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A survey on multi hull ships

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***Abstract*— Many multi-hull ships, vessels, and boats are used for various purposes. But a large variety of multi-hull ship characteristics is a sufficient basis for wider applications of multi-hulls. Three new concepts for local needs are described below:**

– A super-fast car-passenger ferry,

– A fast small-sized carrier of underwater vehicles,

–A seismic ship with low underwater noise and high seakeeping ability.

***Index Terms*— Super-Fast Ferry; "Wave-Piercing" Trimaran; Achievable Speed; Seaworthiness; Triple-Hull SWA Ship; Underwater-Vehicle Carrier; Outrigger Ship; Pulling Propeller; Low Underwater Noise.**

I. Introduction

Many multi-hull ships, vessels, and boats are used for various purposes. But the large variety of multi-hull ship characteristics is a sufficient basis for wider applications of multi-hulls. Some new concepts are proposed for some new purposes of fleets.

II. Theory

A. *Super –fast car-passenger ferry*

Today a catamaran ferry for 50 cars and 200 passengers is built for the Doha–Dubai line. The full speed of the catamaran will be 43 knots. The main competitive commercial idea is the following one: a smaller and cheaper ship with half the capacity and twice the speed can ensure the same yearly flow of cars and passengers, but the ship will be more attractive (due to time economy) and, therefore, can ensure greater application of the ship's capacity on any trip. Currently, the majority of fast ferries have speeds at the higher limit of the transient regime of speeds: the Froude number of hull displacement is about 2.7–2.8 (the formal frontier between the transient and planning regimes of speed is a Froude number of 3.0).

This means that doubling the speed corresponds to Froude number larger than 3.0; that is, the ship-competitor must be planning one. However, all planning boats must have a smaller aspect ratio of their hulls than the catamarans of the transient speed regime (Fig. 1).

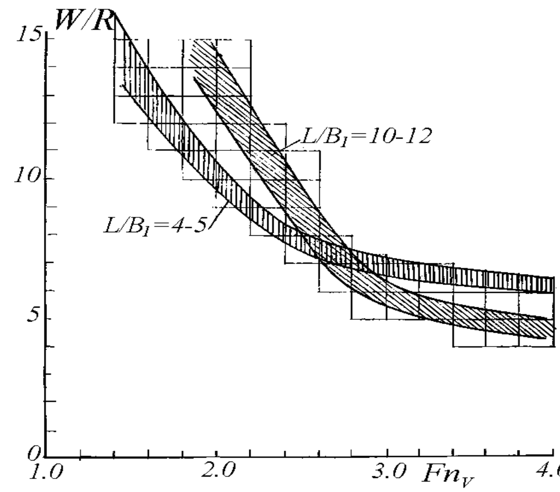

Fig. 1 Hydrodynamic Quality W/R of Hulls of Various Relative Length L/B (W – Hull Displacement, R – Towing Resistance, $Fn_v = V / (W^{1/3} g)^{1/2}$, V – Speed, M/Sec)

Figure 1 shows that from a performance point of view, longer hulls are better when the Froude number is below 3.0, while shorter hulls are better at bigger Froude numbers. While the need for a sufficient area of the deck and longitudinal stability defines the optimal way to transition from smooth hulls to chine ones: the two hulls of a catamaran must be changed to three hulls arranged as an arrow in the horizontal plane. Besides, the above-water platform must have a smooth wing like shape for minimal air resistance and the possible generation of airborne lift.

All planning boats differ from smooth ones in that greater slamming of the hull bottom occurs in waves. To eliminate this disadvantage, a so-called "wave-piercing" shape must be applied.

Such reasons were the basis of a new type of super-fast ship: the "wave-piercing" planning trim ran with airborne unloading (see [1]).

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Towing tests and test in air tubes showed the average hydrodynamic quality (Fig. 1), about 5 at Froude numbers with a hull displacement up to 7.5. At the speeds, the airborne unloading is about 15–25%, depending on the absolute speed.

Seaworthiness tests have shown that bottom slamming of such hulls is absent with Froude numbers up to 4.5 in any waves.

This basis allows the main dimensions and general characteristics of the ferry for 24 cars and 100 passengers to be defined as follows: a full speed of 300 (up to 600) NM.

The general arrangement of the ferry is shown in Fig. 1 and Fig. 2.

