Multipurpose icebreakers for the Finnish National Board of Navigation

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ABSTRACT

Finnyards LTD has delivered the first multipurpose icebreaker and is building another for the Finnish National Board of Navigation. The first vessel, MSV FENNICA was delivered in March 1993 and the second one, MSV NORDICA will be delivered in January 1994.

The multipurpose icebreakers are of a completely new type of vessels. The hull form combines successfully the functions and requirements of two completely different vessel types: an icebreaker and an ocean going offshore vessel with good sea keeping properties.

The vessels are used as icebreakers on the Baltic Sea in wintertime and for summer/autumn seasons they are chartered to the Norwegian Ugland Offshore AS company to be used on the North Sea for cable and pipe laying as well as for many other offshore operations.

To guarantee the vessels' superior manoeuvring properties both in ice and in open water the vessels are equipped with two azimuth propulsion units of 7500 kW each, being the most powerful of this kind in the world, and with three bow thrusters. For accurate track/position keeping a fully redundant dynamic positioning system has been installed on board the vessels.

INTRODUCTION

Finland is situated in northern Europe between 60th and 70th latitudes having its only sea connection abroad through the Baltic Sea which is more or less frozen every winter. Finland's economy is very much depending on sea transport both in export (pulp, paper, timber products etc.) and in import (oil, coal, consumer goods etc.). That's why it is vital to Finland to have its sea routes kept open even during the hardest winters. This fact has lead to the situation that Finland has a unique fleet of nine effective icebreakers.
So far icebreakers have been designed purely for ice breaking and assisting purposes in icy water, which has led to a design not so suitable for any open water operations. The effective operation time of these vessels is only from three to five months per year.

When the Finnish National Board of Navigation (FNBN) started to plan the replacement of the oldest icebreakers in the middle of the eighties, there already were some ideas of finding "secondary" uses of the new vessels for summer seasons. But the thought of a "multipurpose vessel" became more realistic only in the beginning of the nineties.

After many discussions and contacts concrete response was given by the Norwegian Ugland Offshore AS, who without prejudice took the opportunity to install their equipment for cable and pipe laying as well as for many other offshore operations on the working deck of the novel type of a vessel.

The basic solution to combine the demands on an icebreaker and an offshore vessel with good seakeeping properties was developed by FNBN together with their consultants, Consulting Engineering Company ILS Lehtonen & Siirilä. After signing the shipbuilding contract Finnyards LTD developed the final design and construction into a multipurpose icebreaker (figure 1).

### MAIN CHARACTERISTICS OF THE VESSEL

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>116,0 m</td>
</tr>
<tr>
<td>Breadth, max.</td>
<td>26,0 m</td>
</tr>
<tr>
<td>Depth</td>
<td>12,5 m</td>
</tr>
<tr>
<td>Draught/deadweight:</td>
<td></td>
</tr>
<tr>
<td>- Baltic icebreaker</td>
<td>7,0 m/1650 t</td>
</tr>
<tr>
<td>- Arctic icebreaker</td>
<td>8,0 m/3900 t</td>
</tr>
<tr>
<td>- Offshore operations</td>
<td>8,4 m/4800 t</td>
</tr>
<tr>
<td>Speed</td>
<td>16 knots</td>
</tr>
<tr>
<td>Bollard pull</td>
<td>234 tons</td>
</tr>
<tr>
<td>Accommodation for</td>
<td>82 persons</td>
</tr>
<tr>
<td>Bunker capacity</td>
<td>abt. 2500 m³</td>
</tr>
<tr>
<td>Provision stores</td>
<td>abt. 175 m³</td>
</tr>
</tbody>
</table>
HULL FORM DEVELOPMENT

The hull form was developed with a very extensive series of model tests both in open water and in ice. The model tests had two main tasks: firstly to create a hull form which fulfils the requirements of a good icebreaker and an offshore vessel with good sea keeping properties in heavy seas and secondly to prove that the requirements of the owner will be fulfilled.

As the result of these tests a unique hull form was developed with the following basic elements (figure 2):

* Bow region wide enough (about 26 m) to create ice channel with required breadth
* Stern region as narrow as practicable to give water plane area as small as possible to reduce rolling
* Underwater bilge steps to reduce rolling further
* Reamers that break ice downwards when backing
* A plough in the stem for steering ice blocks sidewards and for installing three bow thrusters.

