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MULTIPURPOSE ICEBREAKER MSV BOTNICA, BASIC DESIGN ASPECTS

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ABSTRACT

MSV Botnica is the latest multipurpose icebreaker delivered to FMA in 1998. Its main task is to operate as an escort icebreaker in the Baltic. In the summer season it is working as an offshore vessel in the North Sea. Compared to its larger sisters, Fennica and Nordica, Botnicas design, tasks and characteristics are different although some basic solutions as hull form and azimuth propulsion has been kept in principle similar.

The design requirements and different tasks considered for the vessel during design evaluations are described in the paper.

The vessel is intended for escort icebreaking mainly in the Gulf of Finland but is also capable to operate in the gulf of Bothnia. On the other hand the offshore tasks including well intervention mean very strick safety and seakeeping requirements for a vessel of this size. The influence of these aspects to hull form, general arrangement and machinery systems are presented.

During the basic design many comparisons and studies were made including eg hull form variations, different machinery alternatives, HFO versus DO use comparison etc. Special attention has been paid in the paper to comparisons made between dieselmechanical and electric drives of different types including also propulsion simulations in ice.

The paper also includes a summary of the operational experiences of the first season at work.

1. BACKGROUND

After the delivery of the multipurpose icebreakers MSV Fennica and Nordica in 1993 and 1994 the need to replace old fleet in the Gulf of Finland service resulted in the development of MSV Botnica.

The size of the vessel is smaller than the first multipurpose icebreakers although same basic hull form and azimuth propulsion formed the basis of the design. The propulsion power is 10 MW with WL breadth of abt. 23 m.

The level ice icebreaking capability was defined as 8 kn at 0,6 m thick level ice.

To keep weight and main dimensions down a subartic ice class "DNV Icebreaker Ice 10" suitable for the Baltic Sea was selected. This is lower than in Fennica class which has arctic ice class "DNV Icebreaker POLAR 10".

The main operating area for the vessel in escort icebreaking is Gulf of Finland, but with above mentioned characteristics it is also suitable for the Gulf of Bothnia service. A full description of icebreaking characteristics of MSV Botnica is given in the paper "The ice capability of the multipurpose icebreaker Botnica - Full scale results" (Nyman etc 1999)

In table 1 is given a comparison between the main dimensions of Botnica and Fennica.

Table 1. Main dimensions of MSV Botnica and MSV Fennica.

	Botnica	Fennica class
Length, oa	96,7 m	116,0 m
Length, wl	77,9 m	96,7 m
Breadth, mld	24,0 m	26,0 m
Breadth, wl	23,1 m	25,2 m
Depth, mld	11,7 m	12,5 m
Draught, max, icebreaking	7,8 m	8,0 m
Draught, design, icebreaking	7,2 m	7,0 m
Draught, max, offshore	8,5 m	8,4 m
DWT, icebreaker	1000 t	1650 t
DWT, offshore	2850 t	4800 t
Main engine output	15 MW	20,3 MW
Propulsion power	10 MW	15 MW
Bollard pull	112 t	234 t
Speed, open water	15 kn	16 kn
Crew, max	72	82

The outboard profiles of the vessels are presented in fig.1.

