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Modernisations Polish fishing vessels on the example of the cutter DZI-102

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Abstract

Fishing limits, necessity to cope with competitive fishermen of other countries, the lack of financial resources to purchase modern vessels have caused that more than 30% of the Polish fishing vessels operating at the Baltic sea were withdrawn from operation between 2003 and 2012. Vessels remaining in service, especially older types have to be upgraded by the owners towards: reduction in energy expenditure; reduce the number of crew boats by the expansion of mechanization of fishing operations; improving the safety of vessels and working on fishing boats. Uncoordinated modernizations of the fishing cutters prevent from comparing the obtained results. A research team of the Maritime University of Szczecin gathered opinions of the ship-owners regarding the effects of the modernizations performed and conducted research which shall constitute the grounds to develop optimal directions for modernization and operation of the fishing vessels. This paper presents range and results of renovation and reconstruction the Polish fishing vessel DZI-102 operated at the Baltic sea.

Introduction

Polish fishing vessels, operating from ports located on the Polish coast, make a numerous group of 881 registered as active fishing vessels. The craft varies in age and, with an average service of 29 years, they are one of the oldest fleets on the Baltic Sea [1].

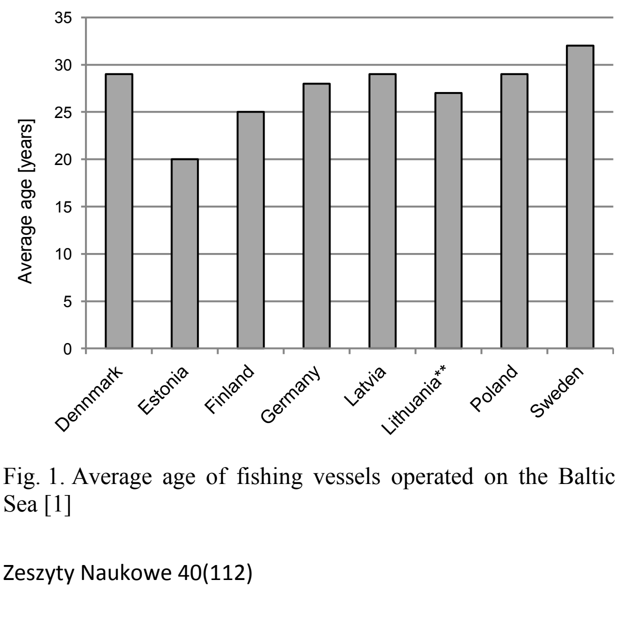

Fig. 1. Average age of fishing vessels operated on the Baltic Sea [1]

The vessels, also varying in size and technological standards, have one of the lowest power ratios among the fishing vessels operating on the Baltic. EU guidelines on modernization require that new engines with lower power output should be installed, so the existing position of Polish craft in this respect will not change in the future.

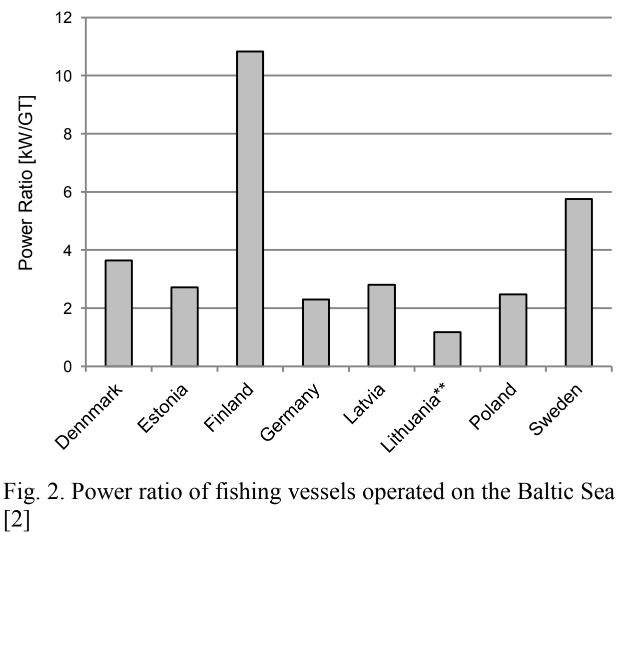

Fig. 2. Power ratio of fishing vessels operated on the Baltic Sea [2]

The technical condition of vessels and power ratio to a large degree affect fuel consumption, one of the main elements used in assessing their economic effectiveness and environmental impact [3].

