International Economic Institute s.r.o. (Jesenice, Czech Republic)
Central European Education Institute (Bratislava, Slovakia)
National Institute for Economic Research (Batumi, Georgia)
Al-Farabi Kazakh National University (Kazakhstan)
Institute of Philosophy and Sociology of Azerbaijan National Academy of Sciences (Baku, Azerbaijan)
Batumi Navigation Teaching University (Batumi, Georgia)
Regional Academy of Management (Kazakhstan)
Ukrainian Assembly of Doctors of Sciences in Public Administration (Kyiv, Ukraine)
Association of Scientists of Ukraine (Kyiv, Ukraine)
University of New Technologies (Kyiv, Ukraine)
Interstate Consultants Engineers Guild (Kyiv, Ukraine)
Institute of Education of the Republic of Azerbaijan (Baku, Azerbaijan)

within the Publishing Group "Scientific Perspectives"

MODERN ASPECTS OF MODERNIZATION OF SCIENCE: STATUS, PROBLEMS, DEVELOPMENT TRENDS

Materials of the 48th International Scientific and Practical Conference
September 7, 2024, Constanta (Romania)

2024

Smetankina N.
Doctor of Technical Sciences,
Head of Department of Vibration and
Thermostability Studies,
Anatolii Pidhornyi Institute of Power
Machines and Systems of the National
Academy of Sciences of Ukraine
Kharkiv, Ukraine

Misiura S.
Candidate of Technical Sciences,
Associate Professor of Department of
Mathematical Modeling and Intelligent
Computing in Engineering,
National Technical University
«Kharkiv Polytechnic Institute»
Kharkiv, Ukraine

Misiura Ie.
Candidate of Technical Sciences,
Associate Professor of Department of
Economic and Mathematical Modelling,
Simon Kuznets Kharkiv National
University of Economics,
Kharkiv, Ukraine

MATHEMATICAL MODELING OF THERMOELASTIC DEFORMATION OF MULTILAYER SHELLS

The joint work of heterogeneous materials gives an effect equivalent to the creation of a new material, the properties of which differ from those of each of its components [1–3]. If the properties of heterogeneous layers depend on temperature, a package symmetrical in its physical and geometrical characteristics becomes asymmetrical with respect to the median surface under the influence of a temperature field inhomogeneous in thickness [4–6]. It is necessary to take into account transverse shears, since in a shell with low shear stiffness, in many cases the shear modulus decreases more significantly with increasing temperature than Young's modulus [7–9].

In a real structure, the displacement and temperature fields are interrelated, which requires the joint solution of the heat conduction and motion equations [10–12]. However, the influence of the effect of thermomechanical interaction for metals is small, about 2.5 %, so with sufficient accuracy for engineering calculations it is possible to solve the unrelated problem, first determining the temperature field and then the stress-strain state [13–15]. There are not enough publications devoted to the problems of thermal stability of composite shells according to the refined theories. Therefore, the problem of investigating the influence of temperature effects on the value of the ultimate load in calculations of composite shells by refined theories is urgent.

In this study the efficiency of application of various refined mathematical models in the stability problems of multilayer shells is investigated. Conservative difference schemes for boundary value problems within the Timoshenko-type model are constructed using the variational-difference method on the basis of the basic variational equations of the theory of hollow shells. A method of difference approximation of odd-order differential operators arising in the theory of multilayer shells with asymmetric layer packet is developed.

The problems of static stability of multilayer orthotropic shells of an arbitrary package of layers with the temperature field on the basis of different refined shell theories for different curvatures, number of layers and physical and geometrical parameters of the layers are solved on the basis of the conducted studies. The peculiarities of application of the method in stability calculations of shells with asymmetric layer structure are revealed. The results obtained will be useful in creating structures with reduced mass [16–18] as a result of solving the optimization problem by the hybrid optimization method [19].

References:

1. Sierikova O., Strelnikova E., Gnitko V., Degtyarev K. Boundary calculation models for elastic properties clarification of three-dimensional nanocomposites based on the combination of finite and boundary element methods. In: *2021 IEEE 2nd KhPI Week on Advanced Technology (KhPIWeek)*. 2021. P. 351–356.

2. Miroshnikov V., Younis B., Savin O., Sobol V.A. Linear elasticity theory to analyze the stress state of an infinite layer with a cylindrical cavity under periodic load. *Computation*. 2022. Vol. 1, No 9. P. 160.

3. Sklepus S.N. Numerical-analytical method of studying creep and sustained strength characteristics of a multilayer shell. *Strength of Materials*. 2017. Vol. 49, No 2. P. 313–319.