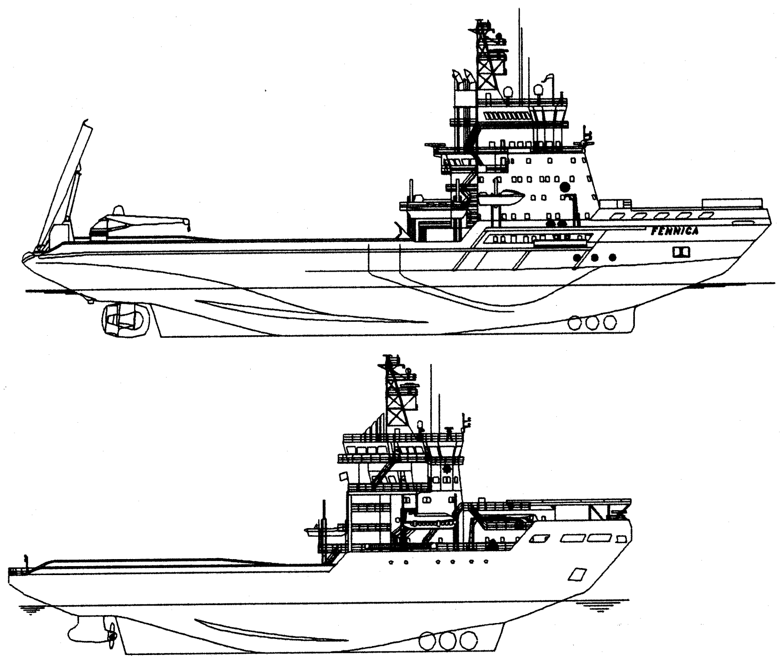

Figure 1. Profiles of MSV Botnica and MSV Fennica.

2. SUMMER TASKS

The highly successful summer operation experiences of Fennica class made it clear that also Botnica would be built as a multipurpose icebreaker.

The summer tasks considered included both summer jobs in Finnish waters and offshore jobs.

The first versions were designed to work in the summer time as multipurpose vessel for the Finnish authorities. The studied possible tasks included:

- rescue, salvage, patrol and support
- escort operations
- research functions
- chemical hazard recovery
- oil recovery

A moonpool was included in the design already at this stage.

Based on this project discussions with DSND, the offshore partner of FMA, led to the conclusion that this type of vessel could be used as a cost effective alternative to semi-sub rigs for North Sea subsea operators. Especially the expanding market of well intervention with a removable derrick built above the moonpool gave top of the market summer job alternative.

Thus a charter agreement was made between FMA and DSND. Summer period offshore services include:

- moonpool/derrick operations
  - -- light well intervention
  - -- slim hole drilling
- ROV support
- hoisting of umbilicals
- offshore construction tasks

The influence of well intervention workover on the vessels general arrangement can be seen in fig.2.

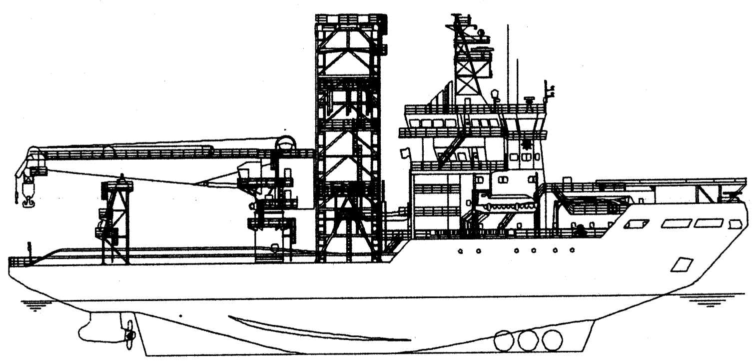

Figure 2. MSV Botnica with offshore equipment

The well intervention brought extra safety requirements demanding:
- the highest redundant DP-class, with also machinery, thruster and DP control rooms divided into two independent spaces
-explosion proof main deck arrangement and A-class bulkhead against deckhouse and lifesaving equipment due to blow out risk

Other special equipment include:

- removable derrick
- bow thrusters
- removable 160 t offshore crane
- Intering antiroll/antiheel tank
- Removable stern section

The 6,5 m x 6,5 m moonpool is equipped with bottom hatch which is closed in winter time and floated away for summer operations.

The patended asymmetric bridge design with the main control station on SB side already introduced in the Fennica was further developed in Botnica.

Also the patended removable stern section is installed above towing notch during summer time.

3. DEVELOPMENT OF THE HULL FORM

The good operational experiences gained by the patented Fennica class hull form meant that in principle the hull form was kept similar.