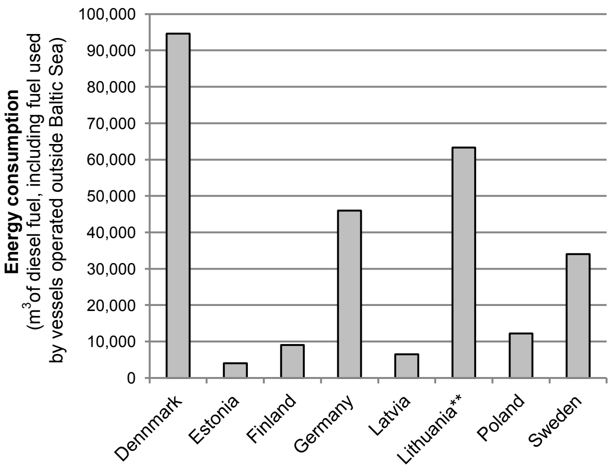

Fig. 3. Fuel consumption by fishing vessels operated on the Baltic Sea (in 2011) [2] (** includes data from vessels operated in other seas)

In the years 2003–2012 more than 30% of Polish fishing vessels operating in the Baltic were withdrawn from service. The vessels that remained in operation, older ones in particular, are modernized by their owners in order to:

- reduce energy use;
- reduce the number of crewmembers by increasing the role of machinery in fishing and cargo care activities;
- enhance the safety of vessels and work on board.

Uncoordinated vessel conversions do not assure optimized effects of modernization. To support Polish fishermen on the Baltic, a team of the Maritime University of Szczecin does research under the project No. 00020-61720-OR1600009/12/13 that will result in guidelines for effective methods of modernizing fishing vessels that vary regarding age and size. To this end, vessels representative for Polish fishing fleet were chosen, and the existing technical condition of their hulls, machinery and equipment, and previous modernizations of the vessel to date were recorded. The project's objectives and outcomes for the modernization of specific types of vessels were as follows:

- low-budget investments aimed at the enhancement of the safety of vessels themselves and work onboard;
- while modernization was intended to increase the safety of the vessel, the basic aim was to substantially raise its efficiency. The analysis was performed to determine whether modernization of the following components was justified:
  - hull;
  - main engine and power plant installations;
  - propulsion system;
  - fishing gear and equipment.

The co-operation between the team of project [4] and fishermen included the fishing vessel DZI-102. Its modernization had the objectives and effects described in the following chapter.

Modernization performed on the fishing vessel DZI-102

The scope of modernization work was related to the execution of two tasks [5]:

a) enhance the safety of navigation, facilitate work and improve its safety on board the vessel DZI-102;
b) increase energy efficiency.

Modernization work was divided into two stages. The first stage of DZI-102 modernization aimed at the safety of:

- navigation;
- work on the vessel.

Design work started from making an inventory of the above-water forward part of the hull to define the scope of work to be done in order to meet the objectives. Then the NAVAL CONSULTING firm was subcontracted to prepare class documentation for DZI-102 conversion. The documentation made up a basis for cutter conversion of the forward part of hull above the main deck and satisfied the Ship Classification and Construction Regulations of the Polish Register of Shipping, part IV: Intact and Damage Stability for fishing vessels, included in section 3.7.1: "Requirements of this chapter apply to fishing vessels which obtain in their class symbol an additional mark *Fishing Vessel* or *Fishing Cutter*" [6]. Fishing vessels should also comply with EU Council Directive No. 97/70/EC of 11.12.1997 [7] with amendments introduced by EU Commission's Directive No. 2002/35/EC of 25.04.2002 [8]. To meet the above regulations, a design requirement was to increase minimum height between water surface and the upper edge of the shelter deck to two metres. Raising the bow part of the shelter deck by 800 mm and complete line of bulwarks heightened by additional 900 mm make a permanent and rigid protection for fishermen against wind and considerably limit the shipping of green water, direct hazard to life of people remaining in that space (risk of being washed away). A detailed non-invasive underwater hull thickness measurement was carried out to detect possible hazards to vessel's safety due to exceedingly thin plating,

