest alternative."

In the life cycle assessment (LCA), the environmental impact is added to the cost to ensure that any choices are not detrimental in this regard.

"With the help of these analyses we have looked at multiple aspects and costs over time: what does transfer from fossil fuel to fossil-free fuel mean, what is the balance between cheap and expensive acquisition prices, what can we expect in terms of fuel prices combined with fuel consumption. As an example, our reference concept required more energy to advance because it is a wider ship," says Broström.

"On top of the LCC and LCA analyses, we have strived to look at costs and emissions on a system level," Orädd adds. "With a properly sized and efficient icebreaker fleet assisting modern and future commercial vessels equipped with decreasing installed power, the total amount of all shipping emissions, along with the cost to the taxpayer, will be minimized."

Decision to construct

The project is advancing well and on-time. Aker Arctic will deliver the final tender design in mid- February 2022. The Swedish Maritime Administration is hoping for a construction decision as soon as possible, whereas the Finnish schedule is open.

"Sweden needs new icebreakers very soon. The old icebreakers date back to the early 1970s, with technology from the 1960s. They use components no longer available which have to be specially manufactured if they break. This is both difficult and expensive," Broström says.

The Finnish icebreaker fleet is more modern, with *Otso, Kontio, Fennica, Nordica* and *Polaris* built later than the *Atle/ Urho* class.
"In addition to the Bay of Bothnia, the Gulf of Finland also requires large icebreakers," Orädd adds.

According to Broström, the project team is planning to be fully prepared before a decision to construct. "The earliest date we could hope to begin construction is June 2023," says Broström.

If Sweden and Finland achieve a joint order of five A-class icebreakers, three for Sweden and two for Finland, Broström believes the price tag would be less than if separate construction decisions were made. To receive cost indications and possible construction schedules, a request for information (RFI) will be sent out to shipyards this autumn.

Long tradition of cooperation

Finland and Sweden have a long tradition of successful cooperation, both in icebreaking and icebreaker acquisitions. The *Atle/Urho* class vessels built in the 1970s in Helsinki, which are now being replaced, were developed together.

"During the ice season, we work together daily, especially in the Bay of Bothnia. We have joint technical follow-up systems and a well-functioning system of cooperation using both country's icebreakers flexibly. Therefore, it made perfect sense to partner up in this project," both Broström and Orädd emphasize.

Broström adds that they have an excellent working relationship with Aker Arctic, especially in finding new solutions quickly to advance the project. "It is a pleasure to work with Aker Arctic; the design spiral approach they use is very efficient."

"Both our countries are learning thoroughly about icebreaker design and acquisition," Orädd adds.

Furthermore, both are convinced that this will be the world's most modern assistance icebreaker, once it is ready. ■

Night-time icebreaking to release a vessel from ice north of the lighthouse Nordvalen located between Sweden and Finland, March 2021. Photo by Dan Broström.

Le Commandant Charcot, which features a Polar Class 2 icebreaking hull and hybrid-electric power plant powered by liquefied natural gas (LNG), will go to the Arctic region during the northern hemisphere summer, and to Antarctica for its summer months.

Le Commandant Charcot in ice

A team of Aker Arctic experts travelled onboard *Le Commandant Charcot*, the world's first icebreaking hybrid-electric expedition cruise ship, for full-scale ice tests in June 2021.

Le Commandant Charcot, which features a Polar Class 2 icebreaking hull and hybrid-electric power plant powered by liquefied natural gas (LNG), will go to the Arctic region during the northern hemisphere summer, and to Antarctica for its summer months. Aker Arctic developed the vessel concept together with Stirling Design International and the luxury expedition cruise company Ponant.

Representatives from Ponant, Vard, the flag administration, and the Aker Arctic team responsible for the ice trials boarded the vessel at the Norwegian shipyard Vard Langsten after it had been outfitted at Vard Søviknes. *Le Commandant Charcot* headed first north to Svalbard, and then west towards Belgica Bank off the east coast of Greenland. Propulsion adjustments were made before the ice trials started. The voyage continued along international waters to areas northwest of Greenland in search of suitable ice fields.

The aim with ice trials is to test various ice capabilities to verify that the vessel fulfils specifications and is safe to use in the intended operational areas.

Test results

Le Commandant Charcot is designed according to the Double Acting Ship (DAS™) principle which allows the vessel to operate both in ahead direction as well as stern-first, depending on the prevailing ice conditions.

Tests in ahead direction were conducted in two level ice thicknesses: 2.0 metres and 2.7 metres. *Le Commandant Charcot* was found to be able to maintain continuous motion even in the thicker ice. Stern-first tests were done in up to 1.7-metre-thick level ice. In addition, the

trials

The aim with ice trials is to test various ice capabilities to verify that the vessel fulfils specifications and is safe to use in the intended operational areas. The Aker Arctic Team responsible for the ice-trials (from left): Teemu Heinonen, Alexey Dudal, Jukka-Pekka Sallinen, Veikko Immonen and Maximilian Vocke.

vessel could penetrate a heavy ice ridge without any problems.

Safety tested

The International Code for Ships Operating in Polar Waters (Polar Code), regulating ships operating in the Arctic and around Antarctica, has many requirements concerning passenger and environmental safety, by, for instance, regulating the equipment for evacuation of the vessel, such as tents, warm clothes and food. One rule requirement specific for passenger ships is that a vessel must be able to return safely to port on its own, even when damaged.

"The Safe-Return-to-Port (SRtP) mode was tested by simulating that one switchboard room was damaged," says project manager Maximilian Vocke from Aker Arctic. "The vessel still achieved a speed of more than 2 knots in 1.6-metre-thick ice."

The results from the full-scale ice tests showed that the vessel fulfils all specifications and that they correspond with the ice model tests which were performed at Aker Arctic's ice laboratory prior to construction. Open water trials were completed earlier in spring 2021 showing that everything functions as it should, also on open sea. ■

First impressions of Le Commandant Charcot

The planning of *Le Commandant Charcot* began six years ago and now she is ready for her first cruise. Ponant representatives share their excitement after the ice trials.

