BOOK REVIEWS

Selection of books for review is based on the editors' opinions regarding possible reader interest and on the availability of the book to the editors. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Reactor Physics

Author	P. F. Zweifel
Publisher	McGraw-Hill Book Company (1973)
Pages	319
Price	$17.50
Reviewer	John M. Carpenter

Reactor Physics, by Paul F. Zweifel, is addressed to advanced undergraduate and early graduate students. It is intended to provide an introductory understanding of the physical principles and calculational methods which are the basis of nuclear reactor design. The author's approach is mathematical, as is necessary for the subject, but a little more so than earlier introductory-level textbooks. The development proceeds from one-speed diffusion theory into more complex descriptions, following an understanding of principles on these simple grounds. The book contains a substantial development of the idea of the basic describing equations of nuclear reactors as operator equations, defining eigenfunctions and eigenvalues. This is done in such a way as to bring a student into this point of view, rather than assuming prior extensive knowledge. The book should therefore appeal to teachers and students having a good mathematical background and a preference for that description of how things work.

There is little emphasis on the fundamental nuclear processes involved in reactor operation. The book will be tractable for any student who has had a one-semester course in the physics of neutron-induced nuclear reactions.

Reactor Physics is devoted almost entirely to the description of thermal reactors. This seems appropriate at the introductory level, since at present thermal reactors are the workhorses of the power reactor industry and are also the only type commonly available for university experimentation.

Of course, the book describes the many traditionally treated subjects, such as self-shielding, resonance capture, slowing down, rod worths, etc. The special strength of the book lies in those chapters on numerical methods, approximation schemes, and variational techniques—welcome introductions not found in many introductory-level textbooks. The appendixes are handy and useful also, particularly those on matrix algebra, the delta function (distribution), Fourier and Laplace transforms, and special functions.

Included as illustrations of the methods developed are descriptions of two of the early fundamental experiments. A unique feature of the book is the section on the French "intermediate experiments"; these were just as basic but were less well publicized than Fermi's well-known experiments with exponential assemblies which led to construction of the first critical pile.

The annotated bibliography is useful and exposes some of Zweifel's personal charm—which appears throughout the book—on Lamarsh's *Introduction to Nuclear Reactor Theory:* "By far the most popular text for introductory reactor physics courses today. In fact, this book is our principal competitor, so what are we to say about it?" The chapters and appendixes are accompanied by lists of problems. These illustrate the desired points, but for a book with such strength on numerical methods, problems requiring the use of digital computers are notably absent.

In addition to its many strong points, *Reactor Physics* has some regrettable, mostly relatively minor, shortcomings. Some important subjects are not discussed (which could have been, using the methods described), such as burnable poisons, flux peaking, xenon-induced spatial oscillations, conventional spectrum-averaged cross sections, etc. Many of the references to data and principles are 15 or 20 years old. While these serve the purpose, more recent sources would in many cases have served much better, particularly to introduce the student to current literature. There are an unfortunately large number of editorial and typographical errors. For example, the student who wishes to find the value of the ^{135}Xe capture cross section will be confused among the possibilities: 2.7×10^6 b (p. 62), 8.0×10^6 b (p. 179), 3.0×10^6 b (p. 181, Eq. 7.61c), or 30.0×10^6 b (p. 181, Fig. 7.11). The first section of Chap. 8 on multigroup methods contains many typographical omissions; for example, the multigroup operator has not been set in type. The conclusion is drawn in Sec. 4.6 that transients in measurements of the asymptotic reactor period vanish within a few seconds after a reactivity perturbation. This was reached by too great faith in a too oversimplified description of the reactor as a one-delay-group system starting at exactly $k = 1$. The conclusion is deceivingly at variance with experimental fact.

Reactor Physics impresses me as a good book, a solid introductory text with particular strength in the more mathematical aspects of reactor theory. Teachers can probably guide students across the few rough spots and fill the remaining few gaps in the treatment of introductory-level subjects.

Professor John M. Carpenter has served for nine years on the faculty of the Department of Nuclear Engineering at the University of Michigan, teaching both graduates and undergraduates in fields of introductory nuclear engineering, reactor theory, reactor power plants, the laboratory in nuclear measurements, and the nuclear reactor laboratory. His research interests lie in measurements of slow-neutron inelastic-scattering cross sections, neutron diffraction from glassy solids, time-dependent neutron thermalization, reactor noise, Cerenkov detectors, proton-recoil fast-neutron spectroscopy, and in the development of intense, pulsed slow-neutron sources. He has worked closely with Argonne National Laboratory and with Los Alamos Scientific Laboratory, and is now on leave, at Argonne, working on the program to develop the intense neutron source, called ZING. He is vice-chairman of the Michigan Section of the American Nuclear Society.