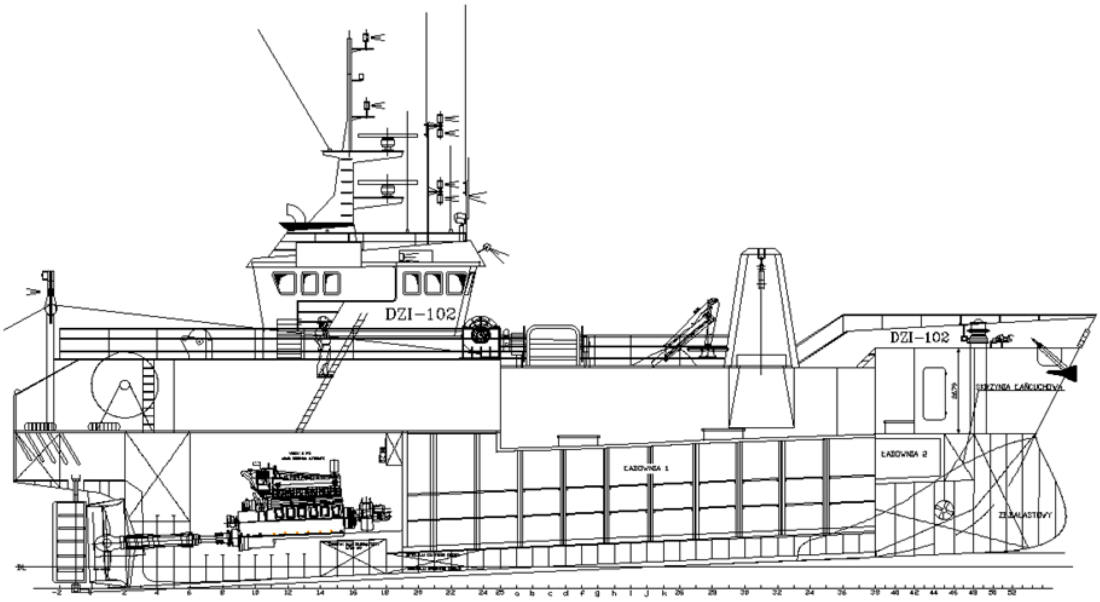

Fig. 4. Cross-section of the DZI-102 cutter after conversion [5, 9]

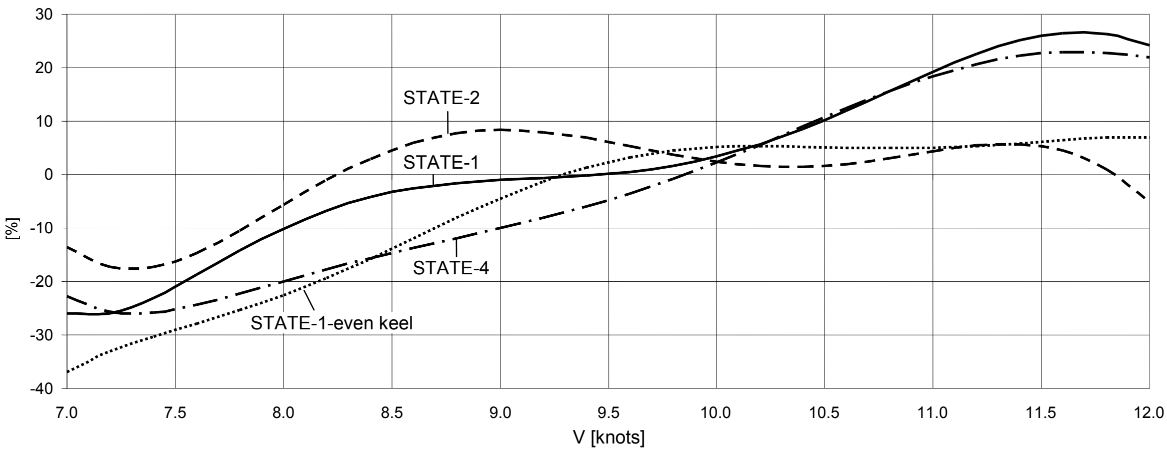

Fig. 5. Towing resistance curves from model tests [5, 10]

