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SUMMARIES

M.P. Lobachev, N.A. Ovchinnikov, A.V. Pustoshny. **Numerical Modeling of Propeller Operation in Non-Uniform Flow.** Pp. 5–10.

Key words: non-uniform velocity pattern, propeller, reynolds equations.

The paper considers two approaches to numerical modeling of propeller operation in non-uniform flow. In the first case non-uniform field is specified at a certain distance in front of propeller, which is based on the data on measurement of nominal velocity field in propeller disk obtained through experiment. In the second case the full task is considered i.e. combined streamlining of ship hull and operating propeller. In both cases one solves Reynolds' equations closed by non-linear k–ε turbulence model.

The paper shows that the first approach is incorrect and its obtaining with right result is impossible. At this approach results agree with obtained in experiment for considered object via integral characteristics and with usually obtained results for velocity field after the propeller.

L.A. Mukhina. **Computation Method for Periodic Pressures' Resultant at Interaction of Propeller with Ship Hull.** Pp. 11–16.

Key words: propeller, ship hull, induced speeds, pulse of surface pressure.

Based on method of linear vertical lifting surface the paper presents computation of pressure pulse induced by propeller operating in non-homogeneous flow after the ship hull as a sum of pressures from propulsor itself and hull surface which is approximated by potential of simple layer. Computation in homogeneous flow has shown that coefficient of influence of plate to resultant of pressures corresponds to the theory and propeller computation.

E.Ya. Semionicheva, D.S. Semionicheva. **Method for Selection of Optimum Wing Shapes and Blade Mechanisms.** Pp. 17–30.

Key words: propeller blades profiles, wings, lifting surface, cavitation, lifting force, nonstationarity, non-uniformity of incoming flow.

The paper considers nowadays topical blades' shapes widely applied in different technical applications. In shipbuilding in particular they are used in propellers, water jet impellers, pump working impellers, turbines, rudders, hydrofoils, etc.

Most justified and efficient solution for shape selection is application of numerical design software, enabling optimum shape depending on purpose for each particular case.

The paper presents results of application of developed method for numerical design of shapes and features of its results' application for most widely met applications in shipbuilding industry. The two different approaches are considered in the paper: production of a common shape or a series of shapes.

Specific operation modes of bearing surfaces in very non-stationary, non-uniform and detaching flows are given much attention. The paper presents new technical solution for such flows – shapes with the fixed detachment zone in the area of trailing edge. The paper considers some analytical aspects of this issue and discusses experimental results obtained for new kinds of shapes.

V.A. Bushkovsky. **Estimation of Non-stationary Forces on Propeller Operating in Turbulent Incoming Flow.** Pp. 31–42.

Key words: propeller, non-periodic forces, turbulent flow, range of forces.

The paper presents computation method for spectrum of non-stationary forces on propeller induced by flow turbulence. Turbulence model is homogeneous isotropic. The paper investigates the influence of flow parameters, main propeller properties and conditions of its operation on spectral characteristics of non-stationary forces.

Computation lay-out given in the paper reflects common laws of formation of propeller non-periodic forces. The paper considers the influence of existence of hull appendages before

the propeller contributing to splitting of large scale vortex structures and changing of flow turbulence degree which sets divergence between computation in the real flow and experiment at frequencies different from blade frequency.

A.Yu. Yakovlev. **Class Library for Development of Methods of Computation of Hydrodynamic Characteristics of Complex Propulsors.** Pp. 43–54.

Key words: programming, mathematic simulation, computation methods, propulsors, azimuthing pods, co-axial propellers, ducted propellers.

The paper presents class library enabling development of ship propulsor computation methods. The paper gives a brief introduction into features of object-oriented programming and gives definitions for class and library class notions. The paper describes most important classes of the developed library. In particular, it shows features of operation of classes modeling certain propulsor elements and hierarchy of such classes. The library was used for development of computation methods of following types of complex propulsors: azimuthing pods, coaxial propellers, propulsors of the kind «azimuthing pod coaxial behind the propeller» and ducted propulsors. For all the types of propulsors computation examples are given.

I.V. Tkachenko. **Simulation of Streamlining of Maneuvering Body Basing on Large Vortex Method.** Pp. 55–66.

Key words: maneuvering, non-inertial coordinate system, large vortex method.

Flow of viscous liquid around hulls of surface and submersible marine objects, as a rule, has a complex three-dimensional nature and is non-stationary. Nonstationarity of hydrodynamic processes is dictated by: (1) streamlining features and (2) body motion mode. This paper on the basis of Large Vortex Method (LES) investigates a rotating ellipsoid streamlining with axes ratio 6:1, located under static angles of attack to incoming flow at changing the trim angle.

