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EXPERIMENTAL STUDIES OF HEAVING TRAINING SHIP MODEL

Abstract

Results of tests of training-ship model's free rolling have been presented in the elaboration. The research was conducted on the laboratory stand of the Naval Academy. Paper presents the description of the laboratory and results of having. The first stage of research is limited only to the immersion testing the ship model. The results recorded during the study are presented in the paper.

INTRODUCTION

Problem of prognosing seakeeping ship's qualities is an important area of concern in a process of the ship designing, as a complex technical system. This task is mainly realized by means of model tests run by specialized research teams. In parallel to the experimental tests, calculations of the parameters in question are made by means of dedicated software using modern numerical methods in numerous scientific centres. It seems that both methods double each other because they are used for almost the same aims. In such a case, theoretically, it would be the best solution to elaborate one universal, yet accurate and inexpensive, method possible for application in tests of ships of any type. Model tests mostly meet the above said conditions provided that one has appropriate (expensive) back-up laboratory facilities at disposal - facilities prepared for tests of various ship types. In case of calculation methods,

implemented in specialist computer software, one may conclude that they are many times cheaper and yet – universal. However, they have one important defect due to which they have not squeezed the experimental tests out. Namely, from various tests of physic's problems, it is difficult to obtain results comparable to experimental tests. In spite of this defect, almost every research centre decides to apply computer calculation methods. Usually, companies having appropriate experience in programming numerical methods are manufacturers of the software. Many research centres undertake difficulty to elaborate their own independent computer programmes which are focused on one specific problem. Possession of back-up laboratory facilities is a trump of such centres - by means of the facilities they may verify and correct code of the computer programme and assumptions for the physical as well as for the mathematical models. Following such institutions, the Naval Academy undertook steps towards research on seakeeping qualities of ships based on both the research facility and the numerical methods. Several years ago, a research facility was built in the Academy enabling conduction of tests with ship models in a scope of both statics and dynamics of vessels. Then, aside from the model tests, there are computer programmes being elaborated in the Academy, executing calculations regarding ship's hydromechanics. This elaboration is a result of initial experiments run in the research facility. It contains results of laboratory tests on heaving of a training-ship model on calm water.

1. AIM AND EXECUTION OF TESTS

Determination of heaving of ship model is a target of the tests' stage under description - based on measurements done in the laboratory facility. The research was executed in the facility for tests on stability and unsinkability stand located in the Naval Academy in Gdynia, Poland. The scheme of the research stand bed is shown in the Figure 1[6,8]. The research conducted on it may be the source of the knowledge according to a ship reaction in the different operating states.

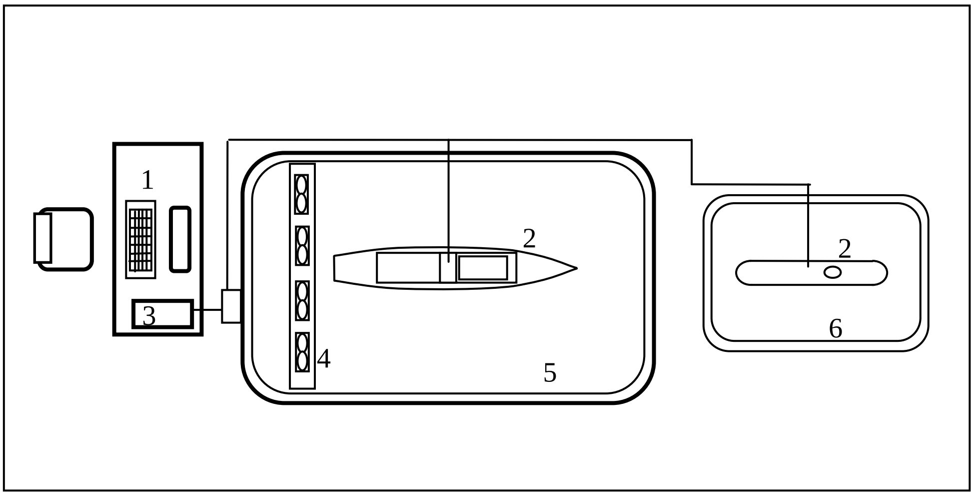

Fig. 1. Scheme of damage stability research station for ship models. 1- manager station, 2 – ship models, 3 – control computer gathering data, 4 – unit of fans, 5 – experimental tank for ship model, 6 – experimental tank for submarine model.