stiffeners or structural members of the hull. Tests revealed that an area of 50 m^2 of hull plating and bulkhead between holds No. 1 and 2 should be replaced, which required an exchange of 4800 kg of steel, including part of hold protection. The conversion of forward part also comprised replacement of manholes (leading from the shelter deck to working decks and from the working deck to hold No. 2). The new manholes substantially prevent a crew-member from falling onto a lower level. To improve safety related to side stability (decrease in ship's rolling): the whole length of bilge keel was widened by 70 mm; steel elements were replaced by lighter ones (cross beam between the davits aft, and angle struts of the forward davit); and redundant elements were removed from the after peak, which resulted in lowered centre of gravity of the vessel. The next step was the design and execution of changes in the hull and its equipment, intended to increase energy efficiency. The hull profile improvement project could be implemented upon a permission granted to the vessel to increase its displacement by 4 GT due to addition of a bulbous bow. The hull modernization began from a model analysis, carried out by NAVAL CONSULTING, to verify cost-effectiveness of the solutions to be implemented in a small fishing cutter (bulbous bow and thruster), which reduce fuel consumption and are used in the majority of sea-going ships.

Towing power was expected to decrease by 5% to 10% depending on vessel's trim and speed. The bulbous bow has another function: shift of the centre of buoyancy towards the bow, which allows to optimize ship's trim so that the characteristics of bulbous bow are utilized to a maximum. Model tests of the DZI-102 hull confirmed the correctness of projected alterations in the hull construction.

Resistance curves in figure 5 confirm that the redesigned part of hull with a bulbous bow has significantly lower values of resistance. For speeds over 9–9.5 knots the towing power was reduced in all conditions of loading, and for conditions of loading with a trim by the stern the difference of towing power before and after conversion reaches 25%. This corresponds, for a speed of 12 knots, to a difference in towing power of up to 80 kW for STATE-1 (departure from port). In addition to the above measurable advantages, the use of bulbous bow resulted in better attenuation of bow wave, and due to lengthened underwater part of the hull, improved manoeuvring abilities, that is course keeping stability. The installation of a thruster increases vessel's manoeuvrability, remarkably shortening the time required for harbour manoeuvres from 40 to 5 minutes. The bow thruster GT 750, with a power of 75 kW and thrust 1125 KG, is mounted in a steel duct. Tests have confirmed that the use of a bulbous bow and thruster will reduce fuel consumption by up to 10% in free sailing, so with a daily fuel use of 2400 litres, resultant savings will reduce total operating costs.

Fig. 6. Modernized DZI-102 fishing cutter

The second stage of modernization was to rebuild the holds and working lower (main) and upper decks to create space for the installation of fish withdrawal from fishing gear, storage of catch in holds and discharge in the harbour. The equipment installed on deck is used for transferring fish by "sucking" the catch by a pump (impeller pump). The complete installation delivered by Danish FORNAES APS firm consists of a 12¨ pump, separator and auxiliary crane DOR 750. The catch is collected directly from a trawl codend and transferred onto the working lower deck. The hydraulically driven 12¨ impeller pump, with a capacity of 300–1500 m^3 of water per hour, is equipped with a reeler for ϕ300 rubber hose and a hydraulic drive pipes reeler. The pump is lifted by the auxiliary crane DOR 750, connected to the codend and lowered into the trawl submerged in water. Then the pump sucks in caught fish together with water through a ϕ300 rubber hose and transfers them to a separator where seawater is separated. Next, fish are transported to the lower working deck.

The cutter is now adjusted to carry fish in bulk at a water temperature of up to –1.5°C, provided by the Refrigerated Sea Water (RSW) installation. For this purpose, one hold was rebuilt to form seven insulated tanks. The RSW installation uses ammonia NH_3 as a refrigerant compressed by piston compressors. The owner purchased the complete installation, including RSW chillers, condensers, compressor, seawater pumps, electric power distribution board, ammonia gas detection controllers, oil. Besides, one hold was modernized: divided into seven tanks thermally insulated by styrofoam sheets and polyurethane foam between the external plating and internal plating of the tanks. DZI 102 was the first Polish fishing vessel to be equipped with the RSW installation, so there were doubts and fear before the decision to modernize was made.

