MONOGRAPHS

Professor
Jan AWREJCEWICZ

Nonclassical Thermoelastic Problems in Nonlinear Dynamics of Shells

(with V.A. Krysko)
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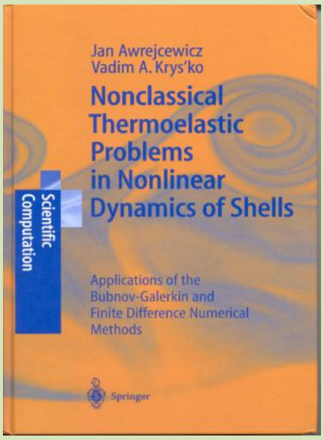
SUMMARY



[Preface & Contents]

[Book Review]

This monograph describes some approaches to the nonlinear theory of plates and shells. By nonclassical approaches we mean the desciption of problems with mathematical models of different sizes (two- and three-dimensional differential equations) and different types (differential equations of hyperbolic and parabolic type in the spatial coordinates). The nonlinearities investigated are also of various categories: geometrical, physical, elasto-plastic and periodic. Creating such types of mathematical models and their detailed justification allows us to achieve the most accurate description of the real behaviour of shell-type structures. These models allow us to include interaction between the strain and temperature fields and coupling between the displacement field and the external influence of a transonic gas flow. The mathematical treatment of such models helps us greatly in obtaining reliable results by numerical computation. It appears that the most dangerous situation for thin shallow shells is the conjunction of a static load with dynamic interactions. Such combined loads very often cause buckling of shell structures, and in many cases a series of bucklings, which can cause fracture. The failure of a structure usually needs a small amount of time. Therefore, the lifetime of a shell structure depends strongly on nonelastic deflections and it is important to mathematically model shell structures as precisely as possible. This monograph is one of several devoted to this subject.

Chapter 1 of this monograph is devoted to an analysis of the current literature concerning the problems that the title of the book refers to. We emphasize, among others, the lack of systematic presentation of these problems and their solutions in the existing literature.

In Chapter 2, a general statement of the coupled thermomechanical problems of flexible shells, with application of threedimensional heat transfer equations is presented, emphasizing a serious problem from the point of view of both the theoretical and the numerical approaches. However, the approach proposed here is one of the most powerful approaches, since it allows one to avoid any a priori hypotheses with respect to the temperature distribution through the shell thickness. In addition, a very important coupled problem of the interaction of shell-type structures with a transonic flow is addressed.

Research into the existence and uniqueness of solutions of linear coupled problems of the thermomechanics of plates and shells, within the framework of both the Kirchhoff-Love kinematic model and Timoshenko-like models with a three-dimensional parabolic equation of heat transfer, is described in Chap. 3. The problem is reduced to an abstract Cauchy problem of a coupled system of two differential equations in a Hilbert space, which generalizes the set of the above coupled problems of thermoelasticity.

In Chapter 4, results of numerical analysis of the estimated errors of the Bubnov-Galerkin method for linear problems in the theory of plates are presented. These results show that the estimates provide high efficiency.

In Chapter 5, a mathematical model of coupled, geometrically nonlinear problems of the thermoelasticity of shallow shells, using a Timoshenko-type kinematic theory and taking into account the rotational inertia of the shell and a three-dimensional thermal field (as in previous chapters), is formulated. The problem of the existence and uniqueness of a solution, as well as the convergence speed of the Bubnov-Galerkin method, is analysed; this generalizes results presented in Chapter 3.

In Chapter 6, a more exact mathematical model of the theory of shells is introduced and analysed. In addition to the hypotheses and assumptions of Chapter 5, nonlinearity of the physical properties of the shell material is included. The kinematic Kirchhoff-Love model is used. The mathematical model is obtained by the Biot variation principle.

Chapter 7 contains numerical methods for solution of the problems introduced in the previous chapter a finite-difference method of order O(h2) and the method of "elastic" solutions are applied in the numerical computations.

Chapter 8 presents even more complicated mathematical model than that applied in Chapter 6. Here, besides geometric nonlinearities, the periodicity of material properties during vibration is taken into account. Numerical algorithms for the solution of such problems are presented. The analysis of the dynamic stability and vibrations of plates and shells for different physical and geometric parameters is performed, and the results are presented in a series of graphs.

In the last chapter, some mathematical problems which have been briefly mentioned in this monograph, but which have not yet been solved, are addressed.