Before contract an extensive model test program was carried out on behalf of the Owner and ILS in the Technical Research Centre towing tank and Helsinki University of Technology ice tank. The aim was to study some alternatives and to get required performance values verified.

After contract Aker Finnyards had model tests made in the same facilities with the final hull form.

In ice model tests before contract following alternatives were studied:

- twin skeg / single skeg versions
- extent of inclined sides in the middlebody
- pushing/pulling azimuth thruster operation in ridges
- nozzle/open propeller; comparison of icebreaking with propeller thrust
- plough shape optimization

Although twin skeg reduces a little backing resistance and it also worked well in manoeuvring situations the as built hull has a more simple single skeg construction.

In open water model tests before contract the target was mainly to reach rolling behaviour near to Fennica. Thus influence of bilge step design was studied, see table 2.

Table 2. Influence of bilge step design on total operability in beam seas. North Sea, Jonswap spectra, limiting criteria 3° rms roll and lateral acceleration on bridge 0,07g, rms.

Bilge step version	Total operability
Bilge steps amidships	72%
Bilge steps aft ship rising towards stern	74%
Bilge steps extended in length and width	78%

In operations through moonpool the vessel can normally do weather vaning in DP. This means that limiting criterias for these operations are pitch and heave, so that e.g. riser angle is not exceeding allowed values or heave compensator limits are not exceeded.

It is also important that water column in the large moonpool doesn't rise to main deck level too often. To quarantee this tests with different perforated cofferdams were done. The best version showed that in Hs = 6,0 m head seas the propability that water will come to deck could be kept at 5×10^{-4} probability level.

The final hull form can be seen in fig 3. It can be seen that it is near the Fennica shape. The bow is however slightly fuller and reamer shape more rounded compared to Fennica class.

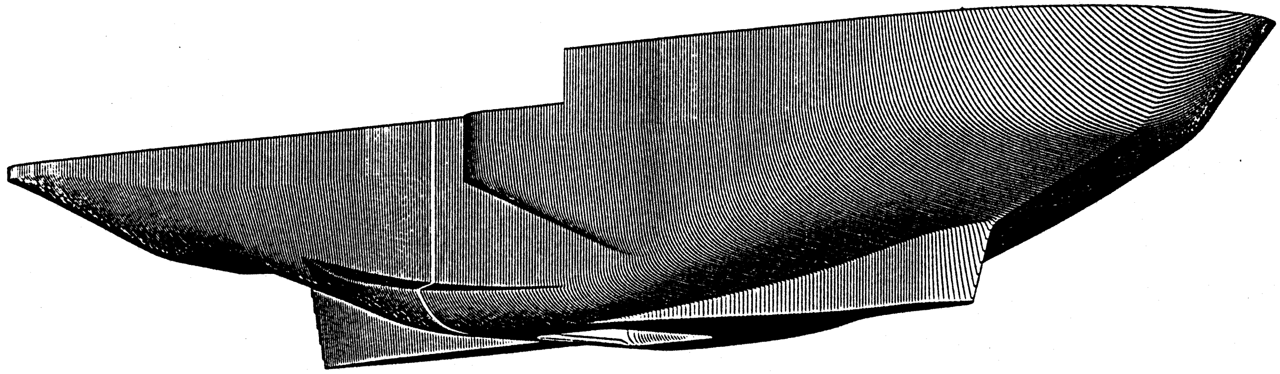

Figure 3. Botnica hull form

4. MACHINERY COMPARISONS

The Botnica propulsion machinery was based from the start on azimuth thrusters. Botnica has however open propellers instead of Fennica type nozzled propellers. The reason for this was the smaller diameter versus ice thickness compared to its bigger sisters.

Generally the basic requirement was to design the machinery as simple, light, flexible and economical as possible not forgetting the icebreaking and redundancy requirements.

To fulfill these conflicting requirements both diesel electric and diesel mechanical versions were studied.

