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Book Reviews

Nuclear Reactor Fuel Elements, Metallurgy and Fabrication. Edited by ALBERT R. KAUFMANN. Interscience, a Division of Wiley, New York, London, 1962. $27.00. 739 pp.

Dr. Kaufmann, Vice-President and Technical Director of Nuclear Metals, Incorporated, is well known and respected in the field of nuclear energy. Most of the authors are staff members of Nuclear Metals, many of whom are recognized as experts in the areas of fuel element metallurgy and fabrication. Other contributors are Samuel Glasstone—"Energy from Nuclear Fission"; David P. Herron, Advanced Technology Laboratories, Division of American-Standard and Bruce S. Old, Arthur D. Little Incorporated—"Fuel Element Economics"; and J. A. Rannsohoff—"Engineering Aspects of Fuel Elements".

The stated purpose of the book is to describe in detail how special nuclear materials are processed into fuel elements. The subject is thoroughly covered, including background information on the nature of nuclear fission, the metallurgy of nuclear fuels, fabrication techniques, and fuel element economics.

Separate chapters on the metallurgy of uranium (J. L. Klein), plutonium (L. R. Aronin), and thorium (I. B. Roll) and their alloys are quite complete and well referenced. These chapters contain numerous figures, charts, and tables along with clear discussions of production and physical metallurgy, alloying behavior, corrosion, mechanical properties, and workability. The indexes are adequate, but greater consistency in the organization of these three chapters would make the book more useful as a comprehensive reference work for instruction in nuclear engineering and metallurgy.

The treatment of "Uranium Dioxide and Other Ceramic Fuels" (N. R. Gardner) provides essential information but lacks detailed discussion. This is unfortunate in view of the broad commercial application of oxide fuels in power reactors such as those at Shippingport, Dresden, Yankee, and Indian Point.

The chapter on "Cladding Materials" (J. P. Pemsler) is not as comprehensive as it should be in view of the author's admission that clad elements will play the major role in nuclear power for some time to come. Illustrative figures, charts, and tables are sparse and the references are incomplete compared to those given elsewhere in the book. As an example, reference to Sawatsky's excellent work at AECL on hydrogen redistribution in Zircaloy is conspicuously absent. This chapter may be of general use in that it surveys current thinking on fuel cladding materials; but it is of little use as a handbook or reference. Furthermore, the author fails to emphasize to the student or the teacher the important role played by fuel cladding in current reactor design and philosophy.

The chapter on "Interactions Between Core and Cladding" (S. H. Gelles) is well illustrated and interestingly presented. In most cases, Gelles' information serves to introduce potential problem areas in cladding-fuel combi nations.

A wealth of information is contained in A. Boltax's chapter on the "Behavior of Fissionable Material Under Irradiation." This chapter is of practical significance to the fuel element fabricator only in that the reasons for some of the stringent design requirements placed on fuel elements are given. However, this material should be very useful to the fuel element designer who must consider radiation effects in designing functional fuel elements. The discussions of irradiation effects in fissionable material are also of value to the teacher and the student as background information for a more thorough understanding of irradiation effects in nonfissionable material.

The chapter on "Engineering Aspects" (J. A. Ransohoff) should be of interest to the metallurgist and fabricator. The author makes it clear that his treatment of the subject is not a comprehensive course intended to develop competent fuel element design engineers. An understanding of fuel element engineering aspects, however, should be required for fuel metallurgists and fabricators. This chapter provides some of the information required for familiarity with engineering aspects of fuel elements.

The chapters on "Fabrication of Core Materials," "Cladding and Bonding Techniques," and "Fuel Sub-Assembly Concepts" are excellent and might be considered required reading for fuel element designers who hopefully might gain understanding of some of the problems involved in transforming a design drawing into a three-dimensional piece of hardware. The authors (P. Loewenstein, P. D. Corzine, J. Wong, F. M. Yans, J. Greenspon, and J. H. Johnston) have included many useful illustrations and descriptive drawings that add appreciably to the instructional value of these chapters.

The chapter on "Inspection and Testing" (W. B. Nowak) is an important contribution to the fabrication portion of the book. In general, this chapter is excellent introductory material for the fuel element designer and fabricator. Radiography is treated more thoroughly than other inspection and nondestructive testing techniques. The addition of a section on the advantages and disadvantages of inspection methods would make this material more useful to the student and the teacher.

The chapter entitled "Description and Performance of Operational Fuel Elements" (L. R. Aronin and B. W. Rothleder) should be of particular use to the student and of general use to the fuel element designer and fabricator.

The chapter on "Processing Irradiated Fuel Elements" (S. Isserow) should be required reading for fuel element designers since, as the author states, economic practicality is

receiving an increasing emphasis over technical feasibility in efforts to institute possible savings in the fuel cycle. Furthermore, significant economic advantages can be realized by carefully evaluated fuel cycles which necessarily include the recovery of fissionable material, and perhaps radioactive isotopes, from the spent fuel element. Aqueous and nonaqueous reprocessing methods are described, and the effect of fuel element composition on processing is discussed. Specific cost estimates for fuel reprocessing and the relation of reprocessing to power costs are also discussed.

