Model tests of fast units on the open waters of Jeziorak Lake

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Abstract

Paper presents model tests of fast units carried out in the years 1956-2000 in the Experimental Centre of the Gdansk University of Technology Shipbuilding Institute on Jeziorak Lake. The experimental tests included single- and twin-hull hydrofoils, amphibian hovercraft, side-wall hovercraft and also speedboats and SWATH type catamarans. The aim of those tests was to acquire data for developing the design and safety criteria as well as computer programs for predicting the hydrodynamic properties of fast units. The gathered experimental material was used in the theoretical studies, publications and conference papers.

Keywords: *fast units, single hull, twin hull, model tests, speedboats*

INTRODUCTION

The dynamic development of fast nondisplacement craft caused demand for model tests not only in the resistance field but also in the manoeuvrability, stability and hull load problems, on calm water and on waves. Experimental determination of the above mentioned characteristics in towing tanks is possible only to a limited extent. Main limitation is the very high financial expenditure necessary for the construction of large towing tanks. Therefore, a conception was put forward to carry out model tests in open waters - lakes, rivers, canals etc. in spite of a significant drawback, i.e. dependence on the atmospheric conditions limiting the test season, in this climatic zone, to 6-7 months. An important advantage of the conception is a possibility of carrying out the tests on big manned self-propelled models. The Experimental Station of the Chair of the Theory of Ships developed into a unique Experimental Centre of the Gdansk University of Technology Shipbuilding Institute, located at Ilawa on Jeziorak Lake, where test programmes were performed of the models of displacement ships, hydrofoils, skimming boats, hovercraft and also the SWATH and Wave-Piercing catamarans. At present the centre is used also for teaching purposes, as a base for international student scientific exercises.

Model tests of hydrofoils

The K-1 hydrofoil

In 1955 pioneering model tests of hydrofoils were initiiated in the Chair of the Theory of Ships. The first of a series of tested units was an L = 4.53 m long model equipped with two V type foils. Preliminary tests were performed on the Motlawa river in Gdansk, with a negative result. The foil system required considerable design modifications. The difficulties connected with a small water area and lack of an appropriate equipment decided of moving the tests of that hydrofoil to the Experimental Centre in Ilawa. Tests on the K-1 model on Jeziorak Lake were resumed in summer 1956. The model was tested on the calm water and on waves. An optimum solution was sought to the foil system allowing to keep steady straight course and circulation as well as a shorter way of starting, i.e. raising the hull above water surface. Profiles of foils and braces were changed, deep and shallow foils tested. The experience gained had a significant influence on other hydrofoil designs developed by the Chair of the Theory of Ships. The K-1 hydrofoil was used until 1967. One of its versions is presented in Fig. 1.

Fig. 1. *Model of the K-1 hydrofoil during tests on Jeziorak Lake.*

The K-2 hydrofoil

Model of the K-2 hydrofoil, length L = 6.0 m, built in 1957, in the first version equipped with wooden foils of laminar profiles and capability of changing their lead angle and span, was used for testing the start characteristics in different loading states, as well as the transverse and longitudinal stability in calm water and on waves. In 1960 the foil system was changed in the model. Renamed to K2-M, the model had very good starting, stability and manoeuvrability characteristics in calm water, on waves and in a canal. In 1961 a divided automatically controlled Hook system bow foil was installed on the K2-M model. In this way the K2-H model was created for tests in calm water and on waves. After dismantling the foils, hull of that model was used for building the SP-03 BADACZ I measurement-towing station for testing small hydrofoil and hovercraft models.