The training ship model is the main object of research because it is set up with specialized devices used for measurement of the position and for the analysis of the ship reaction during simulated states. The shape of the model is shown in Figure 2 [5,9].

Fig. 2. Model of the training ship

Model of training-vessel was an object of the tests, made in a scale of 1:50. Main dimensions of the real ship are: length L-72 m, breadth B-12 m, draught T-4,2 m and displacement 1750 t. This warship is used for training of Polish seafarers taking part in numerous international cruises. The basic data of the model are as the following:

- length between perpendiculars of the model L = 1,284 m
- breadth of the model B = 0,232 m
- displacement of the model D = 13,15 kg
- avg. draught of the model T = 0,079 m

Hull of the model was made out of polyester-glass laminate, based on a drawing of body lines, and plywood was used to build the model's superstructure. Compartmentation of the model hull's internal space roughly corresponds with a real vessel. One compartment that is lengthwise divided into three smaller ones constitutes an exemption. Similar to a real vessel, the model under description has a bilge keel, two screw propellers and rudder. The ship model is equipped, among the others, with an angle of heel and trim sensor and a sensor of average draught [5]. All devices are shown in Figure 3.

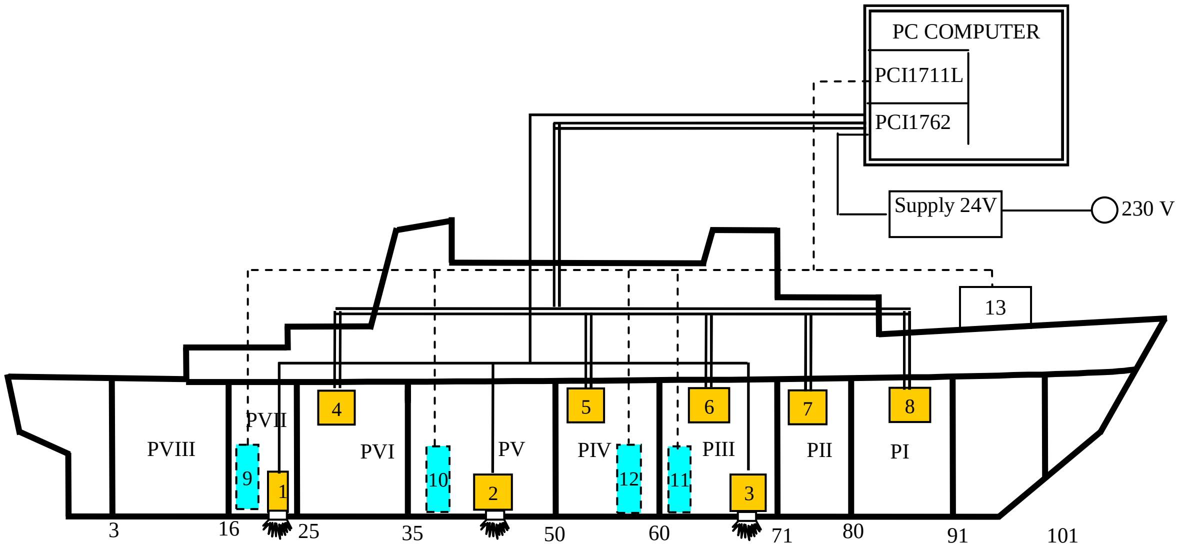

Fig.3. Disposition of elements in the model of training ship 1,2 and 3. Valves for a puncture simulation in the compartment PIII, PV and PVII; 4,5,6,7 and 8. Valves for flooding the compartment PVI, PIV, PIII,PII and PI; 9,10 and 11. Water level indicators in the compartment PVII, PV and PIII; 12. Indicator of a ship draught; 13. List indicator.