"We began this project in 2015, and now six years later we boarded *Le Commandant Charcot* to experience how she performs in ice," says Mathieu Petiteau from Ponant, who has supervised the vessel's construction. "It was an exciting moment for all of us, feeling for the first time the ship's power. We were immensely impressed with its capability in ice and the sensations onboard in ice operations."

Disembarking on the ice for the first time was a spectacular moment. From left: Captain Marchesseau, Captain Garcia, Jukka-Pekka Sallinen, Alexey Dudal, Sophie Wahl and Teemu Heinonen.

The Ponant team was excited to experience the vessel's power in ice for the first time.

Passenger comfort

One of the important design aspects has been to ensure passenger comfort when operating in ice. Petiteau was positively impressed by the low level of noise and vibration.

"We pushed the vessel to the limits and did exactly the opposite of what we will do in real operations, where we will try to avoid ice and find the channels among ice floes, both to save energy and to prioritize passenger well-being. However, even in the extreme condition of the trials, passenger comfort was at its best."

Captain Marchesseau and Captain Garcia from Ponant will be the main captains in charge of the vessel in future. Marchesseau adds that he feels confident about the vessel after the trials. "The performance was above expectations. The vessel is powerful and strong, and despite all the manoeuvres we tried, we did not get stuck in ice, thus providing the level of safety and security we are aiming at."

Spaceship adventure

Petiteau says the trials felt like being on a space adventure. "Disembarking from the vessel on ice gave the impression of discovering a new world, almost like the first step on the moon."
The ridge penetration was an exciting moment after a full day of preparation, with Aker Arctic ice expert Teemu Heinonen guiding the captain in charge on how to control the ship and which way to turn the thrusters.

"We expected the ridge penetration to last much longer and were surprised at how easily we went through," Petiteau says. "The importance of an experienced captain became very clear. You can spend hours or 15 minutes, all depending on the skills of the captain. The azimuthing propulsion units are like multi-purpose tools and the captain needs to master the techniques, such as flushing the hull for lubrication and to reduce friction, how to spray the ridge with water, etc."

"Overall, we were impressed with the Aker Arctic team and their different skills complementing each other," Petiteau adds.

Dry-run in September

After the ship's delivery, Ponant is planning to organise what they call a dry-run, and travel to the North Pole. The intention is to train sailing in ice, practise all safety operations and test all safety equipment such as lifeboats and polar shelters.

"We have worked hard to develop the safety equipment and procedures and want to ensure that all runs smoothly without any gaps," says Captain Marchesseau. "Additionally, we are trying to organise a search and rescue exercise with all Arctic nations."

Scientific research emphasized

Ponant is strongly committed to preserving the polar areas and has decided to give scientists the opportunity to travel onboard the ship for research.

"We have dedicated space for multi-purpose research including both dry and wet laboratories. There is a tube crossing the hull where you can take samples from the sea, a multi-beam sonar current measurement system, a sea-ice measurement system recording the ice thickness along the vessel path, a weather station to collect information about air temperature and humidity, in addition to water temperature and salinity recording systems," Petiteau lists.

"There will additionally be a participating programme for passengers where they can collect samples, attend lectures and learn about protecting the environment."

Passenger reactions

Passengers arriving at *Le Commandant Charcot* will first discover the external design of the ship, which is quite spectacular, looking strong and refined. "Entering inside they will discover a magnificent vessel, where we have put more effort in the architectural design than in any of our previous vessels. The standard in every detail is high and they will feel the comfort at open sea," says Petiteau.

"Experiencing ice for the first time will be another spectacular moment. The sense of direction is lost when you are surrounded by ice as far as you can see. Also, the complete silence is striking."

Captain Marchesseau adds that there is a lot of volume and space on the ship, which will never feel crowded. "The splendid windows allow uninterrupted views to the far horizon."

Le Commandant Charcot will depart on her maiden cruise from Puerto Montt in Chile to open the Antarctic season in November 2021, promising an extra-ordinary experience for the passengers onboard this luxurious ship. ■

Mathieu Petiteau from Ponant has supervised the vessel's construction. One of the important design aspects has been to ensure passenger comfort.

Captain Marchesseau and Captain Garcia from Ponant will be the main captains in charge of the vessel in future.

Special features of Le Commandant Charcot

Le Commandant Charcot is designed according to the Double Acting Ship (DAS™) principle which allows the vessel to operate both in ahead direction as well as stern-first, depending on the prevailing ice conditions.

Le Commandant Charcot features a modern Polar Class 2 icebreaking hull, which combines smooth icebreaking ahead in up to 2.5-metre-thick multi-year ice, and astern in severe ice conditions such as heavy ice ridges using the Double Acting Ship (DAS™) principle. The vessel's performance is comparable to existing polar icebreakers, but with lower ice resistance ensuring better fuel economy.

First hybrid cruise ship

This is the first hybrid-electric cruise ship powered by liquefied natural gas (LNG) and electric batteries, reducing emissions and environmental impact. She also complies with IMO and ECA regulations and fulfils the "clean ship" requirement with advanced waste-water treatment, energy optimisation, a heat recovery system and zero emissions in electric hybrid mode.

New cruise experience

"*Le Commandant Charcot* is a new step for the cruise industry," says Maximilian Vocke. "Technically, the hull is optimised for both icebreaking and open water. All the machinery and equipment chosen is highly advanced with proper winterization, while all interior decorations are luxurious with the aim of creating a once-in-a-lifetime experience for passengers."
During the concept development, Aker Arctic was responsible for everything from the main deck downwards, as well as the machinery and design of the steel hull. Stirling Design International was responsible for the upper decks and interior design, while Ponant provided the guidelines for the development and ensured that everything met their requirements. Vard joined the design team during the contract negotiations.

