

## Transactions of the Krylov Shipbuilding Research Institute

**6, 2011**  
**65(349)**

### CONTENTS

V. Alferov, G. Kryzhevich, L. Podgorny, N. Popov, V. Shaposhnikov. **Transporting super modules of Polyarnaya Zvezda drilling unit and assembling them at sea.** Pp. 5–16.

G. Kryzhevich, M. Tyalo. **Reducing external forces acting on the hull structures of high-speed vessel: experimental study.** Pp. 17–26.

A. Nesterov. **Specifying emergency scenarios and analyzing emergency strength of advanced LNG carriers with various containment systems.** Pp. 27–36.

V. Ryabov. **Stability of shells with broken generatrices. Part I. Conditions of bending and buckling without middle surface straining (geometric instability conditions). Approximate solution for general case.** Pp. 37–52.

G. Efremova, I. Saraeva. **Stability of shells with broken generatrices. Part II. Numerical experiment and determination of main buckling loss for shells with broken generatrices.** Pp. 53–76.

A. Alexandrov. **Numerical calculation of structural ship stability.** Pp. 77–84.

A. Gaina. **Approaches to development of a new model of hull-ice interaction.** Pp. 85–94.

A. Golovkin, A. Nesterov. **Implications of new model of hull interaction with ice for ice loads: analytical research.** Pp. 95–102.

E. Vasilik. **Numerical simulation of ship flooring failures during contact interactions.** Pp. 103–114.

M. Ivanov. **Structural vibrations in the stern of a fast-going vessel.** Pp. 115–120.

A. Ravin, Yu. Myasnikov. **Specifics of applying discrete-phase method in vibration monitoring of naval gas turbine compressor blades.** Pp. 121–130.

Yu. Myasnikov, A. Ravin. **Assessing residual lifetime of bellow compensator.** Pp. 131–142.

## SUMMARIES

V. Alferov, G. Kryzhevich, L. Podgorny, N. Popov, V. Shaposhnikov. **Transporting super modules of Polyarnaya Zvezda drilling unit and assembling them at sea.** Pp. 5–16.

**Key words:** marine structures, semi-submersible drilling units, structure, strength.

The paper briefly describes main technical solutions adopted when developing the project of sea transportation for lower bases and topsides of Polyarnaya zvezda and Severnoe Siyanie semi-submersible drilling units and the technologies applied for their assembling at sea. It provides the results of analytical studies regarding strength and stiffness of the Platform's structures (including docking units) and describes the devices which ensured successful transportation and fixation of the super modules.

G. Kryzhevich, M. Tyalo. **Reducing external forces acting on the hull structures of high-speed vessel: experimental study.** Pp. 17–26.

**Key words:** strength of high-speed vessels, external forces, stabilizers, reduction of loads on hull.

The paper describes the test results obtained for four variants of mono-hull high-speed vessel (with one, two, three couples of motions stabilizers and without stabilizers) running in head regular waves. The model tests in the seakeeping tank detected the effect of passive motions stabilizers on bending moments in transverse hull sections, on motions amplitudes and vertical accelerations at the ends of the model as well as effects of stabilizers on mean additional drag in regular waves. It also assesses how arrangement of stabilizers affects their efficiency in reduction of motions, bending moments and additional drag.

A. Nesterov. **Specifying emergency scenarios and analyzing emergency strength of advanced LNG carriers with various containment systems.** Pp. 27–36.

**Key words:** LNG carriers, emergency strength, comparative analysis, specifying scenarios.

The paper tackles the problem of specifying emergency scenarios and performing comparative emergency strength analysis for advanced LNG carriers. It shows that to compare emergency strength of LNG carriers with different types of cargo tanks, two main emergency scenarios are of interest: collision with another vessel and grounding onto a rock. The main parameter of security in case of rock grounding is rock penetration depth which determines whether cargo tanks are pierced or not. The paper formulates an integral criterion of security in case of rock grounding and provides calculation algorithms for these values with respect to main types of containment systems. The paper also provides comparative analytical security analysis for the LNG carriers with capacity of 155, 000 m<sup>3</sup> and design cargo density of 0.49 t/m<sup>3</sup>. It was found that membrane containment systems are most vulnerable in both cases (rock grounding and vessel ramming), SPB-type containment system being only slightly more secure, whereas security of the LNG carriers with MOSS-type containment system have the highest security as compared to LNG carriers of other types.

V. Ryabov. **Stability of shells with broken generatrices. Part I. Conditions of bending and buckling without middle surface straining (geometric instability conditions). Approximate solution for general case.** Pp. 37–52.

**Key words:** shells with broken generatrices, external break, internal brake, shell stability, buckling with middle surface straining, geometric instability.

The paper investigates stability of cylindrical and conical shells joined at some angle towards each other.

The paper covers three theoretical problems.