4. Сметанкіна Н.В., Шупіков О.М., Угрімов С.В. Математичне моделювання процесу нестаціонарного деформування багатошарового оскління при розподілених та локалізованих силових навантаженнях. *Вісник Херсонського національного технічного університету*. Херсон. 2016. № 3(58). С. 408–413.

5. Smetankina N., Semenets O., Merkulova A., Merkulov D., Misura S. Two-stage optimization of laminated composite elements with minimal mass. *Smart Technologies in Urban Engineering. STUE-2022. Lecture Notes in Networks and Systems*. 2023. Springer, Cham. Vol. 536. P. 456–465.

6. Smetankina N., Ugrimov S., Kravchenko I., Ivchenko D. Simulating the process of a bird striking a rigid target. *Advances in Design, Simulation and Manufacturing II. DSMIE 2019. Lecture Notes in Mechanical Engineering*. Springer, Cham. 2020. P. 711–721.

7. Smetankina N., Merkulova A., Merkulov D., Misura S., Misiura Ie. Modelling thermal stresses in laminated aircraft elements of a complex form with account of heat sources. *ICoRSE 2022. Lecture Notes in Networks and Systems*. 2023. Vol. 534. Springer, Cham. P. 233–246.

8. Сметанкина Н.В., Мисюра С.Ю., Линник А.В. Влияние предварительно напряженного состояния на частоты несущих конструкций гидротурбин. *Вісник НТУ «ХПІ». Серія: Динаміка і міцність машин*. 2018. Т. 1. № 38. С. 42–48.

9. Hontarovskyi P.P., Smetankina N.V., Ugrimov S.V., Garmash N.H., Melezhyk I.I. Computational studies of the thermal stress state of multilayer glazing with electric heating. *Journal of Mechanical Engineering*. 2022. Vol. 25. No. 1. P. 14–21.

10. Smetankina N., Malykhina A., Merkulov D. Simulating of bird strike on aircraft laminated glazing. *MATEC Web of Conferences*. 2019. Vol. 304. P. 01010-01016.

11. Шупиков А.Н., Бузько Я.П., Сметанкина Н.В., Угримов С.В. Нестационарные колебания многослойных пластин и оболочек и их оптимизация. *Харьков: ХНЭУ*, 2004. 252 с.

12. Smetankina N., Postnyi O. Nonstationary heat conduction in multilayer glazing subjected to distributed sources. *Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Środowiska*. 2020. Vol. 10, No 2. P. 28–31.

13. Alyokhina S., Kostikov A., Smetankina N., Gontarovskyi P., Garmash N., Melezhyk I. Methodology for determining the thermal and thermal-stress states of a concrete storage container for spent nuclear fuel for assessment of its service life. *Nuclear and Radiation Safety*. 2021. No. 4 (92). P. 33–39.

14. Smetankina N.V., Postnyi O.V., Misura S.Yu., Merkulova A.I., Merkulov D.O. Optimal design of layered cylindrical shells with minimum weight under impulse loading. In: *2021 IEEE 2nd KhPI Week on Advanced Technology (KhPIWeek).* 2021. P. 506–509.

15. Smetankina N.V. Non-stationary deformation, thermal elasticity and optimisation of laminated plates and cylindrical shells. *Kharkiv: Miskdruk Publishers*, 2011. 376 p.

16. Кантор Б.Я., Андрющенко С.А., Мисюра С.Ю. Исследование напряженно-деформированного состояния крышки гидротурбины и возможностей совершенствования ее конструкции. *Вісник НТУ «ХПІ». Серія: Динаміка і міцність машин*. 2010. № 69. С. 58–66.

17. Місюра С.Ю., Сметанкіна Н.В., Місюра Є.Ю. Раціональне моделювання кришки гідротурбін для аналізу міцності. 2019. *Вісник НТУ «ХПІ». Серія: Динаміка і міцність машин*. № 1. С. 34–39.

18. Лапітан К.Є., Місюра С.Ю., Лістрова Д.В., Руденко Т.М., Місюра Є.Ю., Васильєв А.І. Мінімізація ваги лопаті повітряної установки адаптивним гібридним методом оптимізації. *Вісник НТУ «ХПІ». Серія: «Динаміка та міцність машин»*. 2023. № 1. С. 33–38.

19. Шелудько Г.А., Шупіков О.М., Сметанкіна Н.В., Угрімов С.В. Прикладний адаптивний пошук. *Харків: Око*, 2001. 191 с.