Le Commandant Charcot was built by Vard with the steel hull constructed in Romania, while final outfitting and commissioning were done in Norway. The vessel was delivered in July 2021. ■

Icebreaking bow Saimaa and tug Calypso in ice trials

Aker Arctic designed and delivered the complete shaft lines with propellers for the detachable bow and the ice-strengthened bronze propellers for the pusher

On a sunny week in late March, shortly after the Saimaa Canal had been re-opened for traffic after its annual winter closure, Aker Arctic conducted full-scale trials for the self-propelled detachable icebreaking bow *Saimaa* and the pusher tug *Calypso*. The tests were carried out together with Turku Repair Yard, the Finnish Transport Infrastructure Agency, Alfons Håkans and Danfoss.

The target for development engineer Teemu Heinonen and his team was to test how the icebreaking bow-pusher combination works together in icebreaking duties, and to ensure that it fulfils its specified icebreaking requirements. The ice trials were conducted during the period when the ice conditions are at their most challenging in Lake Saimaa.

Three days of performance tests

The first level ice tests were performed on Lake Paasselkä, in southern Savonia, Finland, where a suitable level ice field with a thickness of approximately 60 cm was found. After the ahead test, in which a speed of 4.7 knots was achieved, flexural strength and compressive strength were measured from the ice.

The turning tests at various angles showed excellent manoeuvrability.
"The combination of a wide bow, the pusher's azimuthing thrusters, and four propulsion units in total provide excellent manoeuvrability," Heinonen says.

The turning tests at various angles showed excellent manoeuvrability.

Over the next two days, performance in ice channels was tested at Pyhäselkä, near Joensuu. The channel tests demonstrated that the combination fulfils the 7-knot speed requirement in a 150-cm-thick unconsolidated channel.
Additional level ice tests were performed in approximately 50-cm-thick level ice, in which a speed of 6.5 knots was achieved.

Finally, operability in astern mode was tested, although the combination is designed to operate mainly in ahead mode.
"The bow is wider than the pusher and the main operational direction of the combination is ahead. However, we could demonstrate that it can manage even 50 cm of level ice in astern mode, if necessary," Heinonen explains.

Ice thickness, flexural strength and compressive strength are measured from the ice during the test.

Vast measurements

Aker Arctic has delivered the complete shaft lines with propellers for the detachable bow and the ice-strengthened bronze propellers for the tugboat.

The shafts and the connector pins used to couple *Saimaa* and *Calypso* are all instrumented and connected to a data gathering system developed by Aker Arctic, which consolidates all the information on one display. Real-time thrust, torque, propulsion power, engine use and pin connection forces were followed from the display throughout the tests and valuable information was gathered.

"With the help of the Distributed Intelligent Vessel Components (DIVEC) data gathering system we received abundant amounts of detailed information, which would not have been possible without the system," Heinonen says.

The Aker Arctic Ice Load Monitoring System (ILMS) was installed during construction. It saves and transmits data from the ice loads on both sets of shaft lines (the bow and the pusher) as well as monitoring shaft line power. The ILMS is also connected to the yard-delivered pin force sensors transferring the loads from the connection between the bow and the pusher to the ship's automation system. This provides the crew with important real-time operational information. Valuable data about this innovative vessel concept is also gathered for possible future projects.

Sensors installed on the hull and the shaft lines send information to a central computer for real-time processing. This data is available on a monitor on the ship's bridge, as well as online remotely. This is an example of a typical view.

Successful tests

The test programme was successfully completed showing that the pusher-bow combination *Calypso* and *Saimaa* fulfils the icebreaking requirements and will improve icebreaking and ice management operations in the Lake Saimaa area and Saimaa Canal during wintertime, just as intended.
"This is the first self-propelled icebreaking bow ever built and it functions well," adds Heinonen.

"We are very pleased with the test results," says Ilari Rainio, Maritime Specialist at the Finnish Transport Infrastructure Agency and responsible for icebreaking in the Lake Saimaa area and Saimaa Canal. The area stretches from the Brusnitchnoe Lock all the way up to Joensuu and Siilinjärvi, with ten locks in total. There are eight locks in the Saimaa Canal with a height difference of 76 metres.

"Aker Arctic performed the tests in an excellent manner. It was a pleasure to follow their professional work and easy to cooperate with them from the start to the end," Rainio adds.

"The first season went well with positive feedback from Calypso's crew, the Masters of the assisted vessels, as well as the nautical pilots. We are already looking forward to next winter." ■

Sinking Caspian Sea needs innovations

The vast majority of higher-class icebreaking vessels working in the region have been designed by Aker Arctic. The Mangystau class vessels have a draught of 2.5 metres.

Water levels in the Caspian Sea have fluctuated for centuries. However, the continuously falling water levels of the past decades have worried investors about the possibility of continuing sea logistic activities in the Northern Caspian Sea. Dredging and vessels with lower draughts offer possible solutions to the problem.

The Caspian Sea is the world's largest enclosed basin of water. Its main source is the Volga River, but it also receives water from the Ural, Kura and Terek Rivers. With no connection to the global oceans, the average Caspian Sea level is about 27 metres below mean ocean level.

Over the past centuries, the water level has fluctuated significantly, including changes of several metres within the past decades. The historical causes are uncertain, but increased evaporation rates over the Caspian Sea are believed to have played a dominant role during more recent times. The current long-term decline is expected to continue into the future, under global warming scenarios, according to research.

Shallow waters

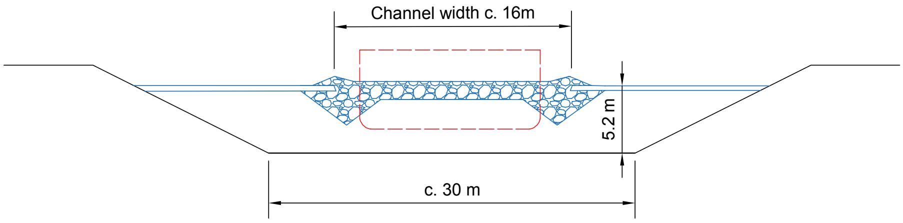
In addition to falling water levels, the Caspian Sea has many areas of shallow water. The northern part of the Caspian Sea is the coldest and most shallow area with a depth of only three to four metres. During winter, the sea freezes due to low salinity levels and subarctic temperatures down to –30 °C, and the support of icebreaking tugs is needed to transport goods and material between the artificial islands of the Kashagan oil field located in the area.

