Yu. V. Polezhaev and F. B. Yurevich

THERMAL PROTECTION*

Reviewed by A. T. Nikitin

As they develop, aviation, rocket, and space engineering are confronted continually by the problem of protecting structures and individual elements from strong energy fluxes which are beyond their capacity to withstand. It is sufficient to note that, if the working temperature of a rocket motor reaches several thousand degrees, the construction of the plasma equipment employed must be able to withstand temperatures reaching hundreds of thousands of degrees.

A similar problem must be solved in modern power engineering, the development of which is tending toward even higher parameters of the thermal-energy processes, and also in the evolution of new sources of highly intense radiation.

Of course, the greatest experience in the development and calculation of thermal protection has been in rocket and space technology. This experience has not been generalized and has not been correlated — or at least not correctly — with the contributions of specialists in other fields who have had to solve problems of thermal protection. Therefore, the recent monograph Thermal Protection by Yu. V. Polezhaev and F. B. Yurevich is of considerable interest. As Academician A. V. Lykov points out in the foreword, this is the first Soviet monograph on thermal protection. The book not only generalizes the achievements of Soviet and foreign scientists in thermal protection, but also affords a proper place to the authors' own research.

The presentation of material in the monograph, beginning with a classification of methods of thermal protection, is well arranged and is accessible to readers of many different kinds. The methods of calculation presented are completely satisfactory for engineering practice, which imposes high requirements with regard to the simplicity and reliability of such methods.

Clearly, the authors cannot give a complete account of all the problems associated with the practical implementation of thermal protection in all branches of engineering. The monograph gives most attention to thermal protection using phase transformations and the driving off of material in the presence of high-velocity inflows, which indicates the emphasis of the book. In fact, most of the 11 chapters are devoted to thermal protection in rocket and space technology; in such situations the structures employed are used once only, and so it is possible to use destructibe thermoprotective coatings (DTP).

Phase transitions (especially vaporization) are among the most effective means of heat absorption and hence also of thermal protection. Unfortunately, in steady-state power equipment this method of thermal protection is of very limited application, and in certain structures, for example, in sources of highly intense radiation, the presence of phase transitions (especially vaporization) leads to their destruction as a result of a sharp pressure rise in an enclosed volume.

Since both Soviet and foreign developments in the field of thermal protection over the last 10-15 years are generalized in the book, in certain chapters (for example, Chaps. 6 and 7) the work of Soviet and foreign scientists should have been more completely covered. This would raise the general level of the treatment considerably.

*Edited by A. V. Lykov; Énergiya, Moscow (1976).

Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 33, No. 2, p. 366, August. 1977.

The material of Chaps. 3, 4, and 9-11, together with the reference data on DTP formulas and the properties of DTP constituents, should be useful in many areas of engineering. The extensive bibliographies given will prove valuable to specialists in many disciplines.

The high quality of the design work throughout the monograph should be mentioned.

Unfortunately, there are a number of stylistic infelicities; it is to be hoped that these will be corrected in subsequent editions. All in all, this book will be of practical use in the development and construction of high-energy equipment of the most widely different specifications.

Ya. S. Podstrigach and Yu. M. Kolyano

GENERALIZED THERMOMECHANICS*

Reviewed by I. A. Prusov and M. D. Martynenko

The development of many fields of engineering requires the study of dynamic processes in solids, taking into account the finite rate of heat propagation. This new monograph is devoted to the development of the principles of a generalized theory of the thermomechanics of anisotropic and isotropic bodies, taking into account that the rate of heat propagation is finite, and in the main contains research work by the authors and their students. Its predecessor, by the same authors, was the monograph Unsteady Temperature Fields and Stresses in Thin Plates [Naukova Dumka, Kiev (1972)], which outlined the principles of nonsteady heat conduction and quasistatic and dynamic problems of the thermomechanics of isotropic and anisotropic plates with heat transfer and, on this basis, studied the effect of various factors — the nonsteady character of the field, heat transfer, the heat-transfer conditions at the edge of the plate, the temperature dependence of the physicomechanical characteristics of the material, and the finite rate of heat propagation — on the distribution of the temperature field and stress in the plates.

The present book consists of a foreword, three sections (comprising 10 chapters), and a bibliography of Soviet and foreign works.

The first section outlines the principles of the theory of generalized thermoelasticity of anisotropic and isotropic bodies. Chapter 1 introduces the equations and relations of generalized interrelated and unrelated dynamic thermoelasticity of bodies with heat sources, formulates the boundary conditions, and provides proofs of the main theorems of the theory of generalized thermoelasticity. In Chap. 2 the generalized thermoelasticity of massive inhomogeneous bodies is considered. The conditions of nonideal thermomechanical contact of heterogeneous bodies joined by thin shells of a different material are formulated, together with thermomechanical boundary conditions for bodies with coatings and spherical inclusions and heat-transfer conditions for bodies with thin cylindrical inclusions. Chapter 3 outlines the principles of the theory of thermoelasticity for plates, shells, and rods. By means of operators and limits, the appropriate equations of generalized heat conduction are introduced and, on the basis of the Kirchhoff—Love hypothesis, the equations and relations of dynamic thermoelasticity are derived. Thermomechanical conditions are formulated for nonideal contact between heterogeneous plates and plates with a supported edge, and with circular and rodlike inclusions.

The second section presents solutions of generalized dynamic problems of thermoelasticity. Chapter 4 considers dynamic problems of thermoelasticity for a half-space, a cylinder,

*Naukova Dumka, Kiev (1976), 312 pp.

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spaces with a cylindrical and a spherical cavity and spherical inclusions, and a layer subject to thermal shock. The effect of the thermal inertia of heat sources on the dynamic temperature stresses in a layer and a sphere heated by uniformly distributed heat sources is investigated. Chapters 5 and 6 consider two-dimensional and one-dimensional generalized dynamic problems of thermoelasticity for various plates, beams, and rods under thermal shock at the end or the sides, and examine the effect of the degree of anisotropy, the thermal inertia of the heat sources, the finite rate of heat propagation, and heat transfer on the distribution of two-dimensional dynamic temperature stresses in thin-walled elements of the structure. Chapter 7 considers harmonic plane waves in a space, a half-space, and a layer, and spherical and cylindrical waves in a space, taking into account the finite rate of heat propagation. The modes of propagation of one-dimensional waves in a space are investigated.

The third section is devoted to the development of the generalized magnetothermoelasticity and thermoviscoelasticity of isotropic bodies. Chapters 8 and 9 outline the basic equations and relations of magnetothermoelasticity and thermoviscoelasticity and obtain, on this basis, solutions of dynamic problems of magnetothermoelasticity in the case of ideal electrical conductivity for a half-space, a cylinder, and a space with a cylindrical cavity, and problems of thermoviscoelasticity for a half-space and a semiinfinite plate of Biot material under thermal shock.

This monograph, together with the authors' previous book, makes a very useful contribution to the scientific and engineering literature on thermophysics, the thermomechanics of solid deformed bodies, applied mathematics, and mathematical physics.