Neptunium-237, Production and Recovery

Authors	Wallace W. Schulz and Glen E. Benedict
Publisher	U.S. Atomic Energy Commission Office of Information Services (1973)
Pages	85
Price	$3.00 (paper bound)
Reviewer	Archie S. Wilson

Neptunium-237 is the precursor to ^{238}Pu; and ^{238}Pu, an alpha emitter with a half-life of 87 yr, is a prime candidate for remote power sources currently used in heart pacers and space applications. Space applications have required the larger amount of plutonium; resting on the moon are three devices, each containing 4 kg of ^{238}Pu. Future ^{237}Np will come from power reactors, and the estimated amount of ^{238}Pu which could be available by 1980 is ~300 kg annually. According to the authors of *Neptunium-237, Production and Recovery,* these considerations have generated the interest in ^{237}Np recovery.

Since between them the authors have about 50 man-years of experience in chemical processes for the recovery of actinide elements from neutron-irradiated nuclear fuels, they are well qualified to review neptunium processing. Their review is written for the process engineer who may be faced with the prospect of recovering neptunium from his or her plant. The language and jargon of the process engineer are used throughout to describe the variations on processing schemes. The review is organized into three sections: (a) Neptunium-237 Supply and Demand, (b) Recovery of Neptunium from Aqueous Solution, and (c) Nonaqueous Methods for the Recovery and Separation of Neptunium. The major part of the review (52 pages) is devoted to the aqueous systems. These aqueous systems are subdivided into solvent-extraction processes, ion-exchange processes, precipitation processes, and then two sections on the separation of ^{237}Np and ^{238}Pu and neptunium recovery in commercial reprocessing plants. The section entitled "Solvent-Extraction Processes" is further subdivided into Purex process recovery schemes, recovery by the redox process, Idaho Chemical Processing Plant recovery scheme, solvent extraction from Purex process wastes, recovery from fluorinated ash, and other solvent-extraction recovery experience. This listing of sections indicates that the authors' choice of organization was to describe the knowledge of neptunium processing in terms of particular plant experiences. Included with these descriptions are over two dozen flow sheets used by the various plants. From the point of view of a process engineer already familiar with the chemistry of the actinide elements, this organization has value in that the experience of a particular plant can be studied and operating details compared. From the point of view of a chemist wishing to understand the chemistry involved, this organization has minimal value. Those unfamiliar with neptunium chemistry should consult the standard texts and reviews to which the authors refer. One section is, however, devoted to one aspect of neptunium chemistry, the oxidation of neptunium. This section, "Process Neptunium Chemistry," describes the lack of agreement among investigators on the rate of the nitrous acid-catalyzed oxidation of Np (IV) to Np (VI) by nitric acid. This lack of agreement is surprisingly not unexpected since the nitric acid—nitrous acid equilibrium and the initial rate of nitrous acid decomposition depend on the partial pressure of nitric oxide in the system. However, lack of knowledge about the details of this oxidation has not impaired the operation of the processes described. Each plant has its favorite technique for oxidation state adjustment for neptunium recovery.

In this review, the authors have summarized these published plant experiences without critical comment as to whether a particular process could, in their opinion, have been made more efficient or better. Personally, I would have liked to have known what Schulz and Benedict thought about a particular process they described. Certainly, from my personal knowledge of these two competent scientists, they are not without opinions. Without opinions, the review lacks some excitement; nevertheless, those readers wishing to obtain a succinct review of neptunium processing will find this volume necessary reading.

Archie S. Wilson (BS, Iowa State University, 1946; MS, University of Chicago, 1950; PhD, University of Chicago, 1951) is presently a professor and associate department chairman at the University of Minnesota. He has been a research associate with the Pacific Northwest Laboratories, U.S. Atomic Energy Commission, operated by General Electric Company up to 1965 and Battelle-Northwest to the present time. In 1950 to 1951, he was a lecturer at the University of Nebraska, and between 1954 and 1971 was a lecturer in inorganic chemistry at the Center for Graduate Studies, Richland, Washington.