BOOK REVIEWS

Principles of Non-Newtonian Fluid Mechanics. By G. Astarita and G. Marrucci. McGraw-Hill Book Company (UK) Ltd. 1974. Pages 289. Cost $19.50.

REVIEWED BY D. D. JOSEPH[7]

Rheological fluid mechanics is an intellectually interesting and technologically important subject. The reason that this subject has not come into a more central place in fluid mechanics is because of uncertainty about the correct form for the governing equations. Constitutive relations which are general enough to describe the tremendously varied responses open to a rheologically complex fluid are too general to solve many problems. And specific constitutive equations, developed from models, suitable for problem solving, are at best guided guesses which leave open the ultimate question about whether the constitutive relation you give is the right one for the fluid you got. Authors have had to decide between a good treatment of principles, without much problem solving, and a good treatment of fluid models, emphasizing problem solving. In the first category the treatise by Truesdell and Noll (*The Nonlinear Field Theories of Mechanics*, Springer, 1965) is without peer; in the second category are the books of Lodge (*Elastic Liquids*, Academic Press, 1964), and Middleman (*The Flow of High Polymers*, 1968).

The book by Astarita and Marrucci follows the line of thought developed by Truesdell and Noll, but from their own more pragmatic point of view and with some attention in the last two of seven chapters, to methods of approach toward solving important problems in the fluid mechanics of non-Newtonian fluids. The book is simply and clearly written. The arrangement of material is good and the book may be read, cover to cover. The technical arrangements for printing text, equations, and notes is outstanding and, in this, the authors and McGraw-Hill have produced an excellent work.

Non-Newtonian Fluid Mechanics cannot, of course, be compared to the *Nonlinear Field Theories* in breadth, rigor, and depth of scholarship. But the Truesdell and Noll book is full of new concepts, notations, and modes of thought and to say the least, demands more than some ordinary folk can give and more than less-ordinary folk will give. Since understanding is always incomplete, it is just a matter of degree, and a more gentle introduction to the theory of nonlinear continuum fluid mechanics developed by Coleman, Ericksen, Noll, Rivlin, Truesdell, and others is most welcome. The Astarita and Marrucci book gives this more gentle introduction. It achieves this greater simplicity in presentation by deleting materials which are not directly related to fluids, by sacrificing completeness and by omitting difficult mathematical demonstrations.

Astarita and Marrucci use their own experience to explain the basic concepts but are always faithful to the Truesdell-Noll point of view. Invariance of the stress to rigid body transformations is explained in terms of Noll's concept of frame indifference; tensors are regarded as linear mappings rather than as sets of numbers with assigned properties under orthogonal transformations; fading memory is framed according to the Coleman-Noll concept of norms defined with weight functions that wipe out the distant past; thermodynamics follows the formulation of Coleman, etc.

Chapter 1 is mainly concerned with vectors and tensors. The authors approach relies heavily on the direct use of reciprocal base vector systems. This method is good; it allows one to generate formulas for transformations between contravariant, covariant, and physical components from first principles. The authors adhere rigorously to the concept of a tensor as a bounded linear mapping (a continuous transformation). They should have said more about the relation of this concept to the more conventional definition of tensors using Cartesian components and orthogonal transformations.

Chapter 2 gives an introduction to the theory of nonlinear continuum fluid mechanics in the context of one of its simplest examples: the Reiner-Rivlin fluid. Concepts of frame indifference and fading memory are skillfully introduced here. Chapter 3 is about kinematics. The exposition is good; compact but clear. The method of convected coordinates, favored by Oldroyd, Lodge, and others is discussed in this chapter. Constant stretch history flows, of which the well-known viscometric flows are a special case, are discussed, and simple explicit examples are given in Chapter 3. Chapter 4 is about simple fluids, fading memory, and thermodynamics. Chapter 5 is about the special flows which rheologists use to characterize fluid properties: viscometric flow, extensional flow, and periodic flow. Chapter 6 contains a good discussion of constitutive equations. Rate equations and integral equations of the memory type are discussed and compared. The model equations of Maxwell and Oldroyd are discussed and compared with simple fluids. The discussion in Chapter 6 is critical and the criticisms which are raised are important. Chapter 7 deals with methods of approach to the solution of problems of fluid mechanics; dimensional analysis, superposed flows, flow around submerged objects, boundary layers, turbulence, waves, and stability.

Non-Newtonian Fluid Mechanics by Astarita and Marrucci is an excellent addition to the developing literature on the application of general principles of nonlinear continuum fluid mechanics to the problems of fluid mechanics. The main value of the book is the discussion of the principles which are necessary as a preliminary to problem solving. The application of these principles to problems is currently in an active period of development and this new book will certainly help in the effort to make the theory of the simple fluid into a practical fluid mechanics.