The highly pressurized Kashagan reservoir contains high levels of toxic hydrogen sulphide (H_2S) as well as carbon dioxide (CO_2). The development of the Kashagan field therefore presents a unique combination of technical complexity and supply-chain coordination in the harsh offshore environment.

The shallow-water field is currently in its first phase of development. Two additional phases are under discussion with authorities, in order to bring the asset to an output of 1.1 million barrels per day by 2055 or later.

Dredging channels

In April 2021, the Kazakhstan authorities gave Kashagan operator North Caspian Operating Company NCOC permission to execute a dredging project to dredge navigation channels from the deeper water area to the existing artificial production islands.



During winter, after icebreaking, the surface of the channel is a mixture of ice sheets and sludge. Every time the ice is broken, the ice sheets and sludge are mixed increasing the formation of new ice. Therefore, the ice formation in a canal is heavily dependent on the frequency of the ice-breaking.

The dredged channels will help NCOC to extend the use of its actual fleet to transport personnel, supplies and equipment to the field's D-island and four satellite islands. The work will be divided into two phases: construction of a long navigation channel to reach deeper waters and a connecting channel to link the islands together, including vessel-turning basins. The total length of all dredged ship channels will be about 45 kilometres.

Challenging winter operations

However, operating in dredged channels during winter presents a further challenge.

In an ice channel, each passing vessel breaks the insulating ice shield, which leads to a heat loss from the water mass. This heat loss accelerates the ice formation, firstly increasing the thickness of the ice sheet or the brash ice layer, and secondly creating ever larger ice blocks, hindering the flow of the traffic.

According to an Aker Arctic study, the passing of four vessels a day may increase the ice formation five times higher than it would be without any traffic. A snow cover further influences navigation, as snow easily turns into ice when coming into contact with cold water.

Ice thickness grows

The ongoing navigation also affects the thickness of the ice layer. Each vessel pushes brash ice to the sides of the channel, increasing the ice layer thickness. This brash ice layer typically reaches a width of one vessel breadth on each side and its thickness may be two to three times the thickness of the brash ice layer in the middle of the channel. The ice collars on both sides of the vessel make navigation even more difficult and increase the risk of collision when other ships are passing by.

The ice mass in the channel grows with time, increasing the vessels' resistance. As a vessel moves in the channel it pushes ice blocks under the hull and in shallow waters the ice mass, though loose, may reach to the bottom and prevent vessels from continuing.

Furthermore, if the channel moves because of currents and winds, and the vessel needs to get out of the brash ice to remain in the dredged channel, the vessel will have to penetrate the thick side walls.

Shallow draught icebreakers

Designing vessels for icebreaking in shallow water is not only about the hull form. Shallow water also has a big effect on various other functions of the vessel, particularly on propulsion efficiency and propeller thrust. Thick, brash ice in connection with shallow water can dramatically reduce propulsion efficiency, resulting in poor vessel performance.

Weight control becomes critical, and understanding the effect of different technical solutions and their effect on weight, such as the steel structure and the use of lighter materials, is vital.

Other important aspects to consider are a shaft-line sealing system for protection, the cooling water intake, and the location of air intakes to ensure minimum freeboard.

Lastly, an important fact to highlight is that shallow water areas are often characterised by a fragile environment, with possibly an ecosystem that is maintained through a delicate equilibrium. Therefore, it is crucial to reduce the local emissions caused by the icebreaker as much as possible. This is done in the design phase, choosing environmentally-friendly propulsion and applying zero-discharge policies, but also during operations, avoiding the most fragile areas when navigating. ■

Aker Arctic shallow draught icebreaking vessels

Aker Arctic has designed shallow draught icebreaking vessels since the 1970s, especially for shallow Arctic rivers in the Soviet Union and operations in the Caspian Sea, gaining solid experience in the field.

"The vast majority of higher-class icebreaking vessels working in the region have been designed by Aker Arctic," says Sales Manager Arto Uuskallio.

"The draught trend has continually moved towards even more shallow vessels, beginning with a three-metre draught in the 1970s to a possible ultra-shallow 1.5 metres today."

The development has so far resulted in four different designs for various purposes totalling 21 vessels.

Kapitan Chechkin class (1970s)

- 6 vessels
- draught 3.25 m
- icebreaking capability 0.7 m
- three 1.17 MW shaft lines

Kapitan Evdokimov class (1980s)

- 8 vessels
- draught 2.5 m
- icebreaking capability 0.9 m
- four 0.95 MW shaft lines

Antarcticaborg class (1998)

- 2 vessels
- draught 2.9 m
- icebreaking capability 0.9 m
- two 1.62 MW azimuthing propulsion units

Mangystau class (2010—2011)

- 5 vessels
- draught 2.5 m
- icebreaking capability 0.6 m
- three 1.6 MW azimuthing propulsion units

A notable addition to the list is the Austrian shallow-draught river icebreaker built for the Danube River: *Röthelstein*, delivered in 1995. She has a minimum operating draught of only 1.57 m and an icebreaking capability of 0.7 m. The vessel has two 0.56 MW azimuthing propulsion units.

Aker Arctic has conducted full-scale ice trials with all of its shallow water vessel designs, and has been able to compare the resulting data against the model test data from the ice laboratory.

"In this way we have been able to further develop the efficiency of icebreaking in shallow waters," says Uuskallio. ■

Kapitan Chechkin class

Kapitan Evdokimov class

Antarcticaborg class

Mangystau class

Röthelstein

Lifetime costs and emissions are important in ship design

Life cycle cost analysis (LCC) and life cycle assessment (LCA) are tools to evaluate the total cost of acquiring and owning a vessel. In addition to assessing costs, the environmental impact of design selections and benefits from new energy-efficiency solutions are considered.