During basic design also a comparison of using heavy fuel oil or pure diesel oil was made, because the prize difference between these has become smaller, especially when using of low sulphur fuel. An important factor in decision to go into pure DO fuel were the labour savings, in practise one person in overhaul work. Also arrangement and weight benefits were recognized.

The diesel mechanical version was based on CP azimuth thrusters driven by high speed diesel engines through reduction gears, see fig 4.

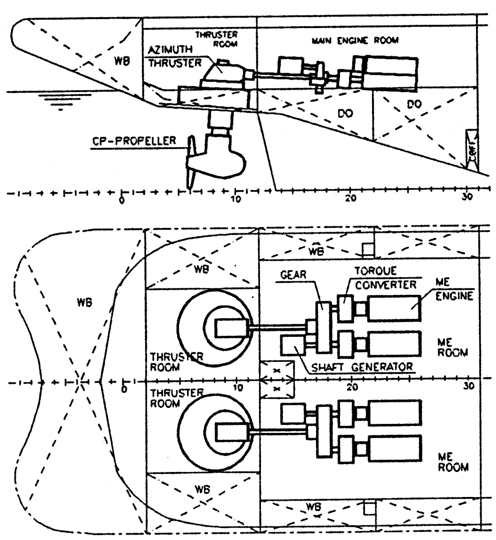

Figure 4. Diesel mechanical version machinery arrangement

To cope with ice loads a torque converter was required between engines and gear boxes. Because of high speed engines, size, weight and cost of converters was kept feasible.

A hydraulic torque converter has in principle a pump wheel, turbine wheel and adjustable guide blades. It can be tuned to give desired torque/rpm curve and thus the torque characteristics are near diesel electric propulsion. The nominal slip is abt 10% and when torque level rises in ice, the losses rise, and extra heat is treated by cooling system. An usefull feature is possibility to "switch off" torque converter to direct drive mode by a clutch. This feature can be used in open water to attain better efficiency.

The diesel mechanical drive is used in offshore operations in constant rpm mode. Electric power needed for thrusters and offshore equipment is generated by shaft generators. In ice the rpm is varying and ship electric supply is fed from auxiliary engines.

The electric diagram of this arrangement is shown in fig 5.

