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Optimization procedure applied to ring-stiffened shells

Igor V. Andrianov, Jan Awrejcewicz, A. A. Diskovsky

ABSTRACT

An influence of ring stiffness distribution along shell defined through $k = k(x)$ on the shell stiffness on example on axially symmetric problem for cylindrical shell is investigated.

In order to compute stiffened shells usually two approaches are applied. The first one is based on discretization of a studied construction using either FEM or FDM. An associated inversed problem is reduced to mathematical programming. Difficulties in getting a reliable solution increase with increase of rings number *N*. Note that for non-uniformly stiffened shell *N* is equal to the number of design parameters.

The second approach is based on homogenization of the differential equations and it attracts recently attention of both mathematicians and mechanical engineers (see, for instance, [1-2]). For the inversed problems this approach is reduced to an optimal design of a construction with distributed parameters.

The differential equation governing deflection between rings of considered shell has the following form

$$w^{IV} + bw = q, \tag{1}$$

where: $b = 12(1-\nu^2)/R^2h^2; q = P(x)/D; D = Eh^3/12(1-\nu^2)$; R is shell radius; h is shell thickness; E, ν are Young modulus and Poisson's coefficient of the shell and rings materials.

The coupling condition of the *i*-th ring can be formulated in the following manner

$$w^- = w^+; (w')^- = (w')^+; (w'')^- = (w'')^+; (w''')^+ - (w''')^- = k(x)w_{x=is}, \tag{2}$$

where $(\ )^+$, $(\ )^-$ are intervals located to the right and to the left of the point $x = is$, where *s* is the distance between rings; $k(x) = EF(x)/(R^2D)$, $F(x)$ is the area of transversal rings cross section.

The boundary conditions on edges $x = 0, L$, for sake of simplicity, are taken in the form

$$w = w'' = 0. \tag{3}$$

If the rings number is large $(s/L = \varepsilon << 1)$, then in order to solve the problem (1)-(3), one can apply the asymptotic method of homogenization [1, 2]. We show how to solve the defined problem analytically via both minimized functional and Padé approximation approaches.

[1] Awrejcewicz J., Andrianov I.V., Manevitch L.I., Asymptotic Approaches in Nonlinear Dynamics: New Trends and Applications. *Springer-Verlag*, Berlin, 1998.
[2] Andrianov I.V., Manevitch L.I., Oshmyan V.O., Mechanics of Periodically Heterogeneous Structures. *Springer-Verlag*, Berlin, 2002.