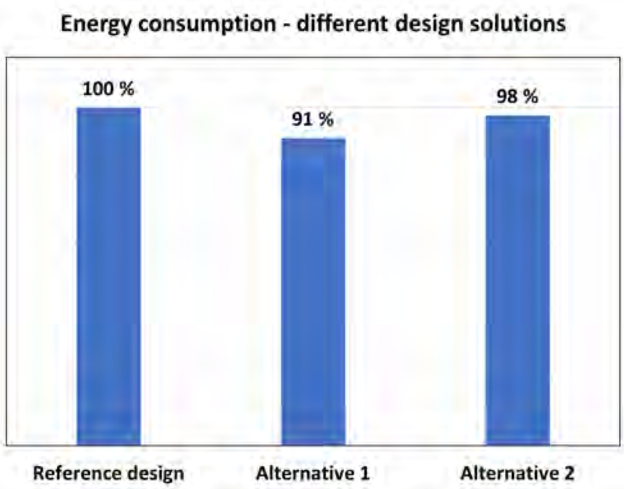
From a shipowner's point of view, acquiring a ship is a significant investment. However, acquisition cost alone does not reflect the full expense of owning, using and maintaining the ship. Calculating the life cycle costs, or LCC, helps to evaluate the economic aspect of a vessel's entire lifetime, from fuel for operations to maintenance costs.

"It is the sum of the acquisition cost, the support cost and the operational cost," says Cayetana Ruiz de Almiron, Head of Consultancy and Technology Development at Aker Arctic.

Evaluating alternatives

An LCC analysis is usually a comparison of two or more alternatives, against a baseline or a reference case.

"The main target is to give the client real values to make the decision regarding which design alternative would be most optimal for the requirements," continues project engineer Jesse Lehtonen who does machinery simulations based on the design, and calculates fuel consumption, emissions and other relevant values based on the operational profile.



Comparing the energy consumption of a vessel to a reference design gives an understanding of which one is the most efficient.

If an operational profile is not available, data from a reference vessel can be modified and scaled accordingly in order to estimate fuel use in similar operations.

"With statistical data, separate calculations for easy, moderate and severe winters can also be made, in addition to looking at how often such winter types may occur during the expected lifetime," Lehtonen explains.

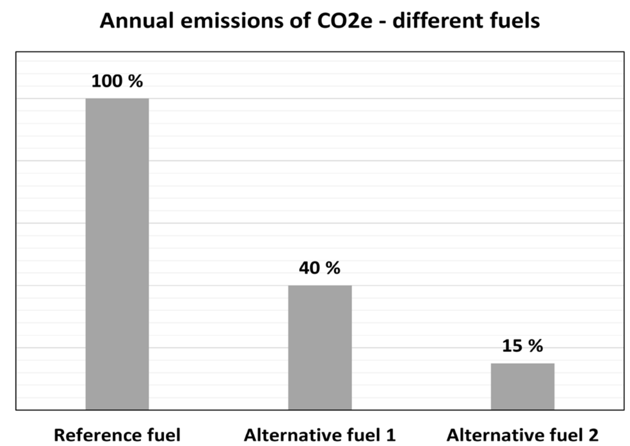
The generated values are then used to determine the life cycle cost and life cycle assessment.

"The LCC and LCA studies provide the information about the cost and environmental impact in the long run for each alternative design solution," Ruiz de Almiron says. "Consequently, they are easy to compare."

Carbon footprint calculations

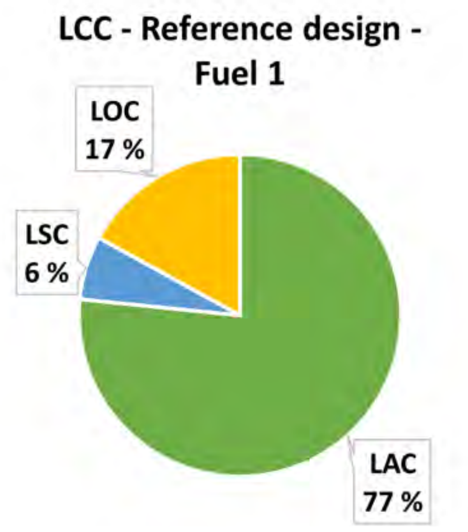
Fuel consumption values are also used in the life cycle assessment (LCA), which shows the amount of emissions generated during a vessel's lifetime.

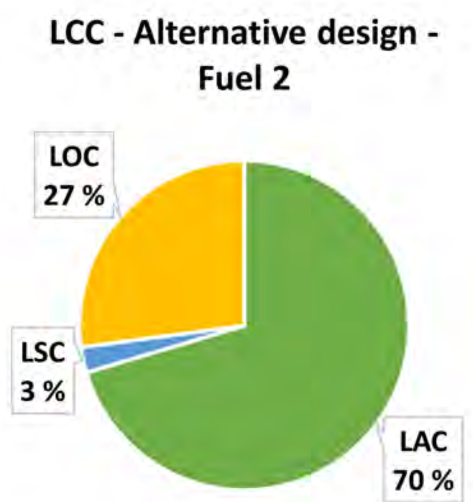
"With the current trend moving towards greener technology and lower emissions, the main focus is on the carbon footprint," Ruiz de Almiron says. "Other emissions can also be calculated, depending on the customer needs, but presently attention is on the CO_2 equivalent."

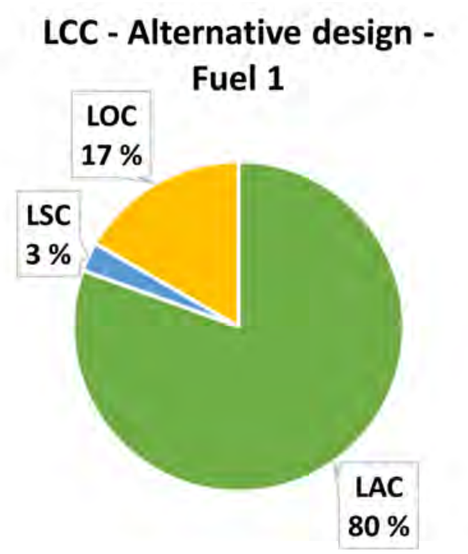


CO_2 emissions depend on the type of fuel. Emissions can be reduced considerably by selecting an alternative fuel.