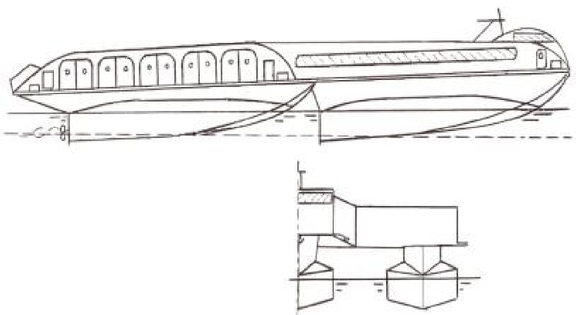

Fig. 2 A Scheme on The Side and Bow Views of The Proposed Ferry

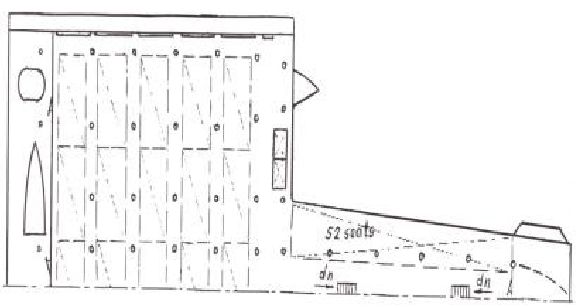

Fig. 3 Plan of the Arrangement of the Super-Fast Ferry

The design draft is about 1.5 m at rest and about 0.5 m at full speed. It must be noted that the super-planning vessel will not generate waves in any depth of smooth water. The specificity of the proposed hydrodynamic scheme is its self-stabilization in the wind. The mass centre of the vessel is arranged nearer to the bow and then the centre of airborne lift is arranged nearer to stern. This means that a gust of wind generates a dynamic trim to the bow, which is compensated by the added lift of the bow hull. Therefore, over-heeling through the stern is not a danger to the vessel.

If the shipbuilding cost is no higher than about half of the ordered catamaran cost, the proposed super-fast ferry could be commercially successful on the Doha–Dubai line.

B. Fast small sized underwater vehicle carrier

Various underwater vehicles (UWV) are widespread now and will be more widespread in the future because of various needs of science and battle fleets. Fast UWV carriers can be useful for fast transportation to special regions and rapid reversing. Underwater outlets and inlets can be useful for restriction of wave action as well as closed service of UWVs. Sufficiently high seaworthiness can be ensured for any type of ship with a small water-plane area (SWA ships). However, usually SWA ships are not so effective at high speeds. Christo Ananth et al. [3] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

A new type of fast SWA ship was proposed previously by the author [1]: the so-called “semi-planning” SWA ship (S/P SWA ship). While a disadvantage of such an option is the absence of stability of the dynamic trim. This means that a twin-hull S/P SWA ship needs permanent action of a dynamic trim control system. The system and the special shape ensure higher performance at high enough speeds (see Fig. 4).

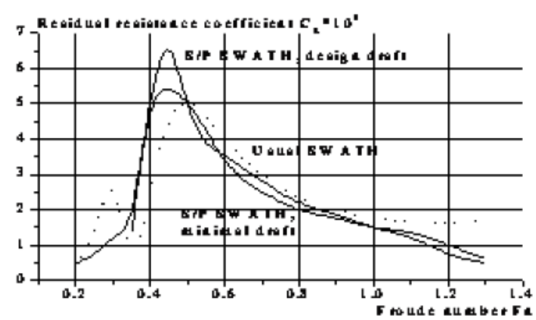

Fig. 4 Residual Resistance Coefficients Of S/P Swath Hull (Solid Lines) And Usual Swath Hull (Dotted Line)

The test results showed present the main difference between the residual resistance coefficients of S/P SWATH and the usual one: the values are approximately twice as low at high enough Froude numbers.

Some estimations of full-scale towing resistance and corresponding ship characteristics show that the proposed hull shape ensures achievable speeds up to Froude numbers of

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3.0–3.2, that is, at the lower values of the planning speed regime.

On the contrary, a triple-hulled S/P SWA ship does not need such control if it is designed correctly. As a result, the triple-hull S/P SWA ship is proposed as a fast carrier of UWVs with full displacement of about 1 000 t, a design speed of 45 knots, and a design Sea State of about 5. Two stern hulls contain the main engines (2 × 20 MW), while the bow hull contains the UWV system. From the previous work, Christo Ananth et al. [5] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller. This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

The triple-hull SWA ship with the special hull shape will have the following main dimensions: an overall length of about 70 m, overall beam of about 20 m, and depth of about 11 m, design draft of about 5 m, and light ship draft of 3.5 m. The ship can receive a big helicopter (without a hangar), four UVWs, and two fast boats.

A simple and sufficiently cheap folding hangar can be used as well. The estimation of the main characteristics of seaworthiness was carried out on the basis of model tests in the sea keeping basin of the Krylov Shipbuilding Research Institute, Russia, by the author.

