the spectrum of the thermal sciences and has published over 60 papers in heat transfer in plasma systems, heat transfer in frost layers, and thermophysical property measurement.

Nuclear Fuel Management

Author	Harvey W. Graves, Jr.
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Reviewer	K. Almenas

Every teacher in the technical field knows that good textbooks are considerably rarer than good technical books. Though the two categories have broad similarities, they are by no means identical. For a good textbook, it is not sufficient to be comprehensive and accurate, a special kind of organization is needed. One that first breaks down the material into comprehensible segments, distinguishes between the very important, important, and merely amplifying facts, and maintains a pace commensurate with the capacity of the prospective reader. It is gratifying to state that Dr. Harvey W. Grave's text *Nuclear Fuel Management* achieves this pace and organization right in its first edition. The advantage of reviewing such a book belatedly (it was published in 1979) is that one can speak from experience. If a pudding's merits emerge through the eating of it, the merits of a good text become clear in a classroom. Dr. Grave's book has withstood this test admirably. After its adaptation in a senior level undergraduate course in fuel analysis at the University of Maryland, the course became better structured, more comprehensive, and easier to teach. The text was well received by the students. Besides filling a long felt need, it helps to define the scope and content of the course on nuclear fuel analysis. That is an important aspect of the text and requires additional comments.

The nuclear engineering discipline is still evolving. The evolution process can be traced by noting the changes that have occurred in the basic texts. Initially they encompassed core neutronics and little else (i.e., Glasstone and Edlund). Currently they have expanded to include heat transfer, thermal hydraulics, material sciences, and even a smattering of economics (i.e., Lamarsh or Duderstadt). However, a point of diminishing returns is being approached. It is becoming increasingly difficult to be thorough and all inclusive at the same time. The discipline now has to evolve into separate subject categories that when linked together form a summation of knowledge and skills that define nuclear engineering. It is thus of interest to review which subject areas are emphasized and which are omitted in a new text.

The book is organized in four parts. The lead-in section encompasses various introductory subjects. Of special interest is the description of the front end of the fuel cycle. This includes mining, milling, fabrication, isotope separation, and the separative work unit (SWU) concept. A compact chapter is devoted to the definition of basic fuel cycle indexes and to an overview of nuclear reactor fuel types.

The second and largest section summarizes core physics methodology required for fuel depletion calculations. The preparatory chapters cover the applicability of diffusion theory, averaging of group constants, cell heterogeneity, and resonance absorption effects. A comprehensive chapter is devoted to various aspects of reactivity control and its effect on fuel cycle lifetime. Description of computational techniques focuses on methods of direct utility in fuel loading calculations. Besides the standard and familiar few group diffusion theory, this includes aspects of flux synthesis and finite elements. Especially welcome is a working description of the nodal technique including the derivation of the nodal equations and methods for evaluating coupling coefficients. The section concludes with the central (at least from the core physics point of view) task of burnup analysis–the evaluation of fuel depletion and isotope buildup.

The third section, called "Power Capability Evaluation," analyzes the physical parameters that limit potential core power density. This includes compact chapters on heat transfer and hydraulics. Considering the space limitations that the format of the book imposes, the material presented has to be very selective. The chapter on material properties has a narrower focus and thus can be more comprehensive. It includes properties of cladding materials, performance characteristics of UO_2, and changes in material properties expected during burnup.

The fourth and final part of the book includes three fuel management topics that do not fit readily under general headings. One of these is a chapter on "Nuclear Power Economics," which deals with cost categories, depreciation, the time value of money, and similar subjects that are in general quite unfamiliar to nuclear engineers but are a very essential part of fuel management. A chapter on loading arrangements and core operation strategies draws profitably on Dr. Grave's experience as a consultant in this area. And, finally, there is a subject that could regain its rightful technical importance–the utilization of plutonium in power reactors.

As this very brief overview shows, Dr. Graves treats fuel management as a self-contained technical subject. That is, the book presents or touches upon essentially all the areas of nuclear engineering that are utilized in performing and evaluating fuel utilization calculations. At this stage of subject category evolution, it is a logical approach. The approach works since he manages to distill the relevant essence of quite complex subject areas into compact (~20 to 30 pages long) chapters. Thus even if for some of the broader subject areas (i.e., heat transfer control hydraulics) one would probably choose to turn to more comprehensive texts, the presented chapters still serve as a useful outline. But once a beginning is made, especially an excellent beginning like this, one is tempted to look toward the future. As subject categories become better defined, the areas of overlap should decrease so that specialized texts like this can afford to amplify those aspects of technology that are unique to them. Thus future editions could expand the chapters on nuclear power economics, in-core fuel management, and hopefully add a chapter on the tail end of the fuel cycle. The chapter describing the front end of the fuel cycle could also be amplified; particularly, it should include quantitative information regarding mill tailings. If it becomes necessary to limit the volume of the book (it should strive to stay a text and not turn into a handbook), then some of the general subject chapters, i.e., on diffusion theory, cross-section averaging, and heat transfer, could be

merged or even eliminated altogether. Well written as they are, these subjects are covered more completely in special purpose texts.

But these are suggestions for the future. For the present, Dr. Graves has provided a very valuable textbook that summarizes an important area of nuclear engineering and that will be useful in classrooms and nuclear power reactor control rooms.

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