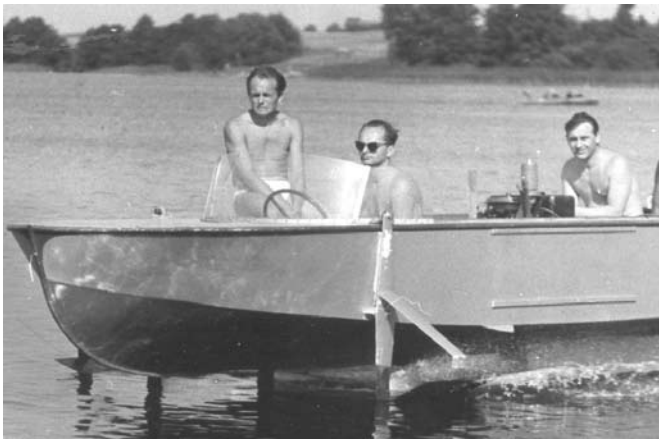

Fig. 2. *Model of the K-2 hydrofoil during tests on Jeziorak Lake.*

The K-3 hydrofoil

Built in the WISLA shipyard in 1958, the K-3 hydrofoil was an 1.5-ton unit with the hull made from aluminium and foils made from stainless steel. Modelled on the PT-20 hydrofoil, it was tested on Jeziorak Lake and on Ilawa Canal in calm water and on waves, in 1959 and 1960. It had good stability characteristics. After dismantling the foils, it was used as a transport unit and the measurement catamaran pusher tug, e.g. in the W-2 hydrofoil model tests.

Fig. 3. *Launching of the K-3 hydrofoil in the WISLA shipyard*

Fig. 4. *The K-3 hydrofoil during tests on Jeziorak Lake.*

The K-6 hydrofoil

The K-6 hydrofoil, length L = 4.24 m, was an 1:3 scale model of the K-4 hydrofoil designed for the Navy. Its tests carried out in 1958-1959 allowed to modify the shape of hull and foils in order to improve the start characteristics. Performance tests of the real K-4 WIESIA hydrofoil were carried out in the Gulf of Gdansk, in 1960-1961.

Fig. 5. *The K-6 hydrofoil during tests on Jeziorak Lake.*

Experimental investigations of small towed hydrofoil models

In the years 1962-1963 systematic investigations were performed in the Experimental Centre of small hydrofoil models towed by the floating measurement station - catamaran. The investigations were aimed at obtaining additional information on the impact of some hull and foil parameters on the hydrofoil start properties.

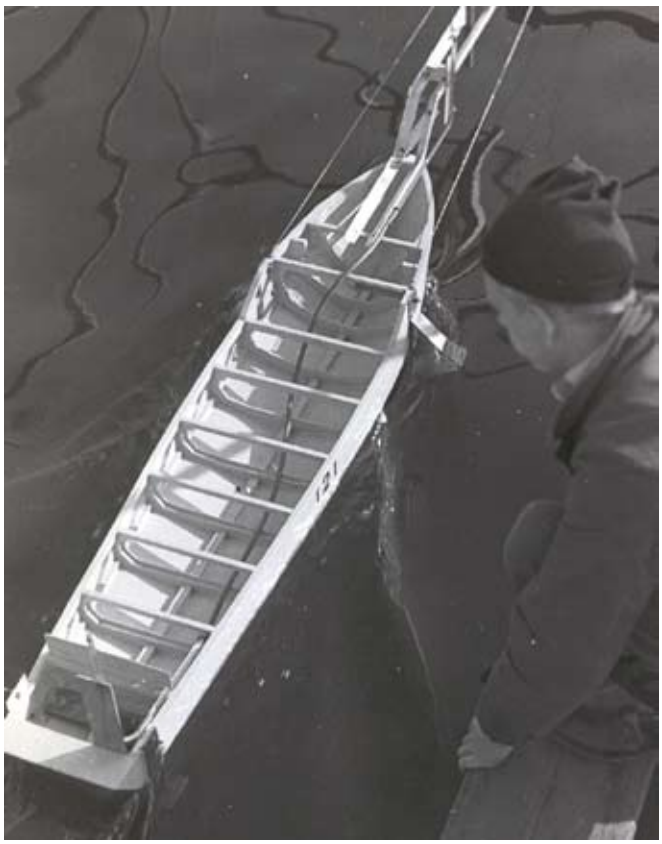

Fig. 6. *View of the towed W-2 hydrofoil model.*

The W-2 REKIN hydrofoil.

