futures. I would highly recommend it as a valuable addition for your own library of energy literature.

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About the Reviewer: Wen S. Chern is presently engaged in long-term planning of the research and development programs at the Lawrence Livermore National Laboratory. Dr. Chern's early academic training was at the National Chung-Hsing University, Taiwan, and was completed at the University of California, Berkeley, in agricultural economics. His present appointment was preceded by seven years at the Oak Ridge National Laboratory, as an economist in the Energy Division, and by professorships at the University of Florida and at the National Chung-Hsing University.

Thermohydraulics of Two-Phase Systems for Industrial Design and Nuclear Engineering. Edited by J. M. Delhaye, M. Giot, and M. L. Riethmuller, Hemisphere Publishing Corporation, Washington, D.C. (1981).

This volume is based on a lecture series at the von Karman Institute of Fluid Dynamics, Belgium, in 1978. Unavoidably, some of the contents have become outdated before its 1981 publication.

Volume I includes several basic aspects of pressurized water and liquid-metal fast breeder reactors (PWRs and LMFBRs) with chapters contributed by a number of authors.

Truly authoritative presentations by Y. Y. Hsu are given in Chap. 1, an overview of PWR and loss-of-coolant accident and emergency core cooling phenomena, Chap. 14 on boiling heat transfer, Chap. 15 on condensation heat transfer, and Chap. 19 on two-phase heat transfer computer modeling. The first three are areas of his personal research. The latter is a candid evaluation of various codes. Hsu has identified the need of in-core instrumentation and the need to improve the confidence in reactor safety margins via accurate modeling.

Definitive experiments on LMFBRs and their problems are reviewed in Chap. 2 by J. Costa. An effort on detailed modeling of the 19-pin voiding study carried out at his laboratory would be very useful, and, in fact, these experimental data can be used for validating the computer code. It would be a very desirable and timely subject to have some discussion in the areas of flow stratification and natural circulation.

Several of the chapters (Chaps. 3, 4, 5, 7, and 8) on formulation, based on first principles by J. M. Delhaye, have been published previously. Their relation to industrial design appears remote, and more work is needed to approximate these equations into a practical usable form. Furthermore, a clear delineation of relative merits and an authoritative recommendation of suitability of particular applications of the various averagings presented appear extremely useful and desirable. His excellent survey on flow regimes gives a systematic account of correlations suggested by various authors. On instrumentation, it appears desirable to clearly state that measurements by local attenuation of light or other beams (optical sensors) give linear or volumetric averages of densities or voids, while electrical probes, anemometers, and micro-thermometers give mass flow measurements or residence times. They give void fractions only when velocities of phases are equal. Overall, these chapters are very informative and provide a part of necessary background for multiphase flow and heat transfer.

Nucleation, friction factors, pressure drops, and critical flow are surveyed in Chaps. 6, 11, 13, and 18 by M. Giot. Their usefulness as a basic reference for engineering design is seen. Not many of the references given were published after 1974.

Regime transition in boiling heat transfer and two-phase flow instabilities and propagation phenomena are explained in Chaps. 16 and 17, written by G. Yadigaroglu. An important contribution is in identifying aspects that are not well understood, such as two-phase interaction laws and causes for oscillation of dryout points. Flow regime recognition and phenomenological approximation in the formulations are expected to continue to be a mode of computer modeling for some time to come.

D. Grand wrote chapters on pressure drops in rod bundles (Chap. 12) and two-phase calculations in LMFBRs (Chap. 20). Relating experimental pressure drop correlation to terms in the momentum equation appears useful. Two- and three-phase flow in LMFBRs at accident situations were illustrated via the SIMMER-1 code, including meltdown, but the accuracy of prediction is not known. Since modeling of sodium boiling is still in the early stage of development, much new information has been rapidly evolved since the publication of this volume.

The editors have made a good effort toward a coherent presentation. Gaps are there, and it is important to recognize that they exist. Accuracy of accident prediction has to be improved from both theoretical studies and experimental validations. Not only are the measurements challenging, but their limitations cannot be entirely eliminated. Further understanding of the physics of multiphase flow and improvements of mathematical procedures are very much needed if the formulations are to give correct modeling.

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About the Reviewer: William T. Sha is a senior scientist and manager of the Analytical Modeling Section, Components Technology Division, Argonne National Laboratory where he has been located since 1967. He is a noted developer of computational methods in the thermal-hydraulics area, and is solely or partially responsible for the development of many important computer codes, such as THUNDER, THINC, SAS, VENUS, THI3D, COMMIX, and BODYFIT. Dr. Sha's graduate training was at Columbia. He was engaged in reactor physics and heat transfer and fluid flow studies with Combustion Engineering and with Westinghouse Electric Corporation between the mid-fifties and the mid-sixties.

Structural Materials in Nuclear Power Systems. By J. T. A. Roberts. Plenum Press, New York (1981). 485 pp. $39.50.

The title of this book contains the phrase "Nuclear Power Systems" and the contents are faithful to the title. All previous books on nuclear materials have dealt almost exclusively with core materials, whereas the present monograph gives nearly equal weight to the balance of the plant. As one proceeds from the fuel element out to the turbine, the objects of concern become more massive and the materials phenomena that affect them change from principally physical to nearly exclusively chemical.