Liquid motion is considered in non-inertial body-related coordinate system, which enables hydrodynamics investigation of object freely non-stationarily moving (maneuvering) in boundless liquid. Turbulent characteristics are simulated in the frame of Smagorinsky model with near wall region. Selection of LES approach is dictated by its ability to describe liquid flows with high degree of non-stationarity. Numerical computations of ellipsoid streamlining were completed using *FlowFES* finite-elements code, developed in Saint-Petersburg Marine Technical College for the purpose of investigation of ship hydrodynamics by means of supercomputer systems. They enabled determination of angles of vortexes detachment from body surface, coefficients of normal force and trim moment. The paper shows that Large Vortex Method more precisely predicts location of flow detachment points on the ellipsoid surface and simulates non-stationary effects and forces better than conventional Reynolds models (URANS methods).

A.S. Vorobiyov. **Computation of Tip and Lifting Vortexes of Wing with Its Flange Supported by a Surface.** Pp. 67–82.

Key words: Viscous liquid, lifting vortex, tip vortex, vortex structures, wing, DARPA, turbulence model, wall-adjacent functions, viscosity.

At wing streamlining there are vortex structures formed in the flow governing the flow downwards. In particular, among the vortex structures formed in the flow at wing streamlining one can distinguish: tip vortex structure and vortex structure of lifting vortex.

Tip vortex structure and vortex structure of lifting vortex are present in the flow near surface of streamlined objects under flow conditions both in laminar and turbulent ones. Here, the speed of incoming flow and consequently Reynolds number values affect only intensity and length of vortex tubes down the flow.

Accounting for existence of vortex structures in the flow is important for design of surface ships and submarines appendages shapes, as these structures can dramatically influence flow nonhomogeneity in propeller disk and, as a consequence, ship noise and dynamics. Vortex influence estimation can be obtained based on analysis of hydrodynamic velocity fields in planes orthogonal to direction of incoming flow, hydrodynamic helicity and vorticity.

The paper considers two tasks. The first one – numerical simulation of flow of viscous incompressible liquid near surface of wing with its flange supported by a surface at characteristic Reynolds numbers Re = 106 – 108. The second numerical modeling of flow of viscous liquid close to surface of wing with finite span with NACA-0015 profile at characteristic Reynolds numbers Re = 105 – 106. The paper shows that modified turbulence models, similar to realized high-Reynolds $k - \varepsilon$ turbulence model combined with modified near-wall functions – with detailed computational grid – enable obtaining numerical simulation results for streamlining of three-dimensional bodies of relatively complicated geometry, outlining features of the flow like lifting and tip vortexes no worse than method of large vortex modeling (LES).

G.I. Kanevsky, S.N. Kruglova. **Computation Method for Hydrostatic Curves of Multi-Hull Surface Ships.** Pp. 83–94.

Key words: multi-hull ships, static elements, computation.

Computation of hydrostatic curves of surface ship hull is a classical problem of ship theory. Bulkiness of computations implies application of computers. Existing software package «Project-1» enables computation for multi-hull ships, however its realization is hindered. Due to all this it is required to develop an algorithm and a program for computation of hydrostatic curves of surface ships. This paper presents a method enabling computation of hydrostatic curves of multi-hull surface displacement ships. It is assumed that a system including a central hull and outriggers is symmetrical relative to center plane of central hull. Task solution assumes bulbous shapes in the bow area and transom in the stern. When setting outrigger coordinates non-symmetry relative to its central plane is assumed. Acceptable shape of stem-post and stern-post of outrigger is the same as for the central hull. This paper approximates hull sections through straight line segments. And the stem-post and the stern-post turn into zigzag lines and bulkhead sections – into polyhedra. The assumed simplification contributes to easier solving of task of ship geometry computation and decrease in length of straight line segments enables obtaining an answer of required accuracy. Basic plane geometry relations are used for problem solution.

The task of hydrostatic curves computation is solved in two stages. At the first stage hydrostatic curves of the central hull are computed. At the second stage hydrostatic curves of the outriggers and the system as a whole are computed.

The results of the completed work let us make the following conclusions:

- The method enabling computation of hydrostatic curves of multi-hull surface displacement with obtaining an answer of any required accuracy has been developed.
- The method is designed for computation of trimaran hydrostatic curves, consisting of central hull and outriggers.
- First computation stage presumes estimation of hydrostatic curves of the central hull, the second – hydrostatic curves of the outriggers and the system as a whole.
- For computation of catamaran hydrostatic curves values of hydrostatic curves of the central hull are assumed equal to zero.
- For computation of pentamaran hydrostatic curves values of trimaran hydrostatic curves are assumed to be curves of the central hull.