With this hull form the vessel fulfils and in many respects exceeds the required seakeeping properties without losing anything in the icebreaking capacity.

PERFORMANCE OF THE VESSEL

BOLLARD PULL
The bollard pull of the vessel is 234 tons, that means a pull of 15,6 kg/kW, when the same value for non-ducted propellers in this power range is normally abt. 11 kg/kW.

PERFORMANCE IN ICE
Due to the novel hull design an extensive series of full scale tests was carried out. Besides the normal propulsion tests in level ice and channels the emphasis was put on the manoeuvring characteristics and operational aspects. The tests were carried out at the end of March 1993 on the Northern Baltic.

Resistance in Level Ice  Results of the various resistance tests are presented in fig. 3. These results show, that the vessel can obtain abt 9 knots speed in 80 cm level ice exceeding so the design criteria set by the owner (8 knots in 80 cm level ice).
Turning Ability Of the basic performance characteristics turning is the one that is most exceptional in this design. Turning tests were performed both at zero speed, i.e. turning on the spot, replacing the traditional star manoeuvre, and at full speed. In both cases the vessel was able more or less to turn around on the spot in the level ice thickness of 65 cm.

Operative Tests in Ice

Breaking out of the Channel A series of tests breaking out of an old channel was performed both ahead and astern. It turned out, that the vessel was able to break out in all tests at abt 90° angle from the channel regardless of speed.

Clearance and Widening of Own Channel The effect of the thruster angle into clearance of the channel broken by the icebreaker was tested in level ice field. The thruster angle here means the angle outwards on both sides. It was found out, that the channel was widening up to 7.5 times of the maximum beam of the vessel due to the water stream from the thrusters, when big thruster angles were used.

Widening of Old Channel Even more remarkable than the icebreaker’s ability to produce a wide new channel is her ability to widen an old channel. The vessel was able to completely clear of the side banks of the old channel and thus widening it by using big thruster angles. Simultaneously some speed forward would be maintained. This means that this operation mode has important practical applications. If during the winter some parts of old channel become too heavy for the traffic, they can be cleared by this ship.

SEAKEEPING PERFORMANCE OF THE VESSEL

To assess the seakeeping performance of the vessel, comparative seakeeping model tests and operability predictions were made for the new design and for a big, modern North Sea supply and support vessel, that was used as the yardstick vessel.

Over 200 separate tests were made with five different models.

Operability Predictions The seakeeping performance evaluation of the multipurpose icebreaker was based on the results of the model tests and operability predictions. The percentage operability is defined as the per cent of time that the ship's motions do not exceed the operability-limiting criteria.

The total operability of the vessel on the North Sea in the season from June to November is over 90 %, clearly higher than the owner’s requirement of 80 %. In beam seas the operability of the vessel on the North Sea is slightly over 70 %, which agrees well with the operabilities of supply and other special vessels. As well as the vessel is close to the big supply vessel with regard to the roll characteristics, as figure 4 shows.
Operability predictions were also made in head seas at the forward speeds of 12 and 15 knots, using commonly used operability-limiting criteria.

The vessel is able to maintain the speed of 15 knots in head seas on the North Sea over 90% of the time, limiting factor being then the vertical acceleration on the bridge in a significant wave height of about 4 m. The seakeeping performance of the vessel in head seas is approximately equal to a cargo vessel of similar size.

Seakeeping Characteristics The seakeeping characteristics of the vessel are as good as those of the big modern North Sea supply vessel, that was used as a yardstick, as can be seen in fig. 4. Improvement compared to traditional icebreaker has been enormous.

Seakeeping performance of the vessel was further improved by the installation of a controlled passive roll stabilizer tank. According to the information obtained from the tank manufacturer Intering GmbH rolling will be reduced by abt. 50% in resonance conditions and 30 - 40% close to resonance. With the stabilizer tank the minimum operability-limiting significant wave height with regard to rolling in beam seas increases from about 2 m to over 4 m.

CLASSIFICATION, RULES

The vessel is classified by Det norske Veritas having the class notation DNV + 1A1, Tug, Supply Vessel, SF, Icebreaker POLAR-10, HELDK, EPR, E0, DYNPOS AUTR.