The W-2 REKIN hydrofoil, length L = 9.50 m, was an 1:3 scale manned model of a passenger hydrofoil intended for operation in the Gulf of Gdansk. The shape of hull and foils was designed from the test data of small models towed on Jeziorak Lake. During the tests performed in 1962 the W-2B hydrofoil achieved excellent results. An interesting solution was the use of the bow foil reserve surface trailing edge flaps improving the start characteristics. Further tests carried out in 1963 showed excellent operating parameters of the hydrofoil. After completion of investigations, the hydrofoil was used in the Experimental Centre in Ilawa for a long time as a recreation and transport unit.

Fig. 7. *The W-2 REKIN hydrofoil during tests on Jeziorak Lake.*

The W-3 hydrofoil.

The W-3 hydrofoil, length L = 9.20 m, was an 1:3 scale manned model of a passenger hydrofoil intended for operation in the Szczecin Bay. The first tests of that unit in September 1961 consisted in choosing of one of two foil versions from the point of view of good start and stability characteristics, in calm water and on waves. The W-3 tests performed in 1962

were aimed at improving the resistance and propulsion and also start characteristics with large longitudinal shifts of the centre of gravity. In 1965, based on those data, a passenger hydrofoil ZRYW-1 was constructed in the WISLA Shipyard in Gdansk. It was operating first on the Szczecin-Swinoujscie and then on the Gdynia-Hel route, in all weather conditions, altogether for over fifteen years. W-3 was used again in 1966 for testing a modified foil system, implemented then on the real unit.

Fig. 8. *The W-3 hydrofoil during tests on Jeziorak Lake.*

The WS-6 hydrofoil.

The WS-6 hydrofoil, length L = 7.15 m, was to be a prototype of a six-person inspection, transport or tourist unit and a model of a 30-person inland navigation passenger hydrofoil. The hull shape similar to that of W-2, the foil system was a combination of systems applied on K2-M and W-3. In front of the bow foil an additional foil was mounted, facilitating start and emerging from water at full speed. For the first time the Z type gear was used for power transmission to the propeller. Comprehensive tests of the WS-6 carried out on Jeziorak Lake in the years 1968-1969 confirmed its good stability characteristics in the whole speed range, from displacement sailing to a 50 km/h flight.

Fig. 9. *The WS-6 hydrofoil during tests on Jeziorak Lake.*

The WS-4 AMOR hydrofoil.

The WS-4 AMOR hydrofoil was a prototype of a four-person inspection or tourist unit intended for inland navigation, with an original patented hull shape and foil system. Propulsion was provided by a 35 HP outboard engine. Built in 1967, it was used as a safeguard unit during the fast craft model tests. In the years 1991-1993, within the research project KBN No. 310439101, a comprehensive set of tests were carried out of the start, manoeuvrability and stability characterisitcs on calm water and on waves, which confirmed excellent performance of the unit. The hydrofoil is still in operation.

The SP-04 BADACZ II hydrofoil.

The hydrofoil catamaran built in December 1971 by the

Fig. 10. *The WS-4 hydrofoil on the Jeziorak Lake waters.*

was obtained for the original structure of the foils. The first tests were performed in small waves on the Dead Vistula river in Gdansk Stogi. The hydrofoil with a load of five persons achieved a 16 m/s speed. Since 1972 the hydrofoil has been used in the Ilawa Centre. In 1974 it was used for comprehensive tests of real size sports kayaks and canoes. After dismantling its foils, it was used for testing of skimming boats, SWATH catamarans, Wave-Piercing catamarans as well as hydrofoils with a system of two or three foils. At present it is being used for model tests performed in the international student workshops.

