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)
Public Scientific Organization "Ukrainian Assembly of Doctors of Sciences in Public Administration" (Kyiv, Ukraine)
Public Organization Organization "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 39th International Scientific and Practical Conference

December 7, 2023, Gothenburg (Sweden)

2023

Smetankina N.
Doctor of Technical Sciences,
Head of Department of Vibration and
Thermostability Studies,
Anatolii Pidgornyi Institute of
Mechanical Engineering Problems of the
National Academy of Sciences of Ukraine
Kharkiv, Ukraine

Misiura S.
Candidate of Technical Sciences,
Senior Researcher of Vibration and
Thermostability Studies,
Anatolii Pidgornyi Institute of
Mechanical Engineering Problems of the
National Academy of Sciences of Ukraine
Kharkiv, Ukraine

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

AN APPROACH TO OPTIMIZATION OF COMPOSITE STRUCTURES UNDER NON-STATIONARY LOADS

Modern aviation equipment has a number of features that distinguish it into a separate class of equipment [1, 2]. At the same

time, the production of aviation equipment units is small-scale in nature [3, 4]. Products are extremely complex both for design and production, have a high cost and must meet strict requirements for reliability [5, 6]. This makes it difficult to analyze the quality of the product and its performance at the design stage, since it is not possible to compare it with analogues [7, 8]. Increasing the efficiency of aviation equipment is largely determined by the structural materials used [9]. The search for ways to solve this problem has led to the trend of using composite materials in structures [10]. The volume and level of responsibility of composite elements of aviation equipment is constantly increasing.

The design of such complex technical systems as composite structures of aviation equipment is a complex multifaceted problem. This problem is related to the fact that composite materials are created in the process of manufacturing the product. In turn, the production technology of these products is largely related to other important components of this complex problem. These components include economic, ecological, which includes the safety of the production and life activities of the operation of the product. Therefore, the creation of objects of this class of technology grows into a multi-criteria problem, in which the results of many studies must be synthesized. However, there are no completed comprehensive studies combining all the components of the discussed problem in a scientific plan (theoretical, experimental and methodological) with a single conceptual approach. This is due to two main reasons. One of them is the need for such a solution to a fairly large amount of data that is gradually accumulating. The second reason is the significant scale of optimization of design parameters in the multi-criteria problem of creating aircraft structures from composite materials.

A distinctive feature of the proposed approach is the possibility of structural-parametric synthesis of rational designs of this class of equipment while ensuring regulated load-bearing capacity under simultaneous power and thermal load, taking into account technological and operational limitations that correspond to the current level of their production. The varied parameters of this class of structures differ for different structural and strength schemes. Thus, in structures with multi-layer load-bearing skins, the varied parameters include the thickness and angles of reinforcement of the layers forming these skins. For sandwich units, in addition to the parameters of the load-bearing skins, the most important design variable is the height of the aggregate. To further reduce the mass of cellular structures, the parameters of the cellular aggregate can be varied. To reduce the search space by minimizing the number of varied parameters or dividing their optimization into stages, the proposed block diagram provides for the possibility of preliminary analysis of the significance of the parameters of each constructive-force scheme.

The optimal design of composite elements under the influence of dynamic, in particular non-stationary loads, is devoted to a small number of publications due to the mathematical complexity of solving the problem of non-stationary deformation of the structure [9]. Thus, despite the fact that nowadays there are many numerical methods for calculating structural elements, there is an urgent need to develop analytical methods that allow analyzing the influence of individual factors on the stress-strain state and optimizing the parameters of composite elements.

The aim of the work is to solve the problem of optimal design of layered orthotropic open cylindrical shells, the layers of which are made of carbon plastic, under impulse loading. The solution was obtained by the immersion method [4] and the search

optimization method with adaptive control of the computing process [11].

The method of optimal design of orthotropic layered shells of minimal mass under impulse loading, which takes into account geometric and strength limitations, has been developed. The influence of the radius of curvature on the optimal parameters of the shells was studied. The effectiveness of the numerical implementation of the proposed technique is achieved due to the application of the immersion method for solving the problem of non-stationary oscillations of shells and the search hybrid optimization method for solving the problem of minimizing the mass of shells. The developed technique can be used for the design of layered elements of energy, transport and construction structures under the influence of high-speed intensive loads. The obtained dependencies allow the designer to choose the appropriate parameters of layered structures and to evaluate their strength and reliability under various operating conditions.

References:

1. Zhang H.M., Xing Y.F. Optimization of a class of composite method for structural dynamics. Computers and Structures. 2018. Vol. 202. 60–73.

2. 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.

3. Smetankina N., Ugrimov S., Kravchenko I., Ivchenko D. (2020) 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.

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

5. Гонтаровський П.П., Сметанкіна Н.В., Гармаш Н.Г., Глядя А.А., Клименко Д.В., Сиренко В.Н. Дослідження напружено-деформованого стану паливного бака вафельної конструкції ракети-носія. Проблеми обчислювальної механіки і міцності конструкцій. Дніпро, 2019. Вип. 29. С. 91–102.

6. 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.

7. Smetankina N.V., Postnyi O.V., Merkulova A.I., Merkulov D.O. Modeling of non-stationary temperature fields in multilayer shells with film heat sources. In: 2020 IEEE KhPI Week on Advanced Technology (KhPIWeek). 2020. P. 242–246.

8. Malykhina A.I., Merkulov D.O., Postnyi O.V., Smetankina N.V. Stationary problem of heat conductivity for complex-shape multilayer plates. Bulletin of V.N. Karazin Kharkiv National University. Series “Mathematical modeling. Information technology. Automated control system”. 2019. Vol. 41. P. 46–54.

9. 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.

10. 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. Springer, Cham, 2023. Vol. 536. P. 456–465.

11. 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.