НАПРЯМ КОНФЕРЕНЦІЇ. МАТЕМАТИЧНІ МЕТОДИ, МОДЕЛІ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ СУЧАСНОСТІ

Serhii Misura
Ph.D. in Technical Sciences, Senior Research Fellow,
A. Pidgornyi Institute of Mechanical Engineering
Problems of the National Academy of Sciences of Ukraine,
Kharkiv

Natalia Smetankina
Doctor of Technical Sciences, Professor,
A. Pidgornyi Institute of Mechanical Engineering
Problems of the National Academy of Sciences of Ukraine,
Kharkiv

THERMAL STRESSED STATE OF SHELL AND ROD SYSTEMS UNDER COMPLEX HEAT EXCHANGE

In various fields of technology, structural elements are used, which can be considered as shells or plates, as well as systems of shells and plates, in particular, those that are connected to each other with the help of rods [1, c. 95; 2, c. 16; 3, c. 145]. Such elements are quite often operated in conditions of high or low temperatures [4, c. 214]. Therefore, the study of their thermal stressed state and strength is a very important issue. A complete study of the thermally stressed state involves, at the first stage, solving the corresponding thermal conductivity problem [5, c. 8673] followed by using the obtained solutions as components of the load when solving the problem of determining the thermal stressed state [6, c. 410; 7, c. 47].

This work examines the temperature field and the stress-strain state of the system caused by it and external pressure. The system consists of a spherical shell, a continuous circular plate and a connecting rod element. The joint operation of the spherical shell and the circular plate was investigated when considering the stress-strain state of portholes of spherical devices. At the same time, the shell was considered hollow, and the lamellar element was considered as a rigid washer. It should be noted that the assumption of the flatness of the shell imposes certain restrictions on the dimensions of the lamellar element. To determine the temperature field of the system caused by convective heat exchange with the external and internal environments, the problem of steady-state thermal conductivity was solved using the immersion method [8, c. 269; 9, c. 554]. The problem reduced to solving systems of Gauss and Bessel equations and further conjugating these solutions. The thermoelastic state of the shell is determined by the moment theory of thin shells of rotation.

Taking into account the conditions of non-ideal thermal and thermomechanical contact when solving the problems of thermal conductivity and thermoelasticity made it possible to take into account the real geometry of the connection of system elements, namely, the non-orthogonality of the contact surface and the middle surface of the shell, as well as the possible asymmetry of the conjugation. On the basis of the obtained solutions, a study of temperatures, forces and moments in the elements of the system was carried out depending on the ratio of thermal conductivity coefficients, Young's moduli, coupling parameters.

Calculations showed that there is such a value of the external pressure parameter at which the stressed state of the shell will be close to momentless, despite the asymmetric coupling of the system elements; while under the action of only external pressure or under the action of only thermal load, the stressed state has a pronounced instantaneous character. It was also established that failure to take into account the non-orthogonality of the coupling of the system elements can lead to significant errors in the determination of both the temperature field characteristics and the forces and moments caused by it in the system elements, especially in the near-contact zone. It is shown that external pressure can reduce the absolute values of bending moments and transverse force in the shell.

The method can be used for further analysis of temperature stresses in the composite structures under heating system effects and studying thermal stresses in other composite structures [10, c. 35; 11, c. 175] for their optimization.

БІБЛІОГРАФІЧНИЙ СПИСОК:

1. Naumenko V., Strelnikova H. Singular integrals accuracy of calculations in two-dimensional problems using boundary element methods. *Engineering analysis with boundary elements*. 2002. V. 26. № 1. P. 95-98.

2. Strelnikova E., Gnitko V., Krutchenko D., Naumenko Y. Free and forced vibrations of liquid storage tanks with baffles. *Journal of Modern Technology and Engineering*. 2018. Vol. 3. No 1. P. 15-52.

3. Sierikova O., Koloskov V., Degtyarev K., Strelnikova O. The deformable and strength characteristics of nanocomposites improving. *Materials Science Forum*. 2021. Vol. 1038. P. 144-153.

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

5. Kantor B.Ya., Smetankina N.V., Shupikov A.N. Analysis of non-stationary temperature fields in laminated strips and plates. *International Journal of Solids and Structures*. 2001. Vol. 38. No 48/49. P. 8673-8684.

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

7. 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.

8. Smetankina N., Merkulova A.I., Merkulov D.O., Postnyi O.V. Dynamic response of laminate composite shells with complex shape under low-velocity impact. *Integrated*

Computer Technologies in Mechanical Engineering-2020. Lecture Notes in Networks and Systems. Springer, Cham, 2021. Vol. 188. P. 267-276.

9. Shupikov A.N., Smetankina N.V., Sheludko H.A. Selection of optimal parameters of multilayer plates at nonstationary loading. *Meccanica*. Rome. 1998. Vol. 33, No. 6. P. 553-564.

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

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