Interest in these calculations is clearly growing, showing that customers are increasingly considering emissions in ship design. Initially, it was related to governmental projects, but now the commercial sector is heading in the same direction.
"There is a rising global demand," Ruiz de Almiron adds.







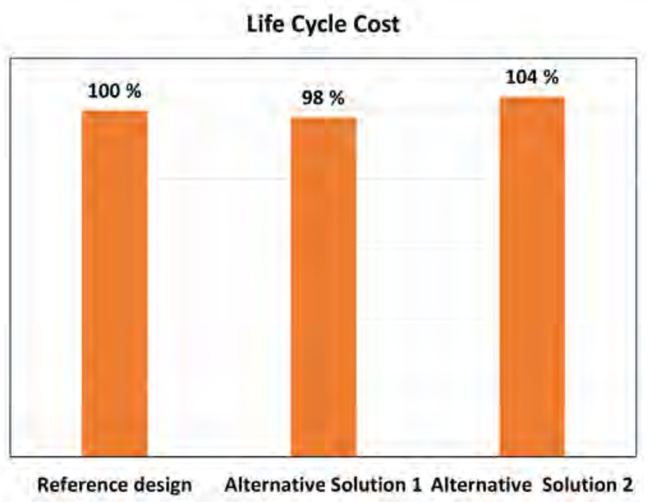
The acquisition cost (LAC) is the biggest driver of total LCC over 50 years in every case. Life Operation Cost (LOC) depends mainly on the fuel price. Life Support Cost (LSC) represents a very small share of total LCC.

Parallel with the design

The biggest decisions in a project are made in the beginning. Having the results from LCC and LCA greatly assist in decision-making, once the main parameters are clear. "LCC can, for instance, help to find out which propulsion configuration would be best from a life cycle cost point of view, or to compare two design options," Lehtonen says.

When the design is refined and goes further into detail, the calculations can be updated with new simulations, as modifications in the design naturally have an impact on the costs.

During the design process, questions regarding new technology can be dealt with thanks to the help of LCC and LCA. For instance, the advantages and cost of installing an energy storage system, or the use of alternative fuels.



The comparison of the total LCC supports investment decisions for different solutions, as the economic impact over the whole life cycle of a given solution can be quantified.

"With these tools we can actually evaluate the benefits and costs of rapidly developing energy-efficiency solutions, which are not standard features currently," Lehtonen underlines.

Addressing open questions

The LCC and LCA service is highly recommended when there are open design questions, such as the selection of characteristics and how to improve energy-efficiency.

"In our own design projects, it is easy to get all the required information from our colleagues, but calculations can also be done to evaluate external designs," Ruiz de Almiron says. ■

Popular webinars about icebreaking continue

Aker Arctic's popular webinars continue to gather professionals with an interest in icebreaking and shipping in ice. Here is a review of the latest topics. Let us know if you find one that you missed but would have been keen to attend. An updated list of upcoming webinars can be found on our website:

https://akerarctic.fi/en/news-category/webinar/

Propulsion and ice load monitoring

Operations in ice and harsh environments place challenging demands on a vessel's propulsion system and hull structure. Building on our experience in icebreaker and Arctic ship design, as well as decades of full-scale trials and measurements, Kari Laukia, Head of Equipment Business, and Rob Hindley, Head of Machinery & Structures, brought their expertise to bear on delivering complete propulsion packages and hull stress monitoring systems.

Aker Arctic's role in the development of Arctic projects (in Russian)

Regional Manager Alexey Dudal and Development Manager Alexey Shtrek presented projects related to the Arctic and the Northern Sea Route where Aker Arctic has assisted clients to successfully develop new vessel concepts and transportation solutions, in addition to harbour ice management. Also, the new regulations on the Northern Sea Route were discussed.

Icebreaking for lakes and ports Case: Detachable icebreaking bow

Sales Manager Jukka Salminen and Development Engineer Teemu Heinonen discussed essential aspects to consider when beginning to plan new icebreakers for lakes and ports. Successful past concepts were presented, with the focus on how innovative solutions have increased cost efficiency and flexibility.

Acquisition of Polar Research Vessels – the early phase is crucial

Sales Manager Arto Uuskallio has been part of many Polar Research Vessel projects. His experience is that every research vessel is, in fact, a one-of-a-kind prototype, regulated by government acquisition laws and with long timelines between projects. Therefore, the procurement and design processes are more complex than in commercial vessel projects. In particular, the effects of early phase decisions are felt throughout the entire project.

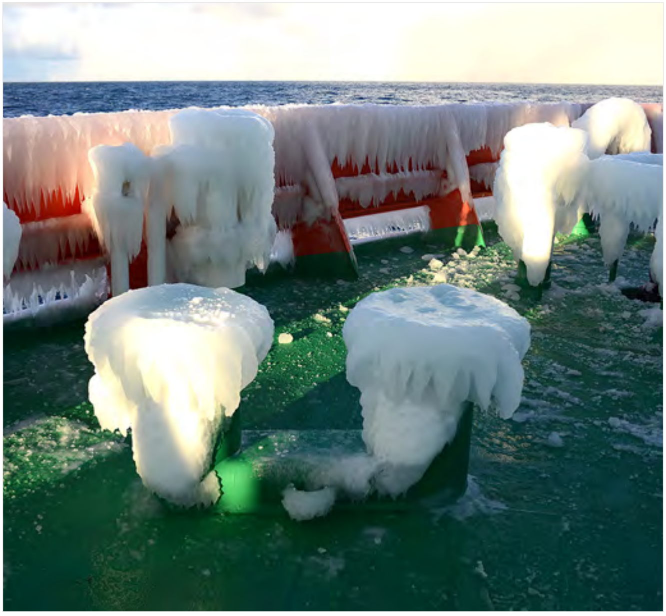
In this webinar, he shared his expertise and recommendations on how to achieve a successful Polar Research Vessel project.