Anelastic Relaxation in Crystalline Solids. By A. S. Nowick and B. S. Berry. Published by Academic Press, Inc., 111 5th Avenue, New York 10003. Published 1972, 670 Pages. Cost $27.50.

REVIEWED BY J. LAWRENCE KATZ[8]

This excellent monograph by two well-known solid-state physicists provides a much needed unified account of anelasticity in crystals. The first six chapters provide a clear and thorough treatment of the formal theory of anelasticity. As the authors suggest, these chapters could provide the basis for an excellent graduate course in this area. Starting with a set of formal definitions, the authors introduce the important response functions which are used to describe the anelastic solid under appropriate experimental conditions. Following with the Boltzmann Superposition Principle they develop the relationships between the response function. This leads into models including the standard anelastic solid with a thorough development of its dynamic properties including temperature dependence. After a discussion of continuous spectra considering both direct and indirect methods of calculation, the authors develop the interrelationships between relaxation spectra and the existence of a set of internal variables by applying irreversible thermodynamics to relaxation phenomena. The introductory portion closes with a tensor treatment of anisotropic elasticity and anelasticity. Here, the authors begin to introduce some of the application to crystalline systems by treating several crystal systems of high symmetry in order to express the various "practical" moduli in terms of the characteristic elastic compliance and stiffness constants. Chapter 7 then acts as a transition chapter introducing the concept of point defects and models of atom movement. Chapters 8–11 then deal with those relaxation phenomena which arise due to point defects; the Snoek and Zener relations are each given a whole chapter. Some background in crystallographic symmetry or group theory would prove quite useful at this point as indeed it would have in Chapter 6 as well. For those not formally grounded in solid-state physics some introductory texts might prove useful for background reading at this point. Chapters 12–15

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15.Nowick, A. S. and Berry, B. S., Anelastic Relaxation in Crystalline Solids (Academic Press, New York, 1972). 16.Underwood, E. E., Quantitative Stereology (Addison-Wesley, Reading, MA, 1970). 17.Ochadlick, A. R. Jr, Solid State Ionics 3/4, 79 (1981). 18.Perez, J., Mai, C., Tatibouet, J., and Vassoille, R., Il Nuovo Cimento 33B, 86 (1976). 19.Vassoille, R., Mai, C., and Perez, J., J. Glaciology 21, 375 (1978). Anelastic relaxation measurements were performed in a Nb-46wt%Ti alloy, in the temperature range of 300 to 700 K, using a torsion pendulum operating at an oscillating frequency near 2.0 Hz. The samples were measured in different conditions: cold worked, annealed in ultra-high vacuum and doped with several quantities of nitrogen.Â [5] A.S. Nowick, B.S. Berry, Anelastic Relaxation in Crystalline Solids, Academic Press, New York, (1972). [6] M. Weller, G.Y. Li, J.X. Zhang, T.S. KÃª, J. Diehl, Accurate Determination of Activation Enthalpies Associated with the Stress-Induced Migration of Oxygen or Nitrogen in Tantalum and Niobium, Acta Metall. 29 (1981) 1047. DOI: 10.1016/0001-6160(81)90056-0. Crystalline solids have a sharp melting point on which they will definitely melt. An amorphous solid will have a range of temperature over which it will melt, but no definite temperature as such. Crystals have a long order arrangement of their particles.Â Amorphous solids have a short order arrangement. Their particles show a lot of variety in their arrangement. Crystalline solids cleavage (break) along particular points and directions. Amorphous solids cleavage into uneven parts with ragged edges. Crystals are also known as True Solids, whereas another name for Amorphous Solids is Super-Cooled Liquids. Learn more about Electrical Properties of Solid here in detail. Solved Examples for You. This book discusses the various physical and chemical phenomena in crystalline solids. Comprised of 20 chapters, this volume begins with a discussion on the formal theory of anelasticity, and then explores the anelastic behavior, which is a manifestation of internal relaxation process. This text lays the groundwork for the formal theory by introducing the postulates. Other chapters explore the different dynamical methods that are frequently used in studying anelasticity. The reader is then introduced to the physical origin of anelastic relaxation process in terms of atomic model. This text als The anelastic relaxation time is determined as a function of the parameters occurring in the defect hopping term in the Hamiltonian. This term is responsible for the dissipation of the anelastic â€˜potentialâ€™ energy into the host lattice. In a lengthy concluding section, the following aspects are discussed point by point: the advantages of the formalism presented, its scope and special cases; the physical implications of the expression obtained for the relaxation time; the similarities and differences between magnetic relaxation and anelastic relaxation, etc. This is a preview of subscription co...Â Nowick A S and Berry B S 1972Anelastic Relaxation in Crystalline Solids (New York: Academic Press). Google Scholar. Powers R W and Doyle M V 1959J.