Fig. 11. *The SP-04 hydrofoil model towed by SP-03 during tests on Jeziorak Lake.*

Fig. 12. *SP-04 BADACZ II during acceptance tests on the Dead Vistula river.*

Model of a hydrofoil catamaran

A model of catamaran, tested in 1996, supported by a set of three foils, was based on the design study of a 260-person passenger hydrofoil with the cruising speed of 40 knots. A 1:13 scale model was towed by the SP-04 measurement station. The tests included longitudinal and transverse static and dynamic stability as well as pitching angles and accelerations above the foils during the unit flight on waves. The results were used as verification of the programs developed within the research

Fig. 13. Model of catamaran, supported by a set of three foils, under tests

Model of a single-hull hydrofoil

A model of a 120-person passenger hydrofoil in a 1:10 scale, towed by the SP-04 measurement station, was equipped with a set of two or three foils. The tests performed in 1999 within the research project KBN No. 9T12C09914 included the start and transverse stability characteristics, particularly in the transient state of a hydrofoil moving in calm water and on waves.

Fig. 14. *Model of a single-hull hydrofoil with a set of two foils under tests on Jeziorak Lake*

Fig. 15. *Model of a single-hull hydrofoil with a set of three foils under tests on Jeziorak Lake*

Fig. 16. *Model of the M2 skimming boat under tests on Jeziorak Lake*

Model tests of a sports motor boat

In the years 1966-1968 a preliminary study was performed of a series of types of four sports motor boats, designated M1 to M4. In order to acquire reliable design data, a large self-propelled model of the M2 unit was built for tests in the Experimental Centre in Ilawa on the open waters of Jeziorak Lake. The tests were carried out in November 1967.

Model tests of a fast skimming boat

In the years 1981-1987 the Gdansk University of Technlogy Shipbuilding Institute performed a research project, financed by the Ministry of Science and Higher Education, on fast dynamic lift units in order to develop a hull shape for a patrol boat of 160-180 m^3 displacement volume and 40-50 knots operating speed. Comprehensive tests were carried out on four models: no.338 in 1:37 scale, no.238 in 1:10 scale, no.370 in 1:16 scale and the self-propelled model no.378 in 1:5 scale. Experimental tests included the influence of displacement and initial trim angle on the resistance characteristics, of longitudinal steps on the resistance and wave phenomena, of rolling stabilizers on the resistance and transverse dynamic stability and finally of model scale on the resistance and wave phenomena. In cooperation with the Rheinisch-Westfälische Technische Hochschule, Lehrstuhl für Schiffbau, Aachen, Germany, measurements were carried out of the pressure distribution and hydrodynamic loads on the bottom of the no. 378 self-propelled model in calm water and on waves, on Jeziorak Lake and in the Kiel Bay.

Fig. 17. *Self-propelled model during the pressure distribution and hull bottom load tests*

Fig. 18. *No. 370 model in 1:16 scale during tests on Jeziorak Lake*

Fig. 19. *No. 238 model in 1:10 scale during tests*

Fig. 20. *Self-propelled model in 1:5 scale on Jeziorak Lake*

Tests of a SWATH catamaran

In the years 1987-1988 within the Central Research and Development Programme 9.5 tests were carried out of a model in 1:18 scale of a SWATH (Small Waterplane Area Twin Hull) type catamaran in order to develop a hull shape of good resistance and stability characterisitics. A patent application was filed for an original hull shape. Based on the test results, a self-propelled model of a SWATH catamaran of 2.18 m^3 volume displacement was built in 1990. It was used for comprehensive tests of the resistance, manoeuvrability, static and dynamic stability and rolling characteristics in calm water and on waves. The tests confirmed a possibility of operating such units without the use of stabilizing fins.

Fig. 21. *Model of a SWATH catamaran during tests*

Fig. 22. *Self-propelled model of a SWATH catamaran during tests on Jeziorak Lake*

Concluding remarks

Experimental investigation of fast craft is a technically and methodologically difficult part of the ship model tests. It requires good and reliable equipment, broad experience and efficient organization. On the other hand, it provides data for development of design methods, safety rules and prediction of hydrodynamic characteristics. The accumulated experimental material has been widely used in theoretical dissertations, publications and conference papers at home and abroad.