V.V. Klichko, E.Ya. Semionicheva, E.A. Kolosova. **Numerical Methods for Determination of Skirt Shape Parameters for Air-Cushioned Amphibious Ships.** Pp. 95–110.

Key words: air-cushioned amphibious ships, lifting system, design, parameters, guidelines, numerical methods, system of automatic design, program module.

The paper discusses issues of design of air-cushioned amphibious ships (ACV) lifting system.

The paper lists main principles of numerical methods for determination of elastic guards' shape parameters for amphibious ACV, gives the lay-out of splitting of full shape parameters computation into a series of computational algorithms for separate parts of elastic guard under condition of fulfillment of limiting conditions on the sides of these parts. The paper is focused on the design of dismountable element (finger) of skirt lowest tier. The paper offers guidelines for computation and construction proceedings when determining its geometry and describes numerical method for realization of these guidelines. The paper gives brief description of software module for geometry determination of dismountable element produced within the frame of ACV skirt automatic design system.

V.K. Dyachenko, N.V. Dyachenko. **Guidelines for Computation of Spray Cloud around Amphibious Air-Cushioned Ship Hovering above Water Surface.** Pp. 111–122.

Key words: slope of air-cushion cavity, amount of water in the cloud, dispersion of water in a cloud, water distribution according to drops radii.

Sea water spray cloud rising around AACV at stop produces a number of problems hindering ship operation. In order to enhance AACV protection means it's important to know amount of water and spray cloud structure at different heights above water level. In this paper parameters characterizing the spray cloud are following: most probable radius of water drops in the spray cloud around AACV, mean-square deviation of drops' radii from this value, amount of water in the cloud.

Observation of air outflow from AC done by means of speed video recording, shows two stages of spray cloud formation: formation of non-stationary waves on the slope of AC cavity, their amplitude quickly grows which leads to destruction of waves and appearance of large amount of drops – spray, the formed drops are carried by the air stream with acceleration and exhaust of water-air stream into atmosphere from AC area. The guidelines for computation of cloud parameters includes following stages:

1. Computation of speeds of drops of different diameter w and air speed V at the exhaust to atmosphere using the law of momentum.
2. Computation of degree of dispersion for water carried at initial time – on the level of sea surface and at different heights above water level. On the level of non-excited sea surface normal law of drops distribution according to their radii. Above the water level this law is being transformed with account of bigger drops fall at small heights.
3. Computation of water amount at different heights above water level is done based on the formulae, coinciding in its structure with well-known Rozin-Rammler formula enabling computation of water amount contained in drops with radius smaller than the specified value.

Computation results are intended for design of water-separating systems for cleaning of air supplied to main ship engines, for development of erosion protection for leading edges of air propeller blades and shoulder blades of superchargers, for enhancement of visibility from ship pilot house.

V.N. Anosov, N.V.Dyachenko. **Computation of Water Amount Carried to Atmosphere by Air Flow from Air Cushion.** Pp. 123–134.

Key words: air-cushion, air jet, water spray formation, amount of water, drop radius.

Sea water spray cloud rising around ACV at low speeds is one of problems hindering ship operation. Data on size and structure of spray cloud are important for development and advance of means of ACV protection from marine water-induced decay. It's quite a problem to determine the amount of water and the structure of water cloud risen by ACV in full-scale conditions, purely analytical computation is also impossible as there are no a priori data on the nature of spray formation process. This paper presents computation method for estimation of amount of water q^*_m, carried into the atmosphere by an air flow from the air cushion, based on data of small-scale models tests.

For measurement of amounts of water grasped by an air flow, the authors developed experimental facilities imitating the process of air outflow grasping water drops from air-cushion region.

Experimental data of measurement of amounts of water q^*_m, carried by the flow from the air-cushion are processed with accordance to methods of law of similarity and scaling and presented in form of relationships with dimensionless parameter U, enabling unambiguous writing of the relationship $q^*_m(U)$ both for full-scale ships and small-scale models for different slope angles to horizon δ of skirt fingers, for deep water and shallow waters. The physical meaning of suggested parameter U is that on one hand it accounts for waves' rise intensity at the slope of AC cavity, during destruction of these waves there appears a cloud of water atomized into drops, and, on the other hand it characterizes momentum, imparted to these drops by the air jet. For the purpose of practical computations experiment results were processed using least-squares method, which enabled describing them through empirical formula $q^*_m(U)$, with which basing on results of model experiment one can predict amount of water q_m grasped by an air jet in full-scale conditions.

S.O. Rozhdestvensky, V.N. Anosov, T.A. Dyakova, A.B. Lukashevich. **Computation of Aerodynamic Characteristics of Full-Scale Ram Wing Surface Effect Ship in Calm Water and Waves with account of Wind and Aerodynamic Scale Effects.** Pp. 135–148.