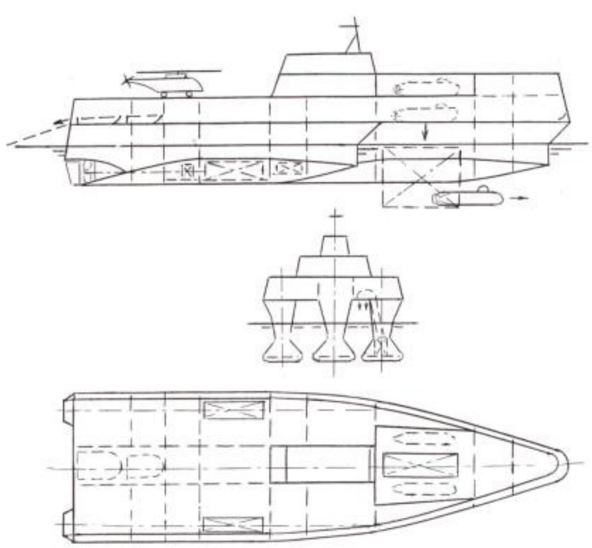

Fig. 5 The General Arrangement Of The Triple-Hull S/P Swa Ship As A Fast Carrier Of Unmanned Under-Water Vehicles

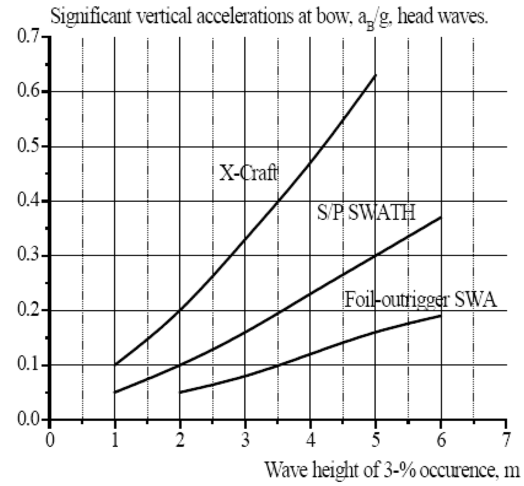

Fig. 6 Vertical Accelerations at Bow with Head Waves

The acceleration level of the built X-craft at Sea State 4 corresponds to the level of the triple-hull SWA ship at Sea State 5.

C. *Low Noise Seismic Ship*

It can be supposed that any seismic ship will be more effective if it has minimal underwater noise. The main sources of noise are the propellers and the engines in the hull or hulls. A new type of seismic ship can be proposed based on pulling propellers [2] and engines outside the ship hull. The proposed ship has two small hulls (outriggers) added at the side of the main hull, each outrigger consists of a small underwater volume, a gondola, and a thin strut, which connects the gondola and the above-water structure. A pulling propeller is placed on the bow end of each gondola (Fig. 7). As discussed previously, Christo Ananth et al. [9] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

Twice amortized main engines are arranged above the outriggers, and the power transmission can be electrified or a special mechanical one (on the basis of a patent of Dr. S. Rudenko, Russia). The outriggers must be washed by an air bubble flow from the gondola bottoms.

The ship with a full displacement of about 2400 t, overall dimensions of 90 × 30 × 11 (draft 5 m), full speed of 14 knots (power of about 2 ×2500 kW), economical speed of 10 km,

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and a thrust of 20 t at a speed of 6 knots, can tow up to nine different towing systems. The equipment weight is 250 t, the laboratory area is 300 sq m, the stern hangar is 600 sq m, and the crew comprises 36 persons.

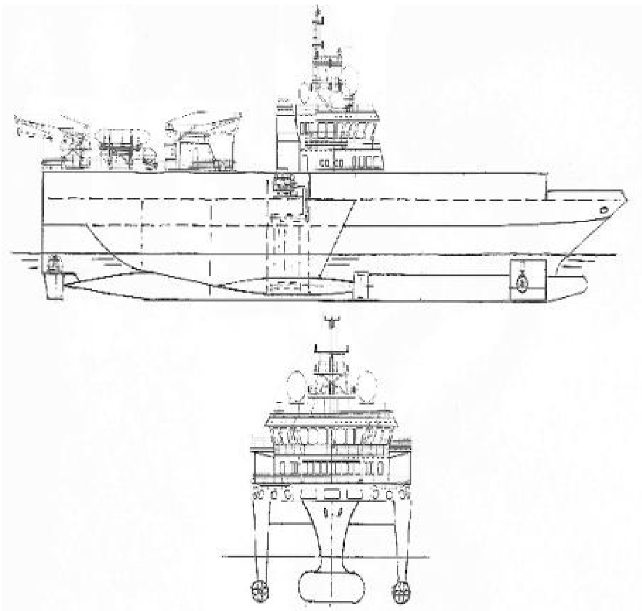

Fig. 7 A Scheme of the General Arrangement of the Proposed Low-Noise Seismic Ship

III. CONCLUSION

The new concepts of multi-hull ships described are based on model tests and preliminary calculations; therefore, they can be a permissible basis for future design of details.

The super-fast ferry shown is recommended for short car-passenger lines on sea without ice. The fast small-sized underwater-vehicle carrier is recommended for invisible outlets and inlets of the vehicles, including severe wave conditions without ice.

The low-noise high-sea keeping ship is recommended to ensure the best conditions for seismic research in severe seas without ice.

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