LAYOUT DIAGRAMS OF WATER VESSELS AND AIRCRAFTS WITH VORTEX PROPULSION UNITS

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ABSTRACT

Layout schemes have been developed and calculated and theoretical estimates of the ranges of operational parameters of water vessels and airships (dirigibles) with vortex propulsion units have been made. A complex comparison of the characteristics of such ships and vessels of the same classes of the traditional separate «hull – propulsion unit» configuration is presented. The possibility of the scheme is shown on the basis of a group of similar modules in the form of surface vessels with two generators of vortex pairs of a family of essentially new types of water vessels – self-contained multipurpose units with an almost unlimited period of autonomous functioning in an arbitrary non-freezing water area of the World Ocean. It is established that in all parameters, in addition to speed, vessels with vortex propulsion units have advantages over their competitors.

Keywords: *vortex propulsion units, water and aeronautical vessels, surface and underwater (toroidal) vessels, mass-dimensional characteristics, layout schemes, operational parameters.*

Background. *In [1–5], basic layout schemes of watercraft and aircraft with vortex propulsion units, hydrodynamics of the vortex pair and methods of its generation, and the principle of using vortex pair generators as vessel propulsion units while simultaneously providing the buoyancy of the entire vessel are described.*

The main advantages of vessels with vortex propulsion units are due to the lack of drag in the vortex pair moving in a continuous medium (water, air), in the volume of which there are initiating generators, and in some cases [4] and the vessel itself. The lack of frontal drag explains the extremely low power required for movement of vessels with vortex propulsion units in the steady state.

Comparison of vessels with vortex propulsion units with vessels of traditional layout for other parameters not related to power consumption is most often problematic due to the incompatibility of their design features.

It seems that for a meaningful evaluation of the advantages of different schemes, it is necessary to compare not the individual parameters, but the maximally complete set of operational and design characteristics of vessels that are close in some integral parameters, for example, by displacement or designation.

Our goal was accordingly to compare the sets of operational and mass-size characteristics of water and air (dirigibles) of the traditional separate layout «hull – propulsion unit» and vessels with vortex propulsion units, the basic schemes of which are given in [2].

In addition, the paper proves the feasibility of realizing, on the basis of a certain number (10–50 pieces) of autonomous surface vessels with vortex propulsion units, the idea of a floating device of a fundamentally new class – multi-module and multipurpose, capable of providing long-term (year or more) operation in the World Ocean.

Objective. *The objective of the authors is to consider layout diagrams of water vessels and aircrafts with vortex propulsion units.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, graph construction, mathematical methods.*

Results.

1. Surface vessels of large and super-large displacement

The largest surface vessels are currently tankers and aircraft carriers. Below are the principal diagrams of vessels with vortex propulsion units of similar purpose and compared some of their performance characteristics with the parameters of traditional vessels.

1.1. Self-propelled tankers

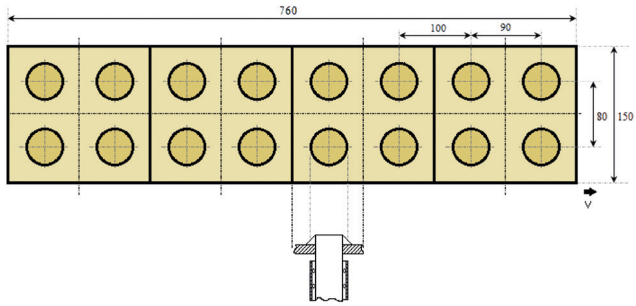
In 1976 in Japan, the oil tanker «Knock Nevis» was built and operated until 2010 with a displacement of 657018 tons (deadweight – 564763 tons), whose dimensions are 458x68 m² with draft (full load) of 24 m.

A schematic diagram of a tanker of a close displacement with vortex propulsion units is shown in Pic. 1. It is based on four identical sections, each of which has two pairs of vortex pair generators made in the form of hollow cylindrical rotors with a diameter of 50 m and a height of 22 m.