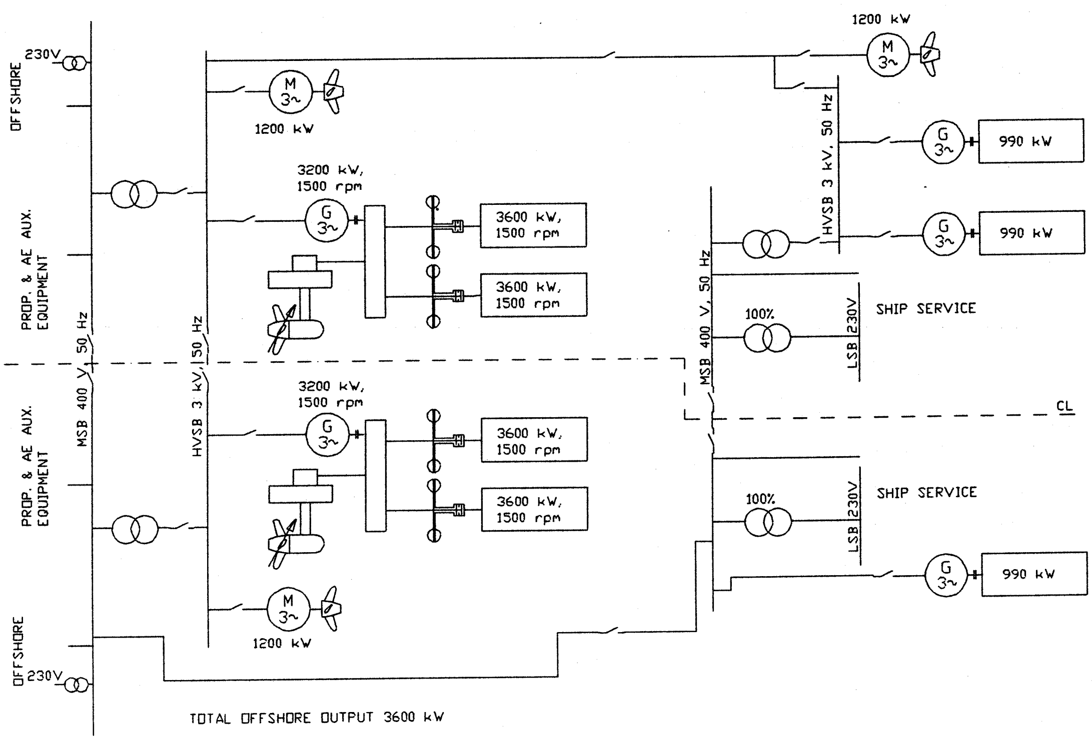

Figure 5. Electric diagram of diesel mechanical machinery

The studied diesel electric drives included z-drive azimuth versions and azimuth units with electric motor in pod.

Comparisons between mechanical and electric versions included arrangement, price, weight and availability studies.

A comparison of total efficiencies between different versions is given in table 3. (The efficiency is calculated from diesel shaft to propeller shaft.)

Table 3. Efficiencies of different propulsion systems

Propulsion	Efficiency
Diesel mechanical drive with torque converter	0,85
Diesel mechanical drive without torque converter, or torque converter switched off	0,96
Diesel electric drive with electric motor in pod	0,91

A propulsion simulation was also made to evaluate the need for torque converter and compare different machineries in ice. As a result it was judged that all versions performed normally well. However even with extra power reserve the direct diesel drive could lead to stopping of engines/ loss of thrust in most severe ice conditions. Thus a torque converter was included in the specification and yards were given opportunity to offer both diesel mechanical and diesel electric propulsion.

In fig 6 torque curves of diesel mechanical drives and diesel electric drive are presented.

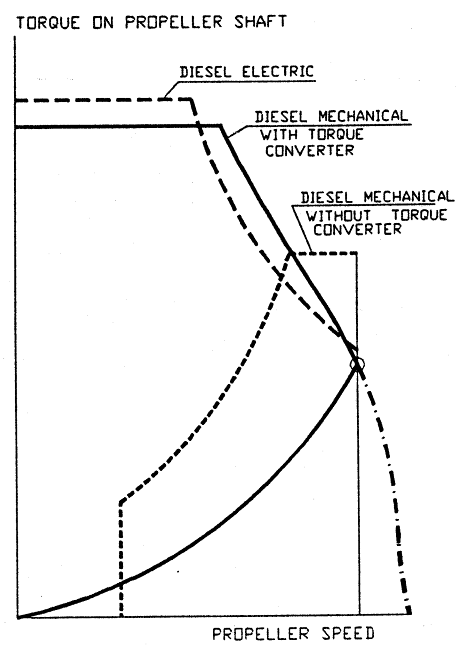

Figure 6. Torque curves of diesel mechanical drive with and without torque converter compared to diesel electric drive

The actual Botnica machinery arrangement is presented in fig 7.