Photo courtesy of PRIC.

Ship operations in ice and practical winterisation

Jukka Salminen presented how ships operate in ice, both independently and with icebreaker assistance. Different design solutions for efficient ice operations were discussed. Salminen also described how icebreaking operations and ship handling in ice can be trained using an ice navigation simulator.

Rob Hindley presented practical methods and approaches for winterising ships. The target being to have a ship that is safe and functional in low temperatures and icy conditions.



The Polar Code and ice strengthening

Rob Hindley looked back at what both regulators and the industry have learned from the years since the Polar Code came into force on 1 January 2017. The goal-based nature of the Code brings opportunities for designers, builders and shipowners, but also requires closer cooperation and an understanding of the overall approach to safety and operational risk in polar environments.

Structural Engineer Ville Valtonen discussed the factors that affect the selection of the most suitable ice strengthening level for a vessel, both from a class notation perspective and the need for additional strengthening beyond the minimum ice class requirements. By selecting the correct ice strengthening level, steel weight can be minimised, while safety is ensured.

Powering of ice classed ships

Ships of any ice class bring additional costs, but there are ways to optimise this. Managing Director Reko-Antti Suojanen explained the requirements of the Finnish-Swedish Ice Class Rules concerning vessel powering, the motivation behind the rules and why they are important for the ice classes 1C, 1B, 1A and 1A Super. Power requirements and installed power can be reduced with the right design selections, and special ice model tests provide the appropriate results for a class approval. Savings can be made in investments and through lower fuel consumption.

Ilkka Saisto, Head of Ship Performance, explained different technical solutions for an ice going vessel's power requirements. What are the advantages and disadvantages of different propulsion concepts when a vessel is operating in open water, in light ice or in heavy ice conditions? Powering design aspects can be different when a vessel is assisted in icy waters or when it is travelling independently. There are also additional measures to improve ice performance. ■

NEWS IN BRIEF

Aker Arctic joins renewable energy team

The world is moving towards cleaner energy in big steps. As projects become more demanding, the need for broader expertise arises. The recently established Team Renewable Arctic Finland brings together all relevant stakeholders, investors, businesses, technology and service providers with governmental institutions for creating renewable maritime energy solutions for a sustainable future.

Aker Arctic, along with 21 Finnish companies, has joined the team to offer competitive offshore expertise to innovate, create, design and deliver scalable solutions for renewable energy. Together, these companies with a multitude of references respond on their part to the global shift towards carbon neutrality and low carbon solutions.

Customers can now access all innovative players in Finland at one point of contact, while reducing environmental impact throughout the value chain.

https://teamrenewablearctic.fi

TEAM RENEWABLE ARCTIC FINLAND

NEWS IN BRIEF

Xue Long 2 in Antarctica. Photo courtesy of PRIC.

Xue Long 2 first experiences

China's first domestically-built polar research vessel, *Xue Long 2*, has performed excellently since its delivery in July 2019, according to Captain Zhao Yanping. So far, the vessel has completed two Antarctic expeditions and is currently on her second Arctic research mission.

Aker Arctic designed the Polar Class 3 icebreaking polar research vessel for the Polar Research Institute of China (PRIC) and supported the owner in ice-related matters during the building phase, culminating in successful ice trials in Antarctica at the end of 2019.

Since then, Captain Zhao Yanping along with his crew and scientists, have continued to test her abilities.
"The wheelhouse functionality and visibility are good, with no freezing issues on windows or doors, and winterization heating mostly working well," the Captain reports.

Easy manoeuvring in ice

One of the special features of the icebreaking research vessel is the propulsion system with two azimuthing units.
"We have not operated stern first in ice conditions very often, but turning in ice has been easy," he says.

Xue Long 2 is designed to break 1.5-metre-thick ice in the polar areas. A high-performance icebreaking hull usually comes with more rolling in high waves. However, the Captain states that the rolling angle in open water is small and the anti-rolling tank works well to reduce it.
"The bow performance is also good with an acceptable level of slamming. The wave breaker prevents too much water from entering the foredeck and accumulating heavy ice."

The laboratory and moonpool areas of the vessel are remarkable and outfitted with the latest equipment to allow for a wide range of research.
"The moonpool has been clear of ice pieces. After every experiment, water has been pumped out and the moonpool kept empty," the Captain says. ■

Ari Huusela completes his race around the globe

Finnish solo sailor Ari Huusela crossed the finishing line of the Vendée Globe sailing race as the first Nordic participant ever. Aker Arctic, jointly with four other Finnish companies, helped Huusela and Merfyn Owen to design and manufacture a new keel for his boat, prior to the race.

This extremely challenging race around the globe clockwise, across the Indian Ocean, the Pacific and the Atlantic, took him 116 days,18 hours and 15 minutes. Eight of the 33 competitors had to abandon the race due to problems with their boats. Huusela did encounter challenges too, but always managed to overcome them and continue towards his goal. The race rules are such that no outside help is allowed, nor any stops during the race.

Stringent safety requirements

The new keel was especially important from a safety point of view. It was designed to fit into the place of the old keel and carry the loads specified in the 2020 IMOCA Class Rules.

The keel was made of one single billet of forged and heat-treated extra-high- strength stainless steel, with a yield strength of 800 MPa. It is strong enough to carry five times its own weight and survive a grounding force of 27 tonnes, which is more than three times the weight of the boat.

"The performance of the new keel was totally different from the original keel," says Huusela. "It was thinner, offering less water resistance, and the more flexible structure was kinder to the boat in hard waves. But above all, it felt reassuring to know that the keel was safe and would not break, as has happened to competitors previously.

