AIAA JOURNAL
Vol. 41, No. 11, November 2003

Book Reviews

BOOK REVIEWS published in this section reflect the opinions of their individual authors. They are not necessarily the opinions of the Editors of this journal or of AIAA.

Thermal Stresses, Second Edition

Naotake Noda, Richard B. Hetnarski, and Yoshinobu Tanigawa, Taylor and Francis, New York, 2002, 493 pp., $115.00

This is the second edition of a book published by the authors in June 2000. As stated in the preface to the first edition, the book had been planned as a textbook that should satisfy the needs of students, scientists, and practicing engineers. In the present edition various errors have been corrected and a number of examples have been added. A new section on thermally induced instability of plates has been introduced. There are 10 chapters ranging from the elementary topic of thermal stresses in bars to a brief section on the thermodynamics of thermoelasticity.

The first chapter is concerned with thermal stresses in bars. The concepts of uniaxial stresses and strains are introduced in a rather complex way instead of the traditional approach in mechanics of materials textbooks. After a brief discussion on free thermal expansion and combined effects of external forces and temperature change, the authors solve a series of example problems involving various boundary conditions and configurations of composite bars with mixed boundary conditions. The disadvantage of this approach is that it makes each problem look different and does not drive home the idea that all of these problems can be solved from the basic thermoelastic equilibrium equation and constitutive relation for the bars, imposing force equilibrium and compatibility at the junction between two bars. The preferred method is to explain the fundamental concepts very clearly so that all example problems can be solved using a common strategy. The section entitled "Thermal Stresses in Bars under Bending" is misleading. The authors should explicitly mention that the bar thickness is much smaller than the distance from the centerline. The bending stresses are smaller because the bars are slender and separated by a considerable distance compared to their cross-sectional dimensions.

The second chapter deals with thermal stresses in beams. Basic equations corresponding to Euler–Bernoulli beam theory are derived. The authors extend the derivations to multilayered composite beams and nonhomogeneous beams. Again the authors fail to provide a unified treatment of the general case followed by illustration of special cases. Such thermal stress equations have been derived elegantly in various textbooks on mechanics of composite materials (e.g., *Principles of Composite Material Mechanics*, R. F. Gibson, McGraw–Hill, 1994). In fact they usually are derived for plates and, of course, can be easily modified for beams. Thermal stresses in curved beams and thermal shearing stresses in thin-walled beams are useful topics not found in many books. There are a good number of example problems and also an equally good number of exercise problems at the end of the chapter.

The development of heat conduction equations is considered in Chapter 3. The three-dimensional equations are derived in different coordinate systems, and a variety of boundary conditions including heat transfer by convection and radiation are discussed. The separation of variables method for one-dimensional problems is given in detail. Laplace transform techniques for three-dimensional problems are illustrated for Cartesian, cylindrical, and spherical coordinate systems. This is a useful chapter for students as well as practicing engineers.

Basic equations of thermoelasticty are presented in Chapter 4. These include equilibrium equations, compatibility conditions, and constitutive relations. The equilibrium equations are also presented in the form of the Navier equations and the compatibility equations as Beltrami–Mitchell equations. The boundary conditions for thermoelastic problems are clearly defined. Another interesting section is that on the body-force analogy of thermoelastic problems. The general solution of the Navier equations in terms of displacement potentials as derived in the book is a useful technique. The various equations are presented in cylindrical and spherical coordinate systems so that many practical problems can be solved with ease. The discussion on multiply connected bodies, usually found in advanced elasticity books, is elegantly presented. Finally, the temperature distribution in a body for zero thermal stresses is shown to be a linear function in the spatial coordinates x, y, and z. Overall this well-written chapter provides a helpful review of the theory of elasticity including thermoelasticity effects.

Detailed solution techniques for plane thermoelastic problems are discussed in Chapter 5. Some three-dimensional solution procedures are specialized for plane problems. The general solution for the thermal stress function is derived, and the complex function representation of the thermal stress function is discussed. There are not many illustrative examples in this section, which is understandable, as only a few problems are amenable to closed-form solutions.