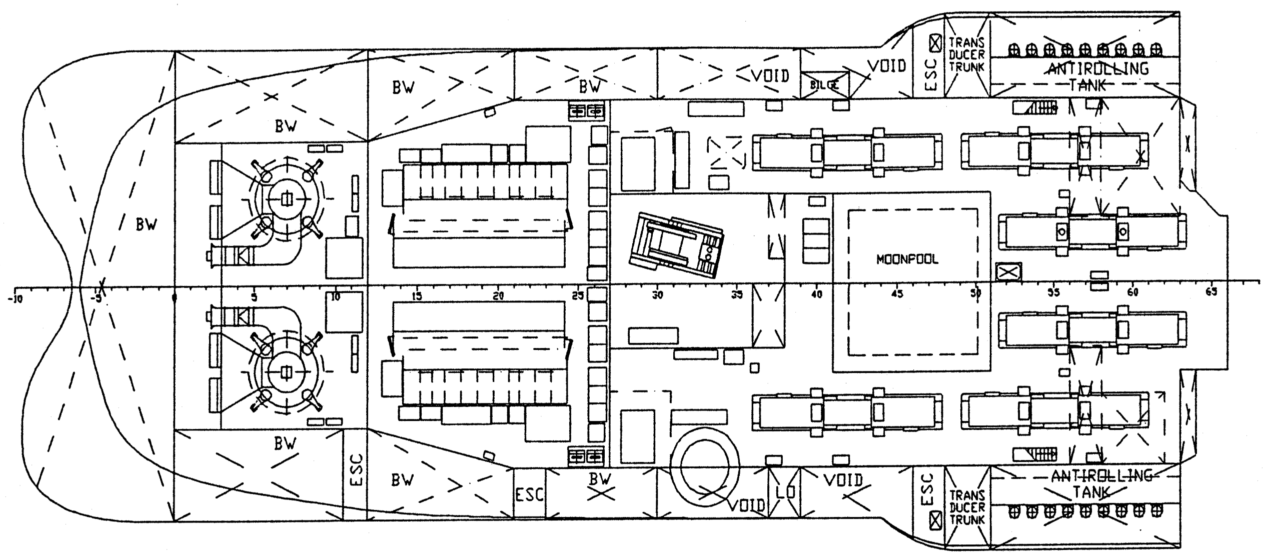

Figure 7. Botnica machinery arrangement as built

It is based on pulling Azipod thrusters. Power is generated by 12 pcs caterpillar 3512 V12 engines arranged in pairs with generators in between.

Thus the power station is very flexible and engines can run at near optimum load in varying conditions. One of the sets is also equipped with separate clutches so that also only one engine can run the generator at time. Thus a separate harbour generator is not needed.

5. OPERATIONAL EXPERIENCES AND CONCLUSIONS

MSV Botnica was delivered end of June 1998 and it worked after that until November in the North Sea. Its tasks included mainly different ROV- support operations.

Although the vessel is smaller than Fennica class it's seakeeping characteristics has been found to be at the level of its bigger sister.

A fuel economy comparison was also made between Fennica and Botnica. The fuel consumption was measured during one month in light offshore conditions. Fennica consumption was 0,0177 l/kWh and Botnica consumption 0,0143 l/kWh. This clearly shows the benefit of dividing power in smaller units which can operate at optimum loading.

In winter 1998/1999 MSV Botnica started its escort icebreaking operations in the Gulf of Bothnia and from March it has been assisting vessels in the Gulf of Finland. The vessel with relatively low propulsion power has shown its efficiency in icebreaking. A detailed description of Botnicas icebreaking capability is given in the paper "The ice capability of the multipurpose icebreaker Botnica - Full scale results" (Nyman etc 1999).

As conclusion, MSV Botnica has shown that an efficient icebreaker can be used succesfully in the most demanding offshore tasks when the seakeeping has been taken into account in the vessel basic design.

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IV. DETAILED COMMENTS:

Ok!

- PAGE NUMBERS AND FOOTER TEXT SHOULD BE REMOVED FROM THE CAMERA READY COPY

Korjattu

- AT PAGE 6 THERE ARE A COUPLE OF UNCLEAR SENTENCES:

  "... THESE FUEL OILS HAS BEGUN SMALLER, ..."

  "... ONE PERSON JOB WORKING IN OVERHAUL ..."

Suurennettu

- FIGURE 7 IS TOO SMALL AND WILL BE FURTHER DECREASED IN SIZE IN THE PROCEEDINGS

lisätty loppuun lause

- ONE WOULD EXPECT SOME KIND OF CONCLUSION OR CONCLUDING REMARKS BESIDES "OPERATIONAL EXPERIENCES"

ja viim. otsikkoon lisätty "Conclusions"