Aker Arctic designed the keel using the same high-tech expertise as in their icebreaker designs. ■

New icebreaking Arctic containership design.

Suez Canal blockage raises interest in Arctic containerships

In late March, the giant container ship Ever Given blocked the Suez Canal and delayed other vessels for weeks, resulting in shortages of certain goods all over the world. A few days earlier, we introduced our new icebreaking Arctic containership design.

The Northern Sea Route is about 40 % shorter when sailing from China to central European ports than the Suez Canal route. However, year-round operation in challenging ice conditions requires specially-designed ice-strengthened vessels, which have not been available until now.

Although ice-classed containerships are more costly to build than open water vessels, the Northern Sea Route presents a viable alternative to the busy Suez Canal. After the accident, interest in the Arctic route has grown while our new Arctic containership design has also received considerable attention.

More detailed information can be found in our previous issue of Arctic Passion News. ■

Ari Huusela was extremely pleased with his new keel during the race.

Low-emission transportation on inland waterways

Two vessel concept designs have been generated in cooperation between Aalto University and Aker Arctic for the "Future Potential of Inland Waterways" (INFUTURE) project: ice class 1A for escorted and 1A Super for independent operation.

The vessel concepts have been designed with the expanded Saimaa Canal locks in mind. Both are of a similar size and capable of handling a variety of general cargo. They have a speed of 11.5 knots and are equipped with lift away hatch covers, movable tweendecks and bulkheads, and an option for gantry cranes. The main difference is their ice capability; the one concept having a traditional hull form and a single fixed pitch propeller, and the other having a double-acting ship hull and azimuthing propulsion, allowing independent operations in ice.

Reduced emissions

Both concepts would be able to extend the navigating season significantly when compared to existing vessels. They are designed to run on biofuels with the potential to reduce carbon emissions. Furthermore, they comply with the IMO BWM Convention to prevent the transportation of foreign species.

To validate the new concept designs, model-scale ice tests were conducted in the Aalto ice tank in March and April 2021.

Since 2018, INFUTURE has been evaluating attractive business opportunities in the context of inland waterway utilization and joint ventures between some key partners from Finland and Russia.

Read the full article written by Pentti Kujala and Li Fang from Aalto University at

https://www.vesitiet.org/post/inland-waterways-can-form-the-leading-edge-for-zero-emission-transport/

ANNOUNCEMENT

Mikko Patalainen has joined Aker Arctic as a structural design specialist in the Machinery and Structures team.

Mikko graduated from the Mechanical Engineering Department at Aalto University in 2010. He studied Mechanics of Materials as his major, and did his master's thesis at VTT (Technical Research Centre of Finland). After working for a few years as a research scientist at VTT, Mikko decided to challenge himself with a new field of expertise and joined Arctech Helsinki's Shipyard Hull Design Department in 2014. There he was introduced to hull design for multipurpose vessels and icebreakers; his main tasks being to carry out structural analyses for hull structures using mostly the finite element method (FEM). It was an interesting and inspiring time for Mikko, and he was able to see the actual vessels being built not more than 50 metres away from his office. Ever since, he has been working with structural design and analyses in one way or another.

Mikko enjoys the outdoors and tries to spend as much time in the nature as possible, whether it's hiking, fly fishing or just hanging out. He is also an enthusiastic badminton player. ■

Summer trainees at Aker Arctic

From left: Tomás Sanches, Eetu Seppänen, Juhan Voutilainen, Aaro Vasama, Victor Granlund, Henry Vesalainen.

Aker Arctic takes on trainees every year to give university students a chance to familiarise themselves with working life and to learn new practical skills.

During the past June to September period, six trainees have supported our teams in various tasks: Victor Granlund, Tomás Sanches, Eetu Seppänen, Aaro Vasama, Henry Vesalainen and Juhan Voutilainen.

Victor Granlund graduated from Aalto University in Espoo, Finland, this summer, specialising in cold climate engineering. At Aker Arctic, his main focus has been on creating data insight tools for the best available open datasets on Arctic ice conditions. "I've learnt a great deal about data analysis methods and working with map data. I've also learnt about the specific needs of the industry and how data can reveal the way forward," Granlund says.

Tomás Sanches is pursuing a master's degree in mechanical engineering focusing on naval architecture at Aalto University. He has previously accomplished a bachelor's degree at the technical university in Lisbon, Portugal. During his internship at Aker Arctic, he has completed comparisons of propulsion alternatives, evaluated shipyard tenders, in addition to other calculations.
"I believe the most important thing I will learn from this period at Aker Arctic is an understanding of how complex a new vessel project is, and the number of different teams involved in accomplishing a good design," Sanches says.

Eetu Seppänen is studying shipbuilding at Aalto University. He has worked with the ice model testing team this summer, carrying out ice measurements and preparing the ice field, as well as helping with maintenance work. "My general knowledge of shipbuilding has increased during this time," Seppänen says.

Aaro Vasama's field of study is energy and environmental technology at Aalto University. He has also worked with ice model tests and maintenance at the ice laboratory in Helsinki, Finland. "This is already my fourth summer at Aker Arctic. I have learnt to perform a variety of tasks in a challenging environment, as well as becoming familiar with how the shipbuilding industry works and how it differs from the energy industry," Vasama says.

Henry Vesalainen will soon receive his master's degree in engineering from LUT University in Lappeenranta, Finland, where he is studying energy conversion. He has been working in the Machinery and Structural Design department and has examined underwater noise, ventilation, and heating systems for icebreakers.
"I have grasped a good understanding of the problems I have researched and also learnt how a design process typically advances, among other things," he says.

Juhan Voutilainen studies shipbuilding at Aalto University. His main tasks have been compiling information about bow geometry and slamming to develop a guideline for future use. "All tasks have been related to my studies and felt meaningful," Voutilainen says.

All trainees have enjoyed the excellent working environment at Aker Arctic and the support they have received from their more experienced colleagues. The group has formed its own bond having lunch together and discussing their different work tasks. The students also compliment the interesting projects they have had the chance to become part of. ■