Designing ships with computer simulation methods

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**Abstract**

Designing a ship is a task of solving numerous problems relating to her later operation. The primary objective is to ensure an adequate standard of navigational safety. The application of computer simulation methods allows at the design stage to take into account factors connected with navigational and hydrometeorological conditions in a planned area of operation. In addition, the process of designing a ship combined with crew training at specialist courses allows to provide high standard of shipping safety for the ship put in operation.

**1 Introduction**

There are several factors critical to the safety of a sailing ship. They can be divided into three groups [6]:

Factors relating to the ship:
- her sea and manoeuvring properties,
- navigational equipment,
- crew qualifications.

Factors external in respect to own ship:
- navigational conditions in the area,
- hydrometeorological conditions,
- traffic intensity,
- traffic rules (related directly or indirectly with traffic control).
Rules concerning:
- navigation and collision avoidance,
- lights, marks and ship signals,
- exchange of information with other vessels.

When the ship moves safely, there is no threat to life, property or the marine environment. Meeting this condition is equivalent to ensuring safety of navigation at an adequate level. Maintaining proper standards of safety depends directly on:
- naval architects and ship builders,
- ship crews,
- waterway and hydrotechnical structure designers,
- hydrographic and hydrometeorological services and maritime administrations,
and indirectly on:
- shipowners, who establish operating tasks,
- stevedores (stability conditions),
- maritime institutions which create legislation, radiocommunication systems, traffic control systems etc.

To what extent the above groups influence navigational safety standards depends on a number of factors. In most cases we deal with a ship already built (being in operation) where these ship-related factors, sea and manoeuvring properties in particular, have already been determined by designers and builders. In such situations the remaining factors are essential to shipping safety. In certain situations this causes substantial limitations in keeping proper navigational safety standards. It particularly refers to navigation in restricted areas where sea and manoeuvring properties of ships may be not fully adjusted to external conditions.

In restricted areas an optimal solution would be to adjust the ship's characteristics to the properties of the area at designing stage. Good examples of this are 'Max' type ships such as Panamax size ships well suited for operation in a particular area.

A shipowner tries to make the biggest possible profit out of an operated ship. When a ship is not adjusted to a certain navigational area the profit is lower; since high safety standard is a priority, the ship's potential becomes limited.

Consequently, there is a noticeable tendency of taking into account external conditions of a future operating area of a ship when being designed. This refers particularly to specialized ships such as sea-going ferries, ro-ro ships, but also bulkcarriers and tankers. That is why ship designing is affected by an increasing number of factors which enforce manoeuvring qualities of a ship matching planned operating conditions (sailing area properties, hydrometeorological conditions). Computer simulation methods enable taking into account all the variables influencing ship safety [3]. The use of these methods make it possible to design ship parameters (manoeuvring properties) adjusted to the area (navigational and hydrometeorological conditions).
Upgrading crew qualifications is an important element raising navigational safety standards. The process can be enhanced by suitable training with the use of simulators. The training may be general or specialized. The latter in particular is important as it offers instruction for a specified ship operating in specified areas. Specialized training combined with ship design based on computer simulation methods allows to obtain high standard of navigational safety after the ship is put into operation.

2 Problems

Designing a ship is a complex process in which a number of problems have to be solved. Computer simulation methods assisting the process of designing and selecting optimal solutions while building a ship enable recognizing dynamic and manoeuvring properties of a ship and steering her movement. The investigation problems concerned with these issues can be divided into a few groups.

The first group comprises recognition of ship basic manoeuvring properties in respect to free and active stopping acceleration, turning manoeuvre, turning ability of a ship for various propellers and driving power.

The second group includes a choice of main propulsion power output and types of propellers, the number and power of thrusters in respect to the assumed maximum hydrometeorological conditions in which the ship can safely navigate in a specified area.

The third group encompasses problems of recognizing ship's manoeuvring capabilities for various hull designs in respect to hull shape changes and determining how these capabilities are affected in changing hydrometeorological conditions.

The second and third groups of problems in particular reveal the advantages of research by computer simulation methods. They make it possible to optimally design parameters of a ship intended for operation in a specified area within an assumed range of hydrometeorological conditions.