At a draft of 20 m the displacement of such a vessel is

$V = 16\pi r^2 h \cong 630 \cdot 10^3 m^3$ *tn.*

Distance between the rotors (across the vessel) – 80 m, between the pair of rotors along the vessel – 90 m, between pairs of rotors of adjacent sections – 100 m. Dimensions of the vessel: length (between the outer generators of the first and eighth rotors) – 760 m, width – 150 m.



Pic. 1. Layout scheme of a self-propelled tanker based on two pairs of generators of vortex pairs (dimensions in meters).

Table 1

Comparative characteristics of tankers

Vessel	Water displacement, tons	Dimension, m^2	Speed, km/h	Power, kV	
				Set.	Maneuver.
Oil tanker «Knock Nevis» [6]	657018	458 x 68, displacement with full load 24 m	21,1	36775	36775
Tanker on the basis of modules with vortex propulsion units	630000	760 x 150, displacement with full load 20 m	33	6	5600

Table 2

Comparative characteristics of carrier platforms

Vessel	Water displacement, tons	Dimension, m^2	Speed, km/h	Power, kV	
				Set.	Maneuver.
Carriers of the «Nimitz» class [7, 8]	100000	330x75	56	194000	194000
Aircraft carrier platform based on modules with vortex propulsion units	315000	600x150	33	2,5	3200

Maneuvering of vessels with vortex propulsion units is quite simple, but it is significantly more energy-intensive than the standard mode of operation [2]. To drive the rotor (with a block of retractable shunting blades), a larger engine power is used – the drive shunting engine, when driving in steady state, ensuring internal needs, in particular, the functioning of the vessel's internal equipment.

1.2. Carrier platforms

The most important characteristic of an aircraft carrier is the size of the runway deck (runway). The runway has an area of about 330x75 m^2 (with a displacement of about 100 thousand tons) [7, 8], which dictates the need to use very complex launch catapults and landing brake systems.

Vortex sailing ships make it relatively easy to provide runways of considerably larger dimensions, for example 600x150 m^2.

For brevity, the parameter estimation was carried out for a vessel similar to that considered in the previous paragraph, but with a rotor height of 12 m at a nominal draft of 10 m, that is, a displacement three times larger (315 thousand tons). While maintaining the driving qualities of the previous type of vessel, the power consumption is lower due to the reduction in the height of the rotors.

The presented estimations testify, among other things, that surface vessels with vortex propulsion units do not have fundamental limitations on the mass-dimensional characteristics existing for traditional layout vessels of the same purpose.

Indeed, the version of the tanker arrangement (Pic. 1) fully allows for an increase in water displacement as the simplest increase in the number of sections along the longitudinal axis, and parallel docking of the second and the following groups of sections. Similarly, it is possible to increase the size of the runway of the aircraft carrier platform.

Large multisectional vessels are expediently to be assembled with the possibility of docking-undocking sections by autonomous drive motors with rigid or hinged connection of their surface parts. Undocking of super-large vessels can simplify maneuvering and passage of limited fairways.

1.3. Multimodule transformer vessel

The independence of the running qualities of vessels with vortex propulsion units from the configuration and dimensions of the superstructure entirely outside the water opens the possibility of developing vehicles that have no analogues among traditional layout ships. The variation of the configuration of the superstructure and the combination of a combination of a group of ships makes it relatively easy to construct floating means suitable for solving a variety of technical tasks on the water surface.

Pic. 2 shows the layouts of two variants of multi-purpose multi-module transformers.

Pic. 2a shows the layout of the vessels based on a specialized central module 1, a large displacement and a group of modules (≈10 pieces) of smaller sizes (vessel 2), performing auxiliary functions as being docked to the vessel 1 and in the autonomous operation mode.

In Pic. 2b there is a group of mutually analogous vessels capable of functioning both separately and in a complex, being docked into a single complex, in this case with the formation of a floating launching complex.

