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DEVELOPMENT OF THE NEW ICEBREAKING SUPPLY VESSEL FOR NORTHERN CASPIAN SEA

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ABSTRACT

The recent interest in developing the hydrocarbon reservoirs offshore Kazakhstan has reached the point when the first facilities for exploration and early production drilling begin to appear in the area building up the need of supply vessel traffic for the offshore platforms. That is why the succesfull supply operator, Wagenborg Shipping BV from Holland, after reviewing the existing tonnage remaining in the area and also the expected winter ice conditions, decided to build new purpose-built vessels for their supply operations of the OKIOC (Offshore Kazakhstan International Operating Company) platform which was scheduled to be installed before winter 1998. Wagenborg contracted Kvaerner Masa-Yards Technology to prepare an icebreaking supply vessel project for this purpose.

In this paper some factors of interest of the project, development of the design and of the resulting vessels are discussed.

1. BACKGROUND OF THE PROJECT

For bidding for the supply operation of the OKIOC drilling platform in the Northern Caspian Sea, Wagenborg Shipping BV from Delfzijl, Holland, made a study of the operation environment in the area. It was found out that the water depth throughout the area, in fact the whole northern part of the sea, is very shallow, c. 4 metres at one of the present drilling sites. The sea freezes every winter and level ice up to 60 to 70 cm in thickness can be found. The ice is constantly moving and breaking into floes. When halted by some obstruction the ice floes driven by wind form ridges which soon reach sea bed and may pile up formidable ice masses and formations up to 10 metres above sea level. Figures 1 and 2 shows some of the conditions.


Figure 1, Flat ice with ridges.


Figure 2, A grounded ice feature.

Another discovery was that there was no existing tonnage of any kind suitable for winter supply operations in the area, without talking about the ice masses described above. Consequently the decision was to construct new purpose-built specialized vessels for the mission: This would allow to extend the operation period of the drilling platforms over the whole year, in case the extreme ice conditions around the platform could be overcome in a reliable way.

Since Kvaerner Masa-Yards has developed the unique Double Acting method for icebreaking and moving in ice, Wagenborg contracted Kvaerner Masa-Yards Technology to develop a suitable icebreaking supply vessel for the task, and to prepare necessary documents for a tendering package for shipyards.

2. CONCEPT DEVELOPMENT

Initial requirements for the new vessels were, in addition to the ice conditions already mentioned; deadweight of 600 - 650 tonnes, ample capacities for dry cargo and dry and liquid bulk cargo, the draught of only 2.9 metres due to the shallow sea, speed 13 knots, ice class minimum 1A, and a double hull for storing oily liquids safely inside the vessel in a highly sensitive environment.

Further the vessel should have accommodation for crew of 12 plus spare beds, and carry equipment for towing and limited anchor handling. The bollard pull force of 32 tonnes is actually due to the towing requirement. Moreover, due to the fact that these vessels are the only ones capable for moving around the platform in ice conditions, also the stand-by, rescue and fire-fighting capacity necessary for the platform had to be built in. In addition to mechanical protection of environment also a dispersant spraying system for pollution clean-up was needed.

Main dimensions, other than draught, were naturally dictated by the canal-river system of Russia.

Considering the rather exceptional ice conditions, the ice strengthening was decided to be nominally Finnish-Swedish ice class 1A Super. In practice the extent of the ice stregthening and the applied ice pressures reflect the ‘non-conventional’ ice situations. The vessels were expected to be used more like an icebreaker than a merchant vessel, and thus considering the unorthodox stern-first icebreaking method , a mark ‘1A Super ++’ could be used.

For propulsion the twin Azipod arrangement was considered the only alternative due to the double acting concept. In the most severe ice conditions the vessels operate not by ramming (bow first) but stern-first, crushing (eating) the ice piles with the propellers. In this type of operation the electric propeller motors are the only choice due to their torque capability at low propeller revolutions and their mechanical strength.

The stern form of the vessel was designed for the chosen twin Azipod arrangement, to suit for backing in level ice and in ridges as much as possible, and to provide ample clearances for the propellers so that ice milling by propeller blades would be minimized. Anyway during the design process the torque capacity of the propeller motor was increased by choosing a bigger motor which brought the power up to 2 * 1620 kW.

The bow is also designed for low ice resistance, considerably full, and for seakeeping capability as far as possible. As a result the vessel can go faster ahead in level ice thinner than 60 cm and in broken ice. The vessels are not expected to ram, but if they do, the bow form should also prevent from getting stuck.

The lines for the hull were drawn according to these considerations of the form of the ends and were dictated by the large beam to draught ratio typical for all shallow draught vessels. Ice model tests were performed in autumn 1997 to verify the icebreaking capability of the vessel. After succesful tests the project documents were finalised for delivery to Wagenborg.

The side view of the projected vessel is in figure 3.