Solution techniques in cylindrical and spherical coordinate systems form the contents of Chapters 6 and 7, respectively. Many advanced techniques such as the

reciprocal theory technique and dislocation technique are presented in great detail. Solution methods for various geometries such as solid and hollow spheres are presented. The fundamental solution for the temperature field in spherical coordinate systems and components of displacement and stresses in terms of displacement functions are derived. These two chapters contain many useful expressions for thermal stresses in cylindrical and spherical geometries and will be of tremendous use to practicing engineers.

The chapter on thermal stresses in plates deals with homogeneous rectangular and circular plates. Kirchhoff's plate theory is used in deriving the equations. Nonaxisymmetric problems for circular plates are solved using a trigonometric series method. With the advent of microelectromechanical systems (MEMS) and widespread use of layered and composite materials, thermal stresses in layered structures have gained tremendous importance in recent years, as is the case of thermal stresses in annular plates used in several MEMS devices. It is unfortunate that these problems are not addressed in this book.

Instability (buckling) of beam-columns and rectangular and circular plates is discussed in Chapter 9. Buckling loads are derived for various boundary conditions under uniform temperature change. Again, inclusion of layered composite plates would have enhanced the value of the book. The last chapter is concerned with the thermodynamic principles of thermoelasticity. The Helmholtz free energy function and Gibbs thermodynamic potential are defined, and the constitutive relations are derived from thermodynamic principles. The variational principle for coupled thermoelasticity is derived, as is the reciprocal theorem that relates the temperature and displacement fields in two identical bodies subjected to different sets of forces. The usefulness of the theorem is illustrated by considering a one-dimensional problem of a circular cylinder subjected to thermal loading.

Numerical techniques for solving thermal stress problems are not covered in this book. Many practical thermal stress problems cannot be solved using analytical techniques alone but require approximate numerical methods such as finite difference or finite element methods. Approximate analytical solutions can also be obtained by using energy principles. The omission of this important topic is glaring when one goes through the book.

In summary this book will be a good reference book for a graduate course in theory of elasticity. Because it is an excellent source of solution techniques for thermal stress problems, it will be valuable for researchers and practicing engineers. The reviewer highly recommends it for the library of any university or research institution conducting research in solid and structural mechanics.

B. V. Sankar
University of Florida

Astronautics Summary and Prospects

A. Kiselev, A. Medvedev, and V. Menshikov, Springer-Verlag, New York, 2003, 600 pp., $99.95

This large tome, by three executives of the Khrunichev space enterprise, is a remarkable, albeit uneven, hodgepodge of material on Russian, U.S., European, Japanese, and Chinese space activities, with bits of information on capabilities in Australia, Brazil, India, Israel, and South Korea.

It divides into four major sections: 1) *Trends in Global Space Exploration*, an ambitious attempt to cover space developments in the United States and all of the countries mentioned in the preceding paragraph except Russia. 2) *The Main Trends in Development of Astronautics in Russia*, which has interesting accounts of the origins of Soviet space systems, even including the efforts to evolve nuclear electric rockets and power systems. Barely mentioned is the aborted program under Sergei Korolev to build the N-1 L-3 launcher for sending cosmonauts to the moon, canceled after four catastrophic unmanned failures, although one striking picture of the vehicle is included. 3) *The Ground-Based Infrastructure*, which begins with engrossing historical accounts of the design of the first launching facilities in the USSR, United States, and Germany, and goes on to cover much material, some of it arcane and almost all of it dealing with Russian systems for space communications, ground control, and tracking systems. 4) *Space Exploration and Ecology*, which is a catchall on the utility of space systems for observing Earth resources and phenomena as well as a compilation of charts and data on the impact of space launches on environmental pollution, including the effect of launch explosions, with tallies of the resulting human casualties.

It is, in all, a heroic effort at compilation from many sources in various languages and therefore a quite useful book, forgiving the numerous typos resulting from inadequate translation from the Russian.

The authors could not resist remarks, on the last text page, about "the U.S. unilateral withdrawal from the 1972 antiballistic missile (ABM) defense agreement which confirmed the declared by certain western experts determination to militarize space" [sic]. They go on to say that this "clears all barriers before the U.S. for building weapon systems (anti-missile defense systems) for which space will play an important—and in the longer term critical—role." The consequence, they fear, will be "the creation of 'space vs space' strike assets."

It is probably asking too much for such an eclectic volume to include an adequate index. The one provided is merely a listing of pages for projects, although it is better than no index at all.

James Harford
Executive Director Emeritus, AIAA