1. It defines bending conditions for a compound shell with broken generatrix without middle surface straining. Basing on the article written by V. Vlasov, it provides general solution. For the cases of shells with one and two breaks it is brought to simple calculation formulas.

2. It shows that solution obtained in Problem 1 is strongly related to the buckling problem of a shell as a system of isolated rings, if the following conditions are met:

$$J \cos^3 \gamma / (r^3 \ell) = \text{const};$$

$$t \cos \gamma / r = \text{const},$$

where  $\gamma$  – conicity angle of the shell part under investigation;  $J$ ,  $t$ ,  $\ell$  – frame inertia moment, spacing thickness and spacing length respectively.

3. It shows that there is an analogy between the stabilities of broken and «nearly cylindrical» shells with constant negative curvature.

Basing on the solutions obtained in Problems 1-3, the paper suggests an approximate solution (for general case) which allows assessing stability of axially symmetric shells with breaks.

**G. Efremova, I. Saraeva. Stability of shells with broken generatrices. Part II. Numerical experiment and determination of main buckling loss for shells with broken generatrices. Pp. 53–76.**

**Key words:** shells with broken generatrices, external break, internal break, stability of shells, buckling without mid-surface straining, geometric variability, asymmetric cones with circular frames, multi-compartment shells.

This paper completes Prof. V. Ryabov's article dedicated to studying cylindrical and conical shells assembled at some angle to each other. It provides and analyses calculation results obtained for a large number of shells with one and two breaks of generatrix.

The calculations confirmed Prof. V. Ryabov's conclusion on drastic stability decrease of the shells under investigations at certain ratios between break radius ( $r_n$ ) and «expanded» shell radius at the same section ( $r_c$ ) and at certain buckling wave numbers.

The paper estimates the applicability of suggested approximate methods of assessing stability of shells with «internal» breaks in general case as well as assessing the influence of neighbouring compartments and of cone asymmetry.

The paper also contains the conclusions which cover both results of this study and above mentioned Prof. Ryabov's research. The most interesting conclusions are as follows:

1. Approximate solution suggested by Prof. Ryabov and generalizing Academician Novozhilov's formula for the case of broken shells allows proper assessment of break influence.
2. In general case, break influence is mainly determined by  $r_n / r_c$  ratio.
3. Even minor breaks ( $5^\circ$  and less) might significantly decrease overall shell stability.
4. It is not practicable to design the frames observing  $J / (r^3 \ell) = \text{const}$  relationship.

The last two conclusions are of great importance for design practice. The researches on the influence of neighbouring compartments and asymmetry of cones, as well as on consideration of reinforced frame near the break allow obtaining good description of these phenomena and may serve as basis for further studies.

**A. Alexandrov. Numerical calculation of structural ship stability. Pp. 77–84.**

**Key words:** stability, FEM-analysis, critical stresses.

The paper provides an algorithm for solving the stability problem of ship floorings and plates considering non-linearity of material properties. Critical stresses are found by means

of step-by-step approximation together with FEM-analysis for solving a number of problems regarding linear buckling. The paper analyses the results of trial calculations regarding non-linear stability of floorings and plates under combined load.

**A. Gaina. Approaches to development of a new model of hull-ice interaction.** Pp. 85–94.

**Key words:** ice strength, ship interaction with ice, updated model.

Current hydrodynamic model (HDM) of ship collision with ice has some deviations from physical picture of ice pressure development along the contact area. Analytical HDM relationships confirmed by integral experimental results have shown smooth pressure distribution, whereas analysis of modern domestic and foreign experimental data (both laboratory and full-scale) shows that pressure distribution has clear peaks. The development of new updated model is aimed at eliminating the contradiction between analytical and experimental data. According to the model suggested, the pressures are maximum at the centre of contact area where intermediate layer is absent, and they decrease as intermediate layer thickness grows. Solution of differential HDM equations provides analytical relationships for ice pressure, load per unit length, shape and size of ice load curve. The processing results for published experimental data allowed making conclusions on maximum pressures and width of direct ice contact area which can be used in analytical analysis for specifying parameters of a new model.

**A. Golovkin, A. Nesterov. Implications of new model of hull interaction with ice for ice loads: analytical research.** Pp. 95–102.

**Key words:** ice loads, new model, variable parameters, analytical analysis.

The paper examines a new model of hull interaction with ice. This model is based on the assumption that ice pressure is maximum in the center of the area where the hull contacts with ice (direct contact zone) and decreases in the neighbouring areas. Physically, it is evident that ice pressure beyond the direct contact zone is not higher than within it. Mathematically, this fact is described by a condition of pressure derivative not exceeding zero by transverse coordinate. This paper provides analytical analysis of implications of such updated model with respect to ice loads and compares them with ice loads for ships of Arc7, Arc5, Ice3 ice classes specified in current RMRS regulations. Maximum ice pressure and relative width of direct contact zone are specified with consideration of experimental data available. It is assumed that maximum ice pressure is determined by ice class because the ships of higher ice classes are supposed to interact with ice of higher strength.