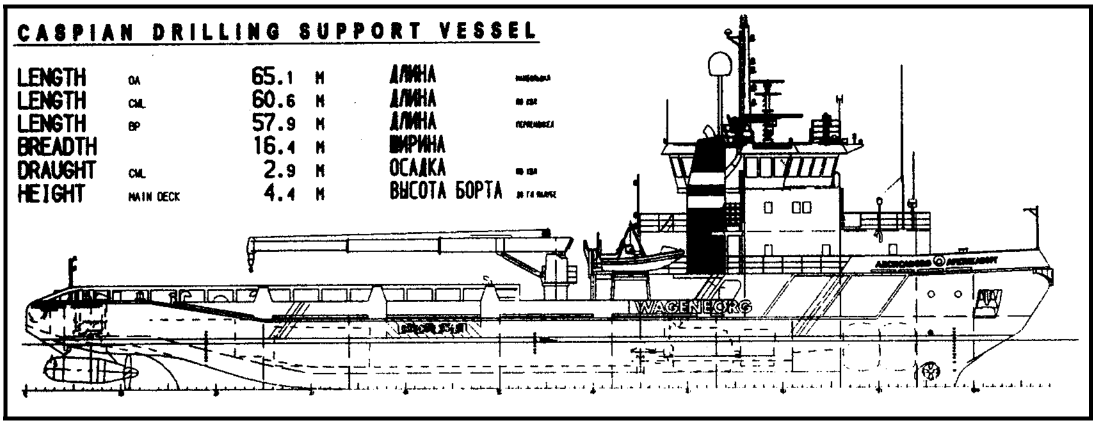

Figure 3, Side view of the Caspian icebreaking supply vessel

3. MODEL TESTS

Model tests in ice were performed by MARC, Kvaerner Masa-Yards Arctic Research Centre, in September 1997. The following tests were run:

- Level ice, 0.6 m and 0.9 m both in deep and shallow water (4.5 m)
- Ridges 6- 7 m thick in deep water and grounded ridges in shallow water (4.5 m)

All tests were run self propelled at different power levels both ahead and astern. During the tests the stern of the model was modified to allow for more clearance between the hull and propeller blade tips, and the torque requirement for the propeller motors was increased to withstand the ice loads due to the 90 cm ice.

According to the tests the vessel should be able to proceed with a speed of 1.7 m/s (3.3 kn) in 0.6 m level ice ahead in deep water, in shallow water the corresponding speed was 1.3 m/s. Astern the speed would be 1.05 m/s and 0.97 m/s in shallow water, trimmed aft speeds of 1.44 m/s and 1.35 m/s were achieved. In 0.9 m ice the vessel could make 0.34 m/s astern in deep water and 0.29 m/s in shallow water.

Ridges made of both 0.6 m and 0.9 m ice in deep water could be penetrated both ahead and astern. The ‘ahead’ tests required multiple ramming resulting in slow overall speed of 0.03 m/s but astern all ridges could be cleared with one run at overall speeds of 0.2 to 0.3 m/s.

Shallow water ridges were tested astern only, in 4.5 m water depth. In a ridge made of 0.6 m ice the speed was abt 0.3 m/s as in deep water, but the ridge of 0.9 m ice proved much more difficult, speed of only 0.1 m/s was recorded. Even when returning back bow first through the pre-broken ridge the vessel needed several rammings to get through.

Open water tests for verifying the resistance/speed characteristics and bollard pull force were run in Austria by Schiffbautechnische Versuchsanstalt in Wien.

Figures 4 and 5 illustrate the model tests.


Figure 4, Model test in ridges.

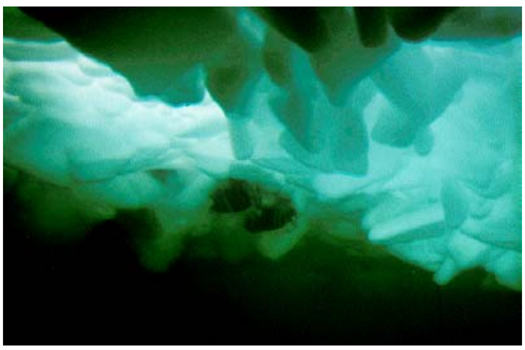
Figure 5, Propulsion eating a ridge.

4. BUILDING OF THE VESSELS

Considering the long experience in designing and building icebreakers and other ice going ships, ships equipped with diesel electric machinery, experience in ships with Azipod propulsion and the extremely short building period it was not surprising that Helsinki New Shipyard of Kvaerner Masa-Yards was chosen among the competitors to build the two vessels. The contract was signed in the beginning of December 1997 leaving only 11 months and one week for the design and building of the first vessel, one week more for the second. The delivery time was dictated by the closing date of the Russian inland waterways (canals) system.

Although the type of the vessels was familiar to the shipyard and the most time consuming components like shaft lines with stern tubes and propeller motors were replaced by the Azipods (quick installation at the end of the building schedule), the vessels included still a number of equipment and systems, which were unknown to the designers. Such items were, cargo handling, fire fighting, rescue and pollution control systems etc. The fact that so many functions had to be packaged in a vessel with so small main dimensions and large cargo carrying capacity made the vessel physically quite crowded made the design work more complex. At that time the work load of the design departments at the shipyard was already high and a considerable amount of the work had to be subcontracted, which added the possibility that something might go wrong. The new systems and equipment required to get in contact with many new suppliers.

