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Book Reviews

Reactor Analysis. BY ROBERT V. MEGHREBLIAN AND DAVID K. HOLMES. McGraw-Hill, New York, 1960. 808 pp., $19.50. [*Review No. 1.*]

Reactor Analysis, had it appeared in 1950 or 1952, would have been a definitive book in the field. The authors follow a fairly traditional format. Thus they first discuss nuclear reactions and the notion of cross sections. Next come chapters on the multiplication constant and neutron flux, infinite medium slowing down theory, diffusion theory, age theory, and transport theory. Homogeneous reflected reactors are next considered, bare cores having been treated earlier in various approximations. Separate chapters are then devoted to reactor kinetics, heterogeneous reactors, and control-rod theory. The book ends with two rather isolated chapters, one on hydrogenous systems and the other on perturbation theory. For all of these subjects, the particular items which are discussed are covered thoroughly and clearly. The authors are extremely careful to point out exactly what physical and mathematical approximations are made and to indicate the consequent limitations in the validity of the results. However, the fact that so many gross and out-of-date approximations are discussed in such great detail leads, in my opinion, not to a clear physical insight into the field, but rather to an impression that things are extremely uncertain and confusing. I do not believe a student should be exposed to such uncertainty unless the subject matter admits of no greater precision. As it is, however, the reader is engulfed by pages of mathematical manipulation only to find that the final result is an approximation which in real situations is so gross as to be practically useless. (The 36 pages devoted to the "Feynman-Welton" method and most of the chapter on control rod theory are, to my way of thinking, examples of this; there are today hand methods which are just as accurate and much simpler.)

Possibly the field of Reactor Analysis is progressing so fast that any book on the subject must be out of date the day it is published. Whatever the reason, I feel the present book is out of date in two major respects. First of all, there are today a number of simple approximation schemes which have replaced many of the more elaborate hand methods described. For example, there are simple algebraic formulas which predict the worth of control rods fully as well as the Nordheim-Scalettar method (which is barely do-able on a hand computing machine). Secondly the change in attitude and emphasis which has resulted from the use of electronic computers as a tool in reactor analysis seems to have been neglected almost entirely. Although computers are mentioned in "Reactor Analysis," they are on the whole dismissed, and one even gets the impression that they should be used only as a help in the final design of a reactor.

There are, so far as I can see, two objections raised against the use of large computers as a tool for reactor analysis. The first is that, because results are always numerical, physical insight is obscured whereas analytical methods, since they result in algebraic formulas, yield physical insight. This argument, stripped of hidden implications is, I believe, quite false. It first of all implies that a man with a complex problem programmed for a large machine simply runs hundreds of cases in a sort of random fashion and then looks at them. But this is an example of *misusing* a computer; I am recommending they be *used.* Next, the argument implies that analytical methods always provide algebraic results from which physical trends can be discerned. But only in the simplest cases does this really happen; generally numerical examples must be run to indicate trends, and this is the same situation encountered when the computer is used.

The second objection to use of a large computer is that they are expensive. If this objection is raised by academic institutions doing research in reactor theory for its own sake, then I suggest that there are certain areas of the field (for instance, the comparison of theory with experiment) which should be avoided. If it is raised by industrial concerns seeking to build new power reactors, I suggest they regard the computer as a, perhaps frustrating, but necessary expense—like physicists. A new power reactor *can* be built without using a computing machine (several were), but it will be either a very dangerous device or one very much overdesigned.

Fairly clearly, I feel a computer is an important tool in reactor analysis. It is for this reason that I believe any book on this subject not oriented towards taking advantage of a computing machine is out of date.

The present book is certainly not so oriented. About eight of its 800 pages are devoted to discussing the numerical problems associated with machine use. Oscillation problems and schemes for accelerating convergence are not even mentioned. Virtually all the major mathematical developments are for problems for which an analytical solution (however complex it may be) can be obtained. Thus thirty some pages are devoted to a discussion of resonance escape possibilities in heterogeneous lattices. In all this space Richtmyer's Monte Carlo work (which, given the nuclear data, is the only guaranteed way to solve the problem) is mentioned once (in a two-line footnote). Twenty-two pages are used to discuss the thermal neutron