The introductory chapter gives an overview of the reactor systems (fission and fusion), their materials limitations, and the philosophy with which the latter are addressed. The author's approach is descriptive and qualitative rather than analytical and quantitative. It is also quite successful in bringing to the reader the most important materials problems, their physical or chemical origin, and the remedies most likely to succeed. The first chapter also presents a brief (21-page) summary of the materials science background needed to understand the technological questions that are raised subsequently. This theory review is generally adequate, in spite of the fact that, except for the atypically detailed account of creep models for metals, it is quite brief. This section contains the first example of a pedagogical difficulty that permeates the book, namely judging just how much the reader should already know. For someone with an engineering education, it is probably not necessary to discuss in detail the concepts of yielding, ultimate tensile strength, creep, or fatigue; the concept of creep fatigue is perhaps self-explanatory; however, terms such as "barrier processes," "obstacles," "kinematic hardening," and "crack arrest toughness" need some explanation if the uninitiated reader is not to be left with the frustrating feeling that he is missing something. This reviewer feels that in addition to the Glossary of some phases and terms, which appears as an Appendix, the book should have explained in simple words more of the terms used.

The book continues with a more detailed discussion of light water reactor (LWR) and fast breeder reactor core materials. These chapters do not attempt to describe the broad range of physical and chemical phenomena that occur in nuclear fuels. Rather the author's approach is to single out several topics of current importance and discuss them in some detail. Fully one-quarter of Chap. 2, for example, is devoted to pellet-cladding interaction, commonly thought to be a stress corrosion cracking phenomenon. The excellent section on fuel operating margins contains discussions of fuel element response to loss-of-coolant accidents, fission gas release, and assessment of core damage in the Three Mile Island accident. Here, as in much of the rest of the book, acronymism clouds readability. Most readers are prepared to cope with LOCA, but an RIA (although defined in the glossary) will be a puzzle to most. Even though we are told that a MCPR is a minimum critical power ratio, understanding escapes us. Finally, we choke on MAPLHGR.

Chapter 3 on fast breeder reactors follows the same philosophy as Chap. 2. A brief summary of fuel and cladding behavior is followed by a more detailed exposition of those topics that the author believes to be the most troublesome for this type of reactor, namely internal and external cladding corrosion and duct bowing due to creep/swelling. Good sections follow on advanced fuels (carbides and nitrides), alternate alloys (high-nickel alloys and ferritic steels), and proliferation-resistant fuels.

Chapter 4 is devoted to the pressure boundary of fission reactors, with primary emphasis on the pressure vessel of LWRs. Except for the blemish of a too-cursory presentation of generalized yielding fracture mechanics, this chapter is an excellent summary of the current status of structural integrity analyses of nuclear pressure vessels.

Chapter 5 reviews the materials responses of the fusion reactor first wall to the neutron bombardment from the plasma. Unfortunately, surface effects in structural metals (blistering, sputtering, and vaporization) are not considered because of the author's belief that these surfaces will be protected by low-Z (i.e., carbon and SiC) coatings or liners. However, this chapter makes the reader aware of the order-of-magnitude more serious bulk neutron damage effects in fusion reactors than in fission reactors. In this discussion, the author has neglected to define the term "wall loading" (MW/m^2) as a measure of power level and the lifetime figure $MW \cdot yr/m^2$. However, he makes the very important point that, contrary to a fission reactor, which can tolerate a fraction of a percent leaking fuel elements, a fusion reactor first wall must be absolutely leaktight or the machine will not operate.

Chapter 6 reviews the technology of heat exchangers (principally steam generators) and their particularly troublesome problems of denting, stress corrosion cracking, thinning, fretting, and fatigue cracking. However, to fully appreciate the fundamental causes of many of these phenomena, the reader must have a good understanding of the fundamentals of corrosion and electrochemistry. This chapter includes a good discussion of sodium interactions with fast breeder reactor components as well as a comprehensive treatment of the materials for low-pressure steam condensers.

Chapter 7 deals with steam turbine materials and their damage mechanisms (the same as usual: corrosion fatigue, stress corrosion cracking). The discussion of the bursting of the Gallatin rotor and what was learned from the autopsy clearly illustrate the problems of large turbine components.

Chapter 8, entitled "Future Trends in Nuclear Materials," summarizes the author's views on the proper courses of action to reduce the impact of materials problems on the availability of fission and fusion power plants.

The book is for the most part written clearly in a straightforward prose style. In addition to the acronym problem referred to earlier, several trendy word usages appear. The most common is the use of "impact" as a verb to signify "influence"; we are also introduced to "derate" as a noun, and to a mechanistic model referred to as a "virtual data generator." Fortunately, these usages are infrequent.

The tables, drawings, and photographs are generally satisfactory. The photomicrographs in Fig. 2.15, however, lack sufficient contrast to reveal all phases labeled. The O/M ratio of LWR fuel in Table 2-2 is listed as 2.00 ± 0.01, which erroneously implies the possibility of fabricating urania with an oxygen-to-metal ratio of 1.99. Conversion to metric units has not been accomplished without errors; the constants in the equations on Fig. 1.16 are incorrect as is the abcissa to Fig. 4.7.

Although the author's nonmathematical approach is quite successful in conveying the essential materials problems in nuclear power systems with clarity and brevity, it poses difficulties for students. Aside from the use of terms that are unfamiliar to most students, the lack of problems at the end of each chapter lessens the utility of the monograph as a textbook. However, when used in a nuclear materials course following, or in conjunction with, the more conventional analytic description of the phenomena, Roberts' book makes a very important contribution to education in this specialized field.

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