All elements whose area is significant during research were placed on the decks of the models. Because of the tasks carried out by warships, it was very important to create a ship model designed for simulation of holing. To accomplish this aim, chosen compartments were set up with remotely operated valves which enable the simulation of damage. These valves allow flooding the compartment to sea surface level. The electromagnetic valves are placed in the compartments with the biggest cubature because these compartments influence unsinkability of the model the most. Another group of valves is designed for flooding the compartments used during the process of righting the ship. This model was equipped with water system supplied by pumps located outside the model and water level indicator. An inclinometer mounted on the bow of the model is used for the measurement of the angle of the heel and the trim. The signals received from the indicators are transmitted by a wire to a computer which is equipped with two analog-digital cards and presented on the screen as simple values. Dislocation of main elements of the measurement system is shown in Figure 4.

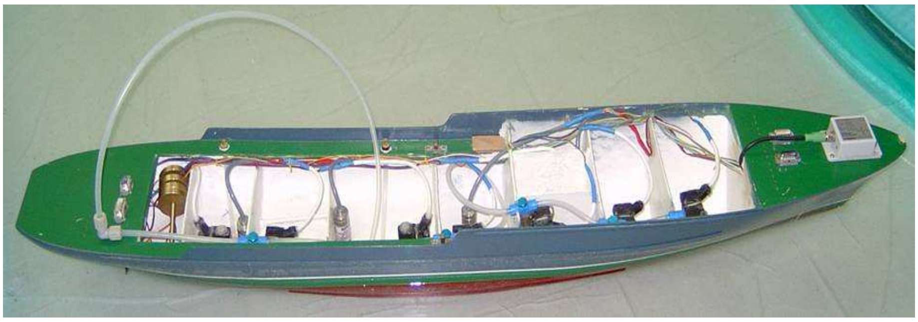

Fig. 4 Interior of the model [8]

The indicators and elements placed on the model are connected with the computer by a little reduced mass conductors which display the received values on the screen. Taking advantage of a computer, we can lead the analysis of the position of the ship during the study. These operations are controlled by a program installed on the computer. The screenshot shown in Figure 5 [5,8] presents the window of the program.

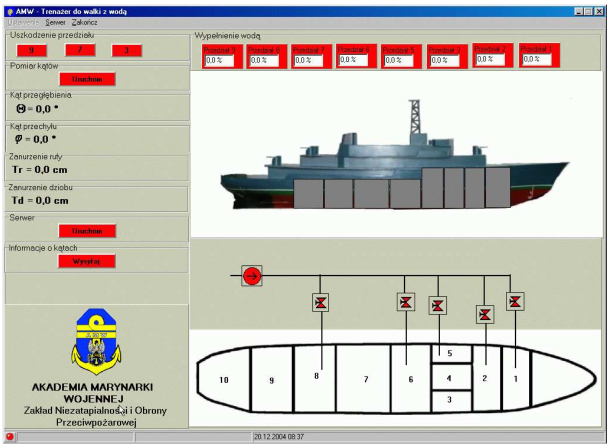

Fig.5. The window of computer program.

In addition, such parameters of the position as the angle of heel, the angle of trim, bow and stern draught are shown in the real time.

Determination of the model's draught is done indirectly by measurement of hydrostatic pressure in respect to water surface. The sensor registers measurements with accuracy of 0.0001 m, while inclinometer makes the measurements with accuracy of 0.01 degree.

Accuracy of the measuring equipment was evaluated during many experiments run with the model. Electric signals are emitted from the ship model to the computer via cable of Insignificant weight, and the results – in a form of given parameters – are registered and displayed on monitor in a real time.

The tests are conducted in the model basin of the dimensions of l = 3 m, b= 2 m, h =0.5 m, filled with water up to the level of 0.4 m. Such dimensions of the tank result in some problems with waves that rebound from its edge and upset the measurements. Therefore, several first seconds of the model movement, when the wave rebound was not visible, were taken into account in the result analysis.

The model used to be placed in parallel to the longer side of the basin during measurements of the parameters under discussion. All compartments of the model were empty. The model was capable of moving free in all degrees of freedom (in the required ranges). The free movement of the model was caused by application of starting conditions different from zero. Also, at the same time, efforts were made in order to minimize a phenomenon of individual movements' coupling (mainly between heaving and pitching). Measurements of the parameters under discussion were taken every 0.05 second.

