Aker Arctic
The Ice Technology Partner

Arctic Passion News

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Year-round Arctic LNG carriers

The next generation Arctic icebreaking LNG carrier comes with improved transport economies, no seasonal limitations and higher cargo turnaround than the previous generation of ships.

Construction of the next generation icebreaking LNG carriers will begin in South Korea later this year. From 2023, all six Arc7 classed vessels will be ready to transport liquefied natural gas from the Gydan Peninsula year-round along the Northern Sea Route, improving overall cost-efficiency of the transportation system.

Fifteen Arctic LNG carriers that Aker Arctic participated in developing for Yamal LNG have been transporting LNG to the markets in Europe and Asia since 2017. At the same time, Novatek has been expanding its liquefied natural gas production in the Gulf of Ob with construction of the Arctic LNG 2 production site, located in the Gydan Peninsula across the Gulf of Ob, as well as in Sabetta.

The first generation of Arctic LNG carriers were designed to use the Northern Sea Route (NSR) to Asia only in summertime, and to voyage west to Europe during winter. Although the vessels are extremely capable of icebreaking, their design is optimised for less arduous conditions, having more emphasis on efficiency in open water.

No seasonal limitations

The economic advantage of using the shorter NSR route to Asia all year without seasonal limitations was the incentive to start development of an improved vessel which could bring LNG from the new production site to the Asian markets faster and with lower transportation cost.

"The goal was to find a technical solution for the most cost-efficient transportation," says Managing Director Reko-Antti Suojanen. "The vessels' sole purpose is to transport LNG; with higher overall load capacity and speed, more savings can be achieved."

Transit speed in ice

The initial development of the second-generation of icebreaking LNG carriers began in late 2018 with a study focusing on improving the overall efficiency of the year-round transportation system.

"In our calculations, we noted at an early stage, that transit speed in ice was a crucial factor, as the ice-covered area on the NSR accounts for a major part of the route and is very difficult to navigate. Speed in open water was secondary, as this area is limited and has less importance for the overall system," Suojanen adds.

Transportation from Yamal LNG will, in the future, focus on the west-bound route to Europe, and from Arctic LNG 2 on the east-bound route to Asia along the NSR. The new Arc7 design allows transportation all year round on this challenging itinerary.

Natural gas is produced at a nearly constant rate, and the amount of LNG to be transported remains the same throughout the year. As a consequence, the winter navigating season and average transit speeds in ice-covered waters determine how many vessels are required. Although the fleet size may be excessive for summer months, this provides the opportunity to save fuel through slow steaming during the open water season.

The target is to transport LNG with special vessels through ice-covered areas to reshipping terminals in Kamchatka and Murmansk, and from there with open water vessels further to the market. This solution proved to be the most economical.

Holistic approach

"We also reached the conclusion that while the second -generation Arctic LNG carries have an extremely high, independent operational capability in ice, icebreaker escorts can further improve the overall efficiency of the transportation system," Suojanen explains. "Instead of over-dimensioning the LNG carriers to manage independently in every possible situation, we could choose a safe and sensible level of performance in ice."

The holistic approach was to design a vessel which works in an optimal way together with the existing icebreaker fleet.

New technical solutions for LNG containment systems were developed together with French company GTT, the world's largest LNG tank provider, which allow the carriers to transport larger cargo volumes.

Fewer vessels needed

The new Arc7 LNG carriers will be able to travel at an increased average speed in and through ice-covered waters.

"This means that 2 to 3 vessels fewer will be needed for the same amount of cargo compared to the previous generation of vessels designed for Yamal LNG," Suojanen highlights.

The speed can be increased even more with icebreaker assistance.

"As a result, the overall cost-efficiency of the year-round transportation system will be noticeably improved, and also show the importance of optimization over particular routes, which in the Arctic are quite different."

Delivery in 2023

The vessel concept design was developed in close cooperation with Novatek and then the design was finalised with DSME, who signed a shipbuilding contract with Sovcomflot and Mitsui O.S.K. Lines for the construction of six Arc7 LNG carriers based on the new design in October 2020. The first vessel will be ready in spring 2023, and the remaining five before the end of that year. ■

Novatek developments in Gulf of Ob

Novatek is expanding its LNG production in the Gulf of Ob with the construction of the Arctic LNG 2 production site, located on the Gydan Peninsula across the Gulf of Ob from the fully operational Yamal LNG.

The first stage is scheduled to be ready in 2023, the second in 2024, and full operational speed will be reached by 2026 when the facility is expected to produce 19.8 million tons of LNG. Three liquefaction trains of 6.6 million tons per year each, as well as a cumulative gas condensate production capacity of 1.6 million tons per year, are planned.

The project utilises an innovative concept with gravity-based structure platforms to reduce overall capital costs and minimise the project's environmental footprint.

Apart from Yamal LNG and Arctic LNG 2, there is a smaller production facility under construction, Ob LNG, which will produce 4 million tons of LNG.