Key words: fast ships, wing surface effect ship, aerohydrodynamic characteristics.

The paper commenting on the ram wing surface effect ship (SES) presents the new method for estimation of hydrodynamic characteristics of fast ship lifting system of which includes elements subject to dramatic aerodynamic impact comparable with hydrodynamic one. The said method is based on computation employing results of model experiment in the test tank and the wind tunnel. Unlike conventional method involving model tests in the test tank behind the wind shield (for hydrodynamic forces estimation) it implies free towing throughout all the considered speed range both without contacting water and decreased weight, and with full weight when both aerodynamic and hydrodynamic forces are applied.

The selected test type enables distinguishing of only aerodynamic forces applied to models in the test tank. These forces, due to the influence of scale effect, significantly differ from those computed using wind tunnel tests data. Hydrodynamic forces are computed after subtraction from forces obtained at full weight loading. Aerodynamic forces for full-scale are determined according to data of dummy-model tests in the wind tunnel at beyond-critical Reynolds numbers. Aero and hydrodynamic characteristics of full-scale ship moving in calm water including with account of wind are computed basing on obtained experimental data from solving equilibrium equations using method of Newton's approximation method. Data obtained using conventional and newly developed methods are compared. The paper also presents the method for estimation of aero and hydrodynamic characteristics of full-scale ship in waves applying computational lay-out for calm-water. All the main principles of the methods are illustrated with drawings, graphs and tables.

D.S. Semionichev. **Practical Points of First Stage of Formal Safety Estimation in Shipbuilding: Methods of Analysis of Risks and Danger.** Pp. 149–158.

Key words: shipbuilding, formal safety estimation, failure tree, danger identification and assessment, modeling, distribution, variation coefficient, forecasting, resource.

One of the ways to increase efficiency of ship operation is enhancing ship equipment and machines quality and safety, as well as advance of practical methods for investigation into propulsion system. With the purpose to decrease probability of unexpected failures during operation different estimation and reliability prediction methods are applied. The guidelines for formal safety estimation is one of them. The paper considers method for analysis of failure tree at identification and estimation of dangers at the first stage of formal safety estimation. The paper offers recommendations concerning selection of probability distribution laws for reliable operation of parts and boundaries of their application for different types of failures.

A.Sh. Achkinadze. **Optimum condition for «hull – propulsor» complex in viscous fluid and upper limit of the propulsive coefficient.** Pp. 159–170.

Key words: hull – propulsor complex, resistance of bare hull, propulsor thrust, total thrust of complex, consumed power, optimum condition, propulsive coefficient, axisymmetric body, field of relative velocity, hydrodynamic wake.

The article contains two parts: analytical and calculations. The analytical part presents optimum condition for «hull-propulsor» complex that moves evenly and rectilinearly in the

infinite incompressible viscous fluid. Obtained theorem demonstrates that upper limit of the propulsive coefficient is equal to one in all cases of self-propulsion or presence of the external axial force that affect vessel or its model. Three derived relations are extended from the obtained theorem; one of them contains estimation of the propulsive coefficient upper limit, which, for example, is equal to one in case of self-propelled complex. The calculation part of the article is devoted to analysis of turbulent flow for viscous fluid near the revolution body that has active disc located at stern. An unexpected result is obtained that demonstrates that change in law of pressure jump distribution over disc surface does not lead to any significant variation of the propulsive coefficient value.

A.N. Suslov, V.I. Serov, V.I. Menshikov. **Methods to increase reliability of navigational data at integration of active and passive radio detection systems.** Pp. 171–176.

Key words: integrated detection systems, infrared radar, navigation watch, reliability of navigational data.

The necessity to improve navigation safety maintenance techniques in the time of both development of hydrocarbon reserves and intensification of overseas traffic in World ocean water area requires enhancement of navigation information support that is ensured by both accurate management and by improvement of navigation safety systems. Infrared radars along with ship navigation radars, i.e. combination of these systems into ship integrated radio detection system (IDS) installed onboard fleet ships is a challenging trend in this area.

IDS application onboard the ships enables enhancing navigation safety due to the increase of tracking speed and advanced detectability as compared to the presently used active navigation radars. At the same time IDS advanced performance is accompanied by significant increase of navigation watch efficiency since during tracking navigation officer gets possibility to control reliability of data obtained from data display device of radar system due to certain redundancy which level is increased when radar observation conditions are impaired.

Thus, when implementing IDS onboard fleet ships it is possible to minimize commands from variety of «dangerous non-system management» and significantly decrease probability of consistency loss in navigation watch and ship control system as a whole.

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