Book Review

Physics of High Temperature Reactors. By Luigi Massimo. Pergamon Press Ltd., Oxford (1975). $20.00

The physics of any reactor concept, in a broad sense, ranges from nuclear data to the cost analysis. It comprises as well the mathematical treatment of physics and engineering as the experimental and the technological features. For reactor development, the key basis is the expertise applied to the importance of the various features and of their combination.

For high-temperature reactors (HTRs), Luigi Massimo is an expert, and we are happy that he has put down his overview of the relevant features in this monograph. Massimo has worked in the pioneering phases of the Dragon Project and in the pebble-bed reactor development. One of his accomplishments is the MAFIA-II code, which considers the important features in their combination and enables following them throughout the lifetime of the reactor. This code has become a basis for the study of the HTR and its fuel cycles.

In this book, the broad field of *Physics of High Temperature Reactors* is subdivided into 114 different sections, each covering one specific feature. A coarser subdivision into 16 chapters characterizes the different fields of consideration.

The first chapter gives an outline of the various concepts of the HTR and of the fuel cycles. It comprises the reactors with prismatic and spherical fuel elements, the on-load and off-load fueling, and the use of low ^{235}U-enriched uranium fuel and of the thorium cycle. The second chapter surveys the methods of numerical simulation. Thereupon the author discusses the relevant aspects of neutron cross sections, giving an excellent survey of the various approximations of transport and diffusion theory, and outlining the principles of their realization in existing computer codes. Chapters 6, 7, and 8 cover those features of neutron physics that are specific to HTRs: the moderation of the neutrons by graphite, the effects of coated particle heterogeneity in the fuel elements and its impact on the resonance absorption, and the peculiarities of cross-section averaging for few-group diffusion theory.

Currently, the attention of the physicist is concentrated on that field of the physics of neutrons. Related fields are reactor control, core dynamics, temperature coefficients, and accident analysis. These subjects are covered in 38 of the 114 different sections of this book. The author outlines the typical peculiarities of the HTRs resulting from the use of graphite as the moderator, the high temperature of the helium coolant in the core, the relatively low power density, and the different fissile isotopes bred in the uranium or thorium fuel cycle, respectively. Beyond that, however, of great merit is the author's discussion of burnup physics, of fuel management, of its feedback to core neutronics and power shaping, and of economic calculations. These subjects are discussed in Chaps. 9 and 10. They are basic for the consideration of HTRs because of the capability of high fuel burnup and because of the flexible application of different fuel cycles. Based on his personal experience, Massimo gives an excellent overview of the in-core and out-of-pile aspects of the fuel cycle. He outlines the methods both for following an explicit reactor through its life and for equilibrium cycle consideration. These two chapters contain many relevant details that are currently not known or at least not observed.

The last three chapters summarize the state of knowledge both for the HTR and for computational tools. Some sensitivity analysis is given for uncertainties in the nuclear data.

The monograph really covers the entire field of HTR physics. The discussion of the various subjects is guided by the relevance for that reactor type. It is supplemented by many notes referring to practical studies of the performance of the reactor and its fuel cycle. As a consequence, the book is very instructive for any expert in that field. Furthermore, it is a unique guide for aspirants who want to learn the features of the HTR and to work on them.

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About the Reviewer: Eberhard Teuchert has been associated with Kernforschungsanlage Jülich since 1964, and he is currently active in the development of computer codes and the analysis of HTRs and their fuel cycles. His special interest is the pebble-bed reactor. Dr. Teuchert earned his doctorate in theoretical physics at the University of Cologne.