The researches have provided the parameters for a new model of hull interaction with ice. These parameters make it possible to practically determine ice loads on the hulls of various ice classes.

**E. Vasilik. Numerical simulation of ship flooring failures during contact interactions.** Pp. 103–114.

**Key words:** structural failure, ship collision, FEM- method, computer simulation.

Nowadays, finite-element method (FEM-method) is widely used in solving ship collision problems because it allows accurate considerations of colliding ships geometries, sufficiently precise simulation of collision itself and assessment of character and scope of damage for structures located in the collision area. This paper provides FEM-based numerical analysis for straining and failures of ship floorings during dynamic interactions. The calculations serve as basis for assessing the capabilities of numerical methods with respect to solving ship collision problems and predicting damage scope by comparing analytical and experimental data. Good correlation

between analytical and experimental data means that computer simulation results obtained for ship structure failures during emergencies are highly reliable.

M. Ivanov. **Structural vibrations in the stern of a fast-going vessel.** Pp. 115–120.

**Key words:** forced vibration, free vibrations, bar, shaft, propeller, stern.

The paper provides calculation results for vibrations of shaft-propeller-bracket (SPB) system and gives qualitative assessment to influence of this system on forced vibration of stern. The problem was solved in ANSYS software package by means of FEM-analysis. The following structures were investigated: isolated bracket without consideration of shaft and propeller, isolated SPB system; stern end with consideration of external fluid and SPB system; stern with consideration of external fluid and without consideration of SPB system.

A. Ravin, Yu. Myasnikov. **Specifics of applying discrete-phase method in vibration monitoring of naval gas turbine compressor blades.** Pp. 121–130.

**Key words:** discrete-phase method, naval gas turbines, vibration monitoring, blades.

The paper investigates the impact of rotor speed, asymmetry and multiplicity of vibrations on accuracy of non-contact vibration amplitude measurements of axial compressor blades.

Yu. Myasnikov, A. Ravin. **Assessing residual lifetime of bellow compensator.** Pp. 131–142.

**Key words:** residual lifetime, bellow compensator, lifetime expiry monitor.

The paper describes monitoring of bellow compensators by means of registering operational loadings and assessing the extent of design lifetime expiry. It also suggests a variant of hardware structure for such monitor.

## INFORMATION ABOUT AUTHORS

*Alexandrov, Anatoly V.*, Cand. of Tech. Sc., senior research fellow of KSRI; (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Alferov, Valentin I.*, Cand. of Tech. Sc., senior research fellow of KSRI (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Vasilik, Yevgenia G.*, engineer of KSRI (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Gaina, Alexander A.*, 2<sup>nd</sup> rank engineer, KSRI; (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Golovkin, Andrey A.*, 2<sup>nd</sup> rank engineer, KSRI; (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Efremova, Galina I.*, research fellow, KSRI; (812) 723-66-10; e-mail: krylov@krylov.spb.ru

*Ivanov, Mikhail A.*, engineer, KSRI; +7-904-334-47-31; e-mail: krylov@krylov.spb.ru

*Kryzhevich, Gennady B.*, Dr/ of Tech. Sc., Head of Sector, KSRI; (812) 415-66-744; e-mail: krylov@krylov.spb.ru

*Myasnikov, Yury N.*, Dr of Tech. Sc., Prof., principal research fellow, KSRI; (812) 415-69-57; e-mail: krylov@krylov.spb.ru

*Nesterov, Alexandr B.*, Cand. of Tech. Sc., Head of Sector, KSRI; (812) 415-67-54; e-mail: krylov@krylov.spb.ru

*Podgorny, Lev N.*, leading engineer, KSRI; (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Popov, Nikolay G.*, senior research fellow, KSRI; (812) 415-65-73; e-mail: krylov@krylov.spb.ru

*Ravin, Alexandr A.*, Cand. of Tech. Sc., Prof., Ship Automatics and Instrumentation Department, St. Petersburg State University of Marine Technology, address: 3 Lotsmanskaya st., St. Petersburg, Russia, post code 190008; 8-921-975-71-71; e-mail: ravinlki@mail.ru

*Ryabov, Vitaly M.*, Dr. of Tech. Sc., principal research fellow, KSRI; (812) 723-66-10; e-mail: krylov@krylov.spb.ru

*Saraeva, Irina A.*, research fellow, KSRI; (812) 723-66-10; e-mail: krylov@krylov.spb.ru

*Tyalo, Mikhail V.*, 2<sup>nd</sup> rank engineer, KSRI; 8-950-048-38-82; e-mail: krylov@krylov.spb.ru

*Shaposhnikov, Valery M.*, Cand. of Tech. Sc., Head of Laboratory, engineer, KSRI; (812) 415-65-52; e-mail: krylov@krylov.spb.ru