An additional advantage of this method is its high flexibility when the investor changes basic assumptions for the designed ship.

3 Methods of implementation

Computer simulation methods for ship designs are implemented with various ship handling simulators. Two types of simulators are used at the Institute of Sea Navigation, Szczecin Maritime University.

Simulators of one type work on PCs and are fitted with programs of ship motion simulation developed and implemented at the Institute. The other type, including visual manoeuvring simulators, is represented by a NMS-90 simulator made by NORCONTROL. In addition to research applications these simulators are used for crew training.
The methodology of research based on simulations in ship designing consists in determining a ship's manoeuvring area on the basis of statistically processed results of simulation research. If the manoeuvring area $w$ belongs to an admissible (safe) area (Fig. 1), then a condition of adequate navigation safety standard is satisfied [2]. The method allows for ship motion dynamics and navigational and hydrometeorological conditions.

By changing the designed ship's parameters one affects her dynamic properties and, consequently, the manoeuvring area. This lets allows to make an optimal choice of the designed ship's parameters. The method requires a series of investigations in real time (Fig. 2) conducted by persons authorized to steer vessels such as those under examination (pilots, experienced captains).

Our attention should be drawn to a specific feedback. When the ship designed is the first of the kind, people experienced in steering vessels having similar properties are chosen. In the course of investigation these persons themselves learn. Observations show that the process progresses fast and has no influence on the research results.

4 Example of application

The design of the universal motor ferry Polonia.

The investigation aimed at a participation in designing parameters for the m/f Polonia [1], [5]. This passenger/rail/car ferry has been designed for operation on the Swinoujscie-Ystad line. The vessel is assumed to have maximum (Ystadmaks) dimensions allowing her to enter the port of Ystad.

The brief foredesign was as follows:
- capacity of 6,000 to 7000 tons,
- principal dimensions: length overall - 170 m,
- breadth - 28 m, approx. draft - 6 m,
- main propulsion: two shaftings with CP propellers,
- two bow thrusters, 1,200 kW each.

The ferry was assumed to operate at winds reaching 20m/s.

The simulation research resulted in working out the following guidelines:
- CP propellers of CLT or Wageningen type are best for the total power of the main propulsion plant,
- three bow thrusters are required, 1,600 kW each.
- one 1,600 kW stern thruster,
- the shape of above-water part should cause ferry's ardency,
- safe manoeuvring area in the port of Ystad and recommendations for hydrotechnical elements to be built or rebuilt.

In addition, a course and pilot training program for captains steering the ferry into the port of Ystad have been prepared.
Specialist training.
Apart from ship parameters, crew training in ship handling is a vital factor enhancing navigation safety standards. This is expressed by regulations defining recommendations for large vessels and those of untypical manoeuvring qualities - resolution 17 of the International STCW Convention 1978. Moreover, maritime administrations of individual states issue specific rules and regulations concerning training in this field which require that crews are trained. Implementation of the above recommendations is based on ship handling simulators. The training consists of suitable courses and programs which have to be developed to satisfy the requirements. Examples of such courses using ship handling simulators are those conducted by the Institute of Sea Navigation, Szczecin Maritime University.

Two groups of courses are offered:
- ship manoeuvring,
- sea ferry manoeuvring.
Both of these include basic and specialist training. In connection with designing parameters for the newbuilding Polonia the maritime administrations of Sweden and Poland have demanded that captains designated to command the ferry undergo specialist pilotage training. To this end a pilot manoeuvring course was devised for the m/f Polonia which at present is employed between Ystad and Swinoujscie. The course program and its practical realization have been approved by both administrations. The training manual "Vademecum of pilot manoeuvring course of the m/f Polonia for the ports of Ystad and Swinoujscie" goes with the course [4].

5 Summary
Supporting the process of ship designing with computer simulation methods is an important element in providing for adequate standards of safety of navigation. The range of application of these methods constantly increases due to various factors. One is a fact that ship designing can be paralleled with specialist crew training which will ensure high level of navigation safety when the ship goes into service.

References
Figure 1: Area of safe ship manoeuvring.
Figure 2: Simulated passage of the Polonia in the port of Ystad.