From the a.m. notations and other rules that the vessel must fulfil, the following may be highlighted:

* DYNPOS AUTR means a fully redundant automatic dynamic positioning system, that is completed by redundant electric propulsion system according to the notation EPR.

  The Register notation ern(99.99.99) gives more detailed requirements for propulsion units, which have to be available in fault situations.

* In addition to the notation Icebreaker POLAR-10 the hull construction has been designed to fulfil the Canadian Proposals for the Revision of the Arctic Shipping Pollution Prevention Regulations (CASPR), according to the class CAC 4.

* For offshore operations on the North Sea the vessel will have the following special documents:
  - Letter of Compliance (L.O.C.) of Norwegian Maritime Directorate
  - Certificate of Fitness of Department of Energy of U.K.

Otherwise the vessel fulfils all relevant international rules issued by IMO and many other organisations.
ARRANGEMENTS FOR OFFSHORE OPERATIONS

The vessel has been designed for the following offshore operations:
* Laying flexible pipes and cables
* Cable repair work
* Anchor handling and suitcasing anchors
* Ploughing
* Towing
* Carrying deck cargo and supply equipment, total max. 2500 tons
* Manoeuvring and mooring at the side of fixed platforms, semisubmersibles etc.

For the a.m. purposes the vessel has the following arrangements:
* Free working deck area 19 m x 55 m = 1045 m², pinewood deck sheathing with T-bar grillage for fastening removable offshore equipment such as winches, cable reels etc.
* Maximum deck load 10 t/m²
* Removable 120 t A-frame
* Removable 15 t crane
* Removable 300 t stern roller
* Towing/anchor handling winch, two drums each 300 t
* Fully redundant DP-system
* Helicopter deck for Super Puma type helicopters
* Stabilizing tank system

PROPULSION SYSTEM

The vessel has a 6,3 kV diesel-electric propulsion system consisting of:
* four diesel generator sets, total output 21000 kW,
* two 7500 kW electric propulsion motors fed by variable frequency A.C. supply from cyclo converters,
* two 7500 kW azimuth propulsion units, made by Aquamaster-Rauma.

The Aquamaster thrusters are based on a new construction type ARC 1, which has been developed specially for icebreakers. The thrusters meet completely DnV Icebreaker POLAR-10 requirements. Additionally they have been dimensioned to operate in more than 1,8 m thick ice. The thrusters are equipped with fixed pitch 4,2 m propellers mounted in nozzles. These thrusters are the strongest and most powerful ever built in the world. They give a bollard pull of 117 t each, and in open water they are able to absorb over 11000 kW each.

For Dynamic Positioning purposes the vessel is additionally equipped with three 1150 kW bow thrusters, giving abt. 15 t thrust each.
INTEGRATED AUTOMATION SYSTEM

An integrated automation system covering both machinery controls and dynamic positioning was delivered by Norwegian Simrad Albatross A/S. The machinery automation system has four operator stations and includes power management, control and monitoring of main and auxiliary machinery, pumps, valves and an alarm system covering about 1000 monitoring points. The dynamic positioning system is of redundant type having acoustic positioning, light weight taut wire and Artemis radio positioning as reference systems as well as interfaces to radio and satellite navigation systems. The thruster control system includes both individual and combined joy-stick control of the bow thrusters and Aquamaster azimuth thrusters.

CONCLUSION

The "multipurpose idea" is realized in full extent for the first time in the above described icebreakers. The idea can, of course, be used for many other variations, too.

Basically it is the question of the hull form. Arrangements inside the hull as well as propulsion type and power can in each individual case be realized according to the task in question. Possible solutions may be e.g. ice breaking tanker, passenger vessel, research vessels, crane vessels and other vessels for constructing work etc.

The multipurpose icebreaker has proven in it’s trials to be an excellent icebreaker not having to suffer more than marginally compromising in performance due to its multipurpose mission and very good seakeeping properties. At the same time it is an icebreaker of a totally new generation setting new standards for manoeuvrability and escort efficiency of icebreakers.

REFERENCES


Figure 1. The General Arrangement of the Multipurpose Icebreaker

Figure 2. Hull form of the Multipurpose Icebreaker

Figure 3. Ice Resistance as Function of Speed

Figure 4. Significant Roll Amplitude of the Vessels in Fully Developed Beam Seas.