The brief chapter on "Fluid Fuel Systems" (S. Isserow) introduces the reader to the major fluid fuel systems that have received consideration. Adequate references are included.

"Fuel Element Economics" (B. S. Old and D. P. Herron) is a subject of major importance to anyone associated with reactor technology, especially to those in the commercial reactor field. The authors effectively introduce the subject of economics to the fuel element metallurgist, designer, and fabricator.

The book has these appendixes: (1) Phase Diagrams, (2) Fuel Element Fabrication Facilites, and (3) a Glossary. The second of these appendixes may not be completely accurate owing to the dynamic nature of fuel element technology. However, this section of the book gives the reader an idea of the machinery and tools used in the manufacture of fuel elements.

It is felt that Kaufmann's book will be useful as a general reference and as a guide to introduce the student, designer, metallurgist, or manufacturer to the intricacies of fuel element fabrication. It is not the purpose of the book to provide all of the information required to become expert in the metallurgy and fabrication of fuel elements. Certain chapters are much more complete than others, and for these alone the book is worthwhile. The serious student or practitioner will want to examine reference material and investigate other sources of information on specific subjects. This practice is recommended since no book, regardless of how well it is written, is purely objective.

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(About the Reviewer: Charles R. Johnson is currently Supervisor of the Structural Materials Group, Atomic Energy Division of The Babcock & Wilcox Company. After receiving a B.S. degree in metallurgical engineering from Purdue University in 1951 he joined the Globe Steel Tubes Company in Milwaukee, Wisconsin, where he was engaged in developmental work associated with tubing manufacture. In 1956 he joined B&W's Atomic Energy Division. At B&W Mr. Johnson has worked on the specification of structural materials for the Consolidated Edison Thorium Reactor at Indian Point, the N.S. Savannah Reactor, and several pool-type research reactors. He was instrumental in developing the boron–stainless steel cladding for the Indian Point Reactor fuel elements and participated in the design and fabrication of fuel elements for the Savannah reactor.)

Small and Medium Power Reactors, Proceedings of the Vienna Conference, September 1960. International Atomic Energy Agency, Vienna, 1961. Vol. I, 632 pp. $9.00. Vol. II, 453 pp., $7.00.

These two volumes present the complete text as well as the accompanying discussions of the sixty-four papers presented at the Conference on Small and Medium Power Reactors held in Vienna in September 1960 under the auspices of the International Atomic Energy Agency. Forty countries were represented by two hundred sixty delegates. The United States was the major contributor with twenty-seven papers out of the total.

By definition the Conference was limited to the consideration of power reactors up to 150,000 electrical kilowatts in size. While consideration was given to the application of power reactors in this size range, many of the reactors discussed are, in fact, reactor experiments or prototypes for reactors which are expected to have their economic applications in sizes beyond those considered at this Conference.

Out of the nine sessions four were devoted to the general review of reactor systems and specific reactor designs.

Of particular interest is the paper by U. M. Staebler of the U. S. AEC which gives a review of the development programs for nuclear power in the United States and presented the U. S. AEC's view of conducting research with relatively small experimental reactors and prototypes which would lead to better understanding of reactor technology. Other papers covered the AEC's small PWR and superheat programs and the U. S. Army's nuclear power program.

Heavy water moderated and cooled reactors were covered by papers from Canada, the United States, and Germany. There were several papers on pressurized water and boiling water reactors. Most of these were by U. S. authors, but there were also papers from Japan and Germany. Babcock & Wilcox presented a paper on the improvement of neutron economy and power distribution by utilizing mixtures of light and heavy water to control PWR Reactors by changing the reactor neutron spectrum.

There were a number of papers on the application of gas cooling to small and medium size power plants. This session included papers from France, United Kingdom, Germany and the United States. There was also an interesting session on the application of organic cooling to small and medium size power plants. The papers in this session were all from the United States.

There are a number of papers from the session on construction and operation which appear to be very useful. The papers are from the United Kingdom, the United States, and the USSR.

A combined session on safety, fuel cycles, and staffing contains several interesting papers and pointed toward many interesting developments in the over-all fuel cycle. As a result of technical reliability, simplification of built-in safety features to reduce costs was anticipated. Some concern was shown toward overstaffing of the nuclear power plants. The question of licensing reactor plants brought up an interesting discussion.

One paper of particular interest reported on the plutonium recycle project at Hanford and presented new material on fuel fabrication, particularly the cold swaging of UO-2 fuel elements in Zircalloy and a process involving high intensity vibrational compaction which is of particular interest for fuels containing plutonium.