Fish stored in the holds are discharged using a vacuum installation.

The modernization of navigational and fishing equipment included the mounting and installation of most modern and technologically advanced

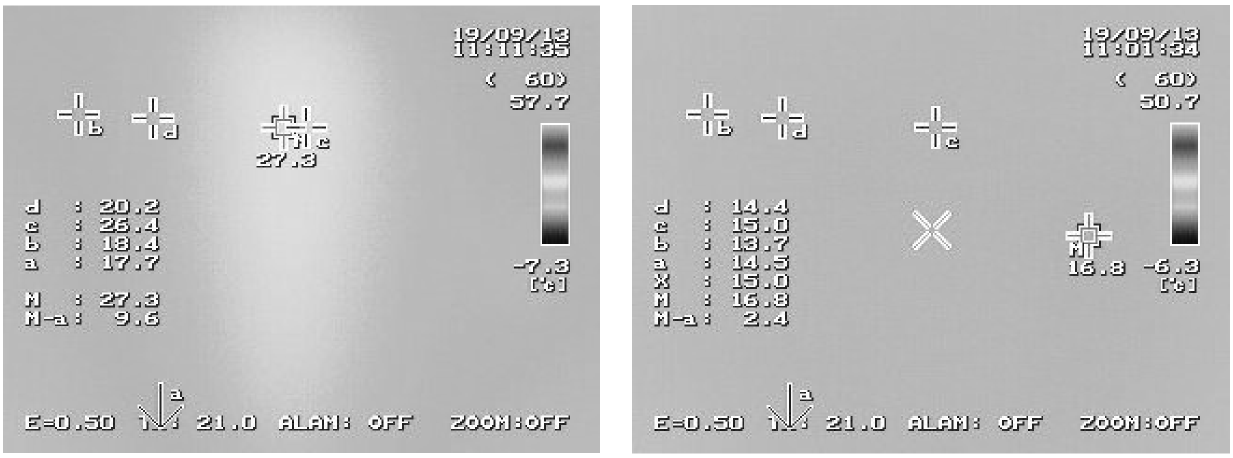

Fig. 7. Image of hold insulation taken by a thermovision camera (arrows indicate places of lower insulation)

Fig. 8. Converted hold

devices and navigational and echo location software. Increased demand for electric energy necessitated the installation of another generating set of 150 kVA, delivering power to the RSW system and vacuum installations for the discharge of fish from RSW tanks.

The installed equipment included an echo sounder ES 70, autopilot AP 50 and a sonar HD 850-110FT. Further improvement of navigational safety was achieved by installing an electronic navigational chart (C-MAP MAX WIDE Baltic with a SODENA bitlock, seaBAX and TURBOWin PRO + 3D program making 3D plots of the seabed).

Conclusions

The modernization by the owner of a 57 year old vessel turned the diesel-driven fishing cutter built in 1957 in VEB Volkswerft shipyard in the former German Democratic Republic into Polish most efficient large fishing cutter operating in the Baltic Sea. The fitting of modern navigational equipment, fishing gear and thruster increased the vessel safety. Installations for fish pumping from the trawl and vacuum method of discharge from the holds reduced the number of fishing crew members by two.

The addition of a bulbous bow increased the course keeping stability, longitudinal stability and speed by one knot at the same main engine load. However, despite model tests, certain irregularities of hull flow were observed. When the vessel is loaded and the stern trim increased, untypical phenomena occur in the propeller stream: splashes of water and audible noise heard in the afterpeak, which may be due to the formation of air cushions. The phenomenon is less intense when the trim decreases.

The method of RSW tanks insulation for the most part proved efficient, but thermovision camera examination performed by researchers of the Maritime University of Szczecin revealed places where insulating foam failed to fill the spaces uniformly.

On the whole, the actual effects of modernization show that it pays to incur modernization costs higher by 6–10% in connection with professional preparation of design and model tests. This author, visiting a number of fishing vessels, has witnessed unprofessionally performed modernization that did not bring effects expected by the owner.

Acknowledgements

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