The estimate is that a total of 20 to 24 new Arctic LNG vessels will be needed to transport the increased amount of LNG to the markets in Asia. Currently, there are 15 LNG carriers in use, based on Aker Arctic's previous concept design.

In the Arctic, there are yearly variations in the ice coverage and ice thickness. The past few years have been fairly easy, and although climate change is diminishing the overall ice cover, there are no guarantees that every year in the future will be as easy. Photo: Alfred-Wegener-Institute/ Michael Gutsche (CC-BY 4.0)

Tailored solution saves capital

In 2018, when Novatek announced that they wanted to explore year-round use of the NSR, Aker Arctic began to investigate how the first generation of LNG carriers could be improved in order to lower overall transportation costs. The calculations showed that a more cost-efficient vessel was indeed achievable.

A joint development project with Novatek was initiated, first with transit simulations for different vessel concepts, seeking the optimal solution for the new route and period of time, followed by design work for the improved vessel concept.

Icebreaking in narrow channel

"The idea from the start was to improve the vessel's efficiency in ice to reach increased transit speeds," says Mika Hovilainen, head of Aker Arctic's ship design. "As a result, fewer vessels are needed to transport the same amount of cargo, which means lower capital costs."

Currently, there are not enough icebreakers on the NSR to ensure safe transits in winter for the number of vessels envisaged on the route. Additionally, the icebreakers available are 34 metres wide.

"The hull form was therefore developed for independent operation in ice and particularly for efficient use in a narrow ice channel," Hovilainen explains. "The 47-metre-wide LNG carrier will be able to follow a 34-metre-wide icebreaker opening a narrow channel and breaking the ice on the channel sides to make it wider."

Hybrid propulsion suggested

Increased propulsion power was a second focus area. The most powerful solution in ice is a hybrid propulsion

The first generation design of Arctic LNG carriers is extremely capable in ice and can sail independently through 2.1-metre-thick ice. The fifteen carriers, built to date, can manage on the NSR from July to December, whereas the second generation will manage year-round with a high transit speed through ice. In January 2021, three of the existing vessels undertook a test voyage along the NSR without icebreaker escort.

solution with two azimuthing propulsion units flanking a shaft line in the middle. The shaft line can be equipped with a large propeller, which gives more thrust in water while improving fuel efficiency.

"A hull optimised for ice uses more fuel in open water. By using a hybrid propulsion solution, this can be compensated," says Hovilainen.

Azimuthing propulsion improves manoeuvrability and shaft line propulsion increases thrust. Combining the two would give the optimal cost-benefit on the NSR. However, in the final solution, three azimuthing propulsion units with boosted power were opted for by the ship owners, selecting a similar solution to the Yamal LNG carriers' design.

Risk of multi-year ice

The new carriers will use high transit speeds in narrow ice channels and consequently travel bow first. "This is the safest option when there is a risk of encountering multi-year ice," Hovilainen emphasises.

"From an engineering perspective, the safest and most economical route is through areas with one-year ice. However, ice is dynamic, and it is impossible to ensure that there is no multi-year ice mixed in. Multi-year ice means amplified rigorous strength requirements on the hull and propulsion, and we have thus also taken this risk into account in the design."

In the Arctic, there are yearly variations in the ice coverage and ice thickness. The past few years have been fairly easy, and although climate change is diminishing the overall ice cover, there are no guarantees that every year in the future will be as easy.

"Our aim was to design a vessel that can fulfil its task independently even in the worst winters," Hovilainen says.

High block coefficient

Compared to the previous generation LNG carrier, the size has been adjusted. The new vessel will be about 47 metres wide and almost 300 metres long. Nonetheless, the ice-optimised hull has a higher block coefficient, which means that the cargo capacity remains the same 170,000 m^3, despite the narrower hull.

Breadth is the most important parameter concerning ice resistance and efficiency.

"The narrower hull will allow an average speed of 10 to12 knots. With icebreaker assistance the speed can be increased a further 2 knots. On a 10-day trip this means turnaround speed is categorically higher. Or, if the same speed is used, fuel savings are achieved," Hovilainen underlines.

Final design verified with tests

After DSME, the world's most experienced builder of icebreaking LNG carriers, was chosen to construct the new vessels, naval architect Maximilian Vocke joined the project to finalise the concept in close cooperation with the shipyard.

"The hull form was slightly modified for the chosen propulsion, and CFD-calculations were performed for improved open-water capabilities," Vocke says. "The performance requirements are significantly superior to the previous generation of LNG carriers, so a 28-day ice model test series was undertaken to verify all operational capabilities before construction."

These included tests in deep water, shallow water, different types of ice, entering harbours, berthing, leaving harbours. The hull form also underwent open water tests at SSPA to confirm the open water targets for the project.

"Cooperation with DSME was, once again, intense and fruitful and we managed to finalise a vessel which fulfils all the rigorous requirements," Vocke highlights. ■