In the initial period of the facility operation, tests on rolling were made many times. Based on them, location of centre of the ship model mass was determined precisely and also her metacentric height was determined which now is 0.0083 m.

2. RESULTS OF MEASUREMENTS OF SHIP MODEL HEAVING

Because of the applied mode of measurement of the ship model heaving, conduction of correct tests on heaving in the facility under description in its current state is made difficult.

The used sensor (converter) of average draught operates in such a way that it measures hydrostatic pressure in respect to water surface. There is an opening in the sensor containing air during execution of measurements. The air is being compressed by water getting inside during increase of draught. Compressibility of air is of insignificant importance at the time of execution of static measurement, but there are pulsations occurring there during execution of dynamic measurements upsetting the test. Moreover, in the course of the research conducted in the facility, it was observed that water “wanders” upwards together with the hull, i.e. the water surface undergoes deformation. Hence, measurement of hydrostatic pressure is burdened with additional error. Execution, for instance, of measurement of the model’s distance from the basin’s bottom could solve the problem. In current state, the laboratory facility does not allow to perform such tests [9]. Results of the heaving measurements registered by means of the described sensor of heaving are presented in Figure 6.

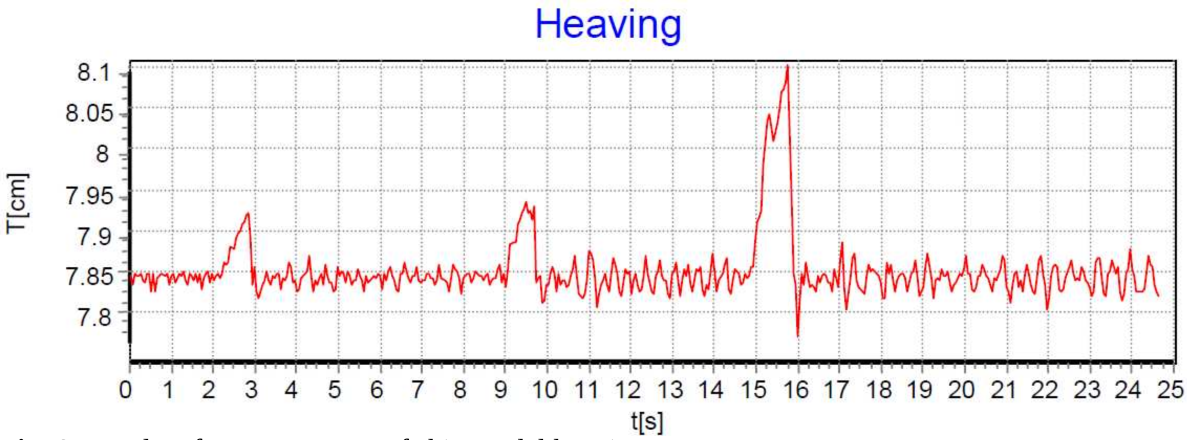

Fig. 6. Results of measurements of ship model heaving

SUMMARY

So far, model tests on vessel’s seakeeping qualities have been run in the Naval Academy in a very limited range and for specific constructions such as submarine model [2] and pinnace model [6]. Tests described in this paper were conducted in a totally new facility, for a model very accurately reflecting geometry of the Polish Navy vessel’s hull being still operated. Thanks to the new laboratory facility, equipped with specialist sensors and vessel models executed in accordance with body lines, technical level and quality of the tests have been seriously improved.

The described tests are a preliminary stage for a broader analysis of phenomena regarding hydromechanics of vessels. In the future, results of measurements included in this paper shall be used for verification of computer programmes engaging numerical methods and being elaborated by the authors of this paper.

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BADANIA EKSPERYMENTALNE NURZANIA MODELU OKRĘTU SZKOLNEGO

Streszczenie

Badania eksperymentalne nurzania modelu okrętu przeprowadzono na stanowisku laboratoryjnym znajdującym się w Akademii Marynarki Wojennej. W opracowaniu dokonano opisu stanowiska badawczego oraz przedstawiono rezultaty badań kołysań swobodnych modelu okrętu szkolnego. W pierwszym etapie ograniczono się jedynie do przeprowadzenia badań nurzania modelu okrętu. Wyniki zarejestrowane podczas badań przedstawiono w referacie.

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