A necessary and sufficient condition for the implementation of the described scheme of a multimodule transformer vessel is the correspondence of two design-performance characteristics of individual modules:

- *firstly, all modules used in the combined complex mode should have options for implementing the same speed of their vortex pairs, i.e. for all modules there must be a generation mode for the vortex pair, at which the values*

$$\frac{\Gamma_i}{2\pi l_i} = \frac{\Gamma_j}{2\pi l_j},$$

where $\Gamma_i = 2\pi\omega_i a_i^2$ – circulation of the water velocity on the surface of the rotor generation, l_i – interaxial distance.

- *secondly, the superstructures of all modules (decks) must have coupling devices and rigid or hinged modules in a single complex with a common superstructure (deck).*

The optimal variant of a separate module is a vessel with a displacement of 10–20 thousand tons with a propulsion unit based on generators of two vortex pairs, i.e. four rotors with a diameter of 15–20 m with a draft of about 10 m. The shape of the deck (platform) of such a vessel is a square with a side of approximately 50 m.

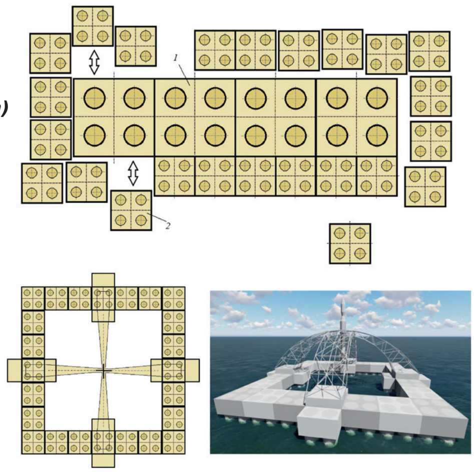
Table 3

Comparative characteristics of carrier platforms

Vessel	Water displacement, tons	Dimension, m²	Speed, km/h	Power, kV	
				Set.	Maneuver.
Of 23 modules	490000	650 x 300	33	6	4800
Of 36 modules	715000	800 x 300	33	8,9	7000
Of 56 modules	970000	950 x 450	33	12,9	9400

a)

b)



Pic. 2. Schemes for implementing the idea of multi-module vessels: a – a scheme with a central base module; b – a schematic diagram of the floating launch complex.

In the autonomous mode, such vessels can perform a number of functions in the interests of the whole complex:

- *to carry out transport communication of the complex with coastal bases;*
- *to carry out exploration of the water area (for example, fishing);*
- *to participate in actions that require synchronization in a large area.*

In Pic. 2b there is a schematic diagram of a floating starter complex of carrier rockets formed from the same type of surface vessels with one pair of vortex generators.

At the preparatory stages, individual modules of the complex can function in an autonomous mode. To start the rocket, they dock, forming a closed loop, inside which remains an open water surface. On two or four opposing modules the bracket-holder of the rocket is mounted. At the launch of a rocket, its exhaust jet acts on the open surface of the water, rather than on the vessel itself, as in the schemes currently used [9, 4].

2. A submarine vessel with a «thermal» vortex generator

Submarine vessels with vortex propulsion units have a shell shape in the form of a torus, which is fundamentally different from traditional vessels [4]. The outer shell of the toroidal body, mounted rotatably around the common axis of the torus, acts as a propulsion unit. In steady state, the shell of the propulsion unit, rotating, maintains the existence of a toroidal vortex in the medium (water or air), which creates a specific flow in the environment with a continuous distribution of the velocity of the medium. This corresponds to the constancy along the radius of the vorticity of the flow, so that there are no speed jumps in the whole flow area, including on the surface of the vessel, which causes the absence of drag associated with the high-speed head of the oncoming stream.

At the same time, the displacement of an underwater toroidal vessel with a shell radius of 10 m and a radius of the center line of 25 m:

$$V = 2\pi^2 r^2 R \cong 49 \cdot 10^3 \text{ tn},$$

where R – radius of the axial line of the torus, r – shell radius.

At different depths, a vessel of this design can develop a different maximum speed [1], which can be estimated using the following expression:

$$v_{max} = 15\sqrt{0{,}1L}\,\frac{r}{R},$$

where L – depth of the vessel sinking.