The flag authorities of The Netherlands, was a totally new organisation for the shipyard and the classification society, Bureau Veritas, a seldom used one, and for both organisations the vessels contained new solutions which raised questions how to apply existing rules for a non-conventional case. In the final stage of the process the flag change-over to Kazakhstan and to the corresponding authorized class, Russian Register, was not without problems.

In many of the problems mentioned above the owner, Wagenborg Shipping, was a great help for the shipyard, providing fast response to all questions, experience with authorities and subcontractors not familiar to the shipyard and a powerfull backing in discussions with the Russian Register of the flag change-over.

Despite ‘normal’ and ‘ non-normal’ problems and difficulties and temporary delays the two vessels were delivered ‘just on time’ on October 9th and 16th 1998 as ‘Arcticaborg’ and ‘Antarcticaborg’. They made the transfer voyage via Mediterranean and Black Sea, rivers Don and Volga down to the Caspian Sea as planned. Once in the operation area they already have met level ice up to 60 cm thick and rafted ice up to 1.1 m during the prevailing winter.

5. ICE TRIALS

The ice trials were run between February 24th and March 4th onboard ‘Antarcticaborg’ in the northern Caspian Sea at the actual operation sites. The winter may have been on milder side and was ending perhaps a bit earlier than expected but the ice conditions could be described as ‘quite normal’ for the area:

Level ice thickness was abt. 0.3 to 0.35 metres where it could be found. Normally the level ice fields were only some ship lengths wide with small or medium ridges, rubbles or even rubble fields between them. Visually smooth level ice could also include rafted and consolidated rafted spots up to one metre thickness. On windy weather also visible ice pressure situations were observed.

Water depth on different test sites varied between (4), 5 and 7.5 (8) metres. In shallow water the moving ice fields driven by the wind had formed formidable ‘stamukhas’ from the sea floor up to 7 - 8 metres above surface. The most severe of them were around the future drilling sites, which are surrounded by tubular steel piles hammered some 17 - 19 metres into the sea bottom, see figure 6 and 7.

Figure 6. Ice rubble around a drilling site.

During the trials the air temperature fluctuated around 0ºC but ice temperature was still c. -0.5°C and the measured flexural strength of ice was 400kPa and the ridges and the 'stamukhas' were heavily consolidated. The ice edge moved during the test period considerably to the north.

Onboard MS Antarcticaborg the speed, rudder angles, power setting and power and the signals by the numerous strain gauges on the hull were recorded continuously during the trials, ice thickness was measured from the low main deck with a stick.


Figure 7. A grounded ridge.

Field measurements were used to determine the ice properties. Flexural strength was measured by in situ cantilever beam tests and compressive strength by compression test samples. The ice thickness, temperature and salinity were recorded simultaneously. The thickness, geometry, and structure of the ridges and 'stamukhas' were investigated by drilling at 5 m intervals as well as the water depth.

All tests were photographed and video taped, ridge tests both from the vessel and from the ice.

6. PERFORMANCE IN ICE

In 0.3 to 0.35 m thick level ice the vessel was able to move at 9 - 10 knots speed ahead and 8 - 9 knots astern, which was in excess of expectations. However no thicker ice fields could be found. All the possible thick ice was rafted around the ridges. Only in some locations thinner ice could be found, still in small floes.

The vessels were able to go easily anywhere wanted to in the ice conditions encountered during the trials. They could break out of the broken channel, make ‘star turns’ and even turn on the spot but most spectacular is their capability to demolish the high ‘stamukhas’ if needed, not by powerful rams but chewing the ice away by propellers. The breaking of the ‘stamukhas’ could be done almost irrespective of water depth. During the tests there was at minimum about one meter water under the keel at the most shallow test sites.

Further is was discovered that the vessel did not get stuck at all in ramming (bow first) but could easily reverse off after the ram. Overall feeling was that in operation ahead the vessel performed better than expected according to the model tests, in astern operation the performance was in line with the prediction.

Due to the shallow water the speed reduction was considerable when passing shallow banks, wave pattern changed to straight angled one and propeller induced vibration was excessive. Propeller streams also brought mud and sand from the sea bottom to the surface. It became clear that the vessels can easily touch the bottom with the bilges when making sudden turns. Even at low speed, because of the steering capability of the Azipod drives.

Course stability of the short and full hull with large beam to draught ratio is naturally only moderate when cruising ahead, but the vessels are still easy to steer both manually and by autopilot. Cruising astern only slow speed can be controlled in open water, in ice conditions the steering is fast and precise at any speed.

Figure 8, Vessel on its way through a grounded ice feature

7. CONCLUSION

With the development of the Azipod and the consequent Double Acting icebreaking method, Kvaerner Masa-Yards has expanded the limits of icebreaking technology, which is demonstrated by the two icebreaking supply vessels ‘Arcticaborg’ and ‘Antarcticaborg’. The vessels are unique in many respects, small size and compact, not very powerfull, but still for the Owner, Wagenborg Shipping, tools to meet and even surpass the requirements of the supply operations on the northern Caspian Sea in harsh winter environment.

8. ACKNOWLEDGEMENTS

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