3. Toroidal airship

The layout scheme and the operating principle of the aircraft propulsion unit is practically the same as the previous one, the difference is only in the transport medium (water or air). Receiving a fundamentally new design of the propulsion unit, the toroidal airship retains the traditional design elements: a shell for placing gas lighter than air under pressure and drive motors.

The toroidal airship with a shell radius of 15 m and a radius of the center line of 40 m has a shell volume: $V \cong 180 \cdot 10^3$ m³, commensurate in magnitude with the largest ever Hindenburg airship (Table 5).

The speed of the toroidal airship at the maximum permissible linear speed of rotation of the shell initiating the vortex equal to the speed of sound in the air ($a \approx 330$ m/s) is uniquely determined by the ratio of the radii of the shell r and the center line R:

$$v_{max} = ka\frac{r}{R},$$

Table 4

Comparative characteristics of submarine vessels

Vessel	Water displacement, tons	Depth, m	Speed, km/h	Power, kV	
				Set.	Maneuver.
Submarine «Shark» [10]	48000	500	46,3	73550	73550
Submarine vessel with a «thermal» vortex generator	49000	100	160	150	600
		300	280	400	1500
		500	360	650	2500

Table 5

Comparative characteristics of airships

Vessel	Volume, m^3	Max. flight altitude, m	Speed, km/h	Power, kV	
				Set.	Maneuver.
Airship «Hindenburg» [11]	190000	1000	130	3200	3200
Toroidal airship	180000	1000	315	850	4000

where k – a coefficient less than unity, taking into account the linear velocity inequality for the shell surface and the speed of the adjacent air layer, which determines the vorticity of the initiated vortex Γ.

The power required for motion in steady-state mode is proportional to the product of r and R, and the shell volume is proportional to the product of r^2 and R. Therefore, with the power required for the steady motion of the toroidal airship equal to the power of the «Hindenburg» airship drive engines, the shell of the rotary airship may have a volume 8 times greater than that given in Table 5, i.e. $\approx 1,4 \cdot 10^6$ m^3.

Conclusions.

1. The analysis of layout schemes and calculation and theoretical estimates of the ranges of operational parameters of water and air (dirigibles) of ships with vortex propulsion units are performed. Areas of shipbuilding are determined, where the advantages of vessels with vortex propulsion units in comparison with the vessels of the traditional «hull – propulsion unit» configuration are most significant.

2. The possibility of creating on the basis of an ensemble of identical modules (sections) with two generators of vortex pairs of water craft of a fundamentally new class – multipurpose floating complexes with an almost unlimited period of autonomous functioning in an arbitrary non-freezing water area of the World Ocean (such as a floating starter complex of space launch vehicles, autonomous fishery and fish processing plant, oceanographic research complex, distributed (multiposition) radar and astrophysical complexes et al.).

3. With regard to the vessels of the existing classes, it is established that for all parameters, except speed, vessels with vortex propulsion units have advantages over vessels of the traditional separate «hull – propulsion unit» configuration, namely:

• surface vessels with vortex propulsion units are absolutely stable, since in the design configuration and loading their center of gravity is below the waterline and, in addition, their horizontal dimensions exceed (sometimes several times) their vertical dimensions, which in principle excludes their tilting or flipping (overquile);

• since the running qualities of vessels with vortex propulsion units are determined only by the parameters of the vortex pair generators, their above-water part (superstructure) allows an arbitrary arrangement in a wide range of mass-dimensional characteristics, opens the possibility of building vessels of known classes with parameters significantly exceeding the parameters of existing ones;

• with comparable weight and size characteristics, vessels with vortex propulsion units in steady state consume power 7–9 orders of magnitude less than traditional layout vessels;

• toroidal underwater vessels with vortex propulsion units in the form of a rotating outer shell have a lower noise level in comparison with traditional submarines, at greater depths at an appreciable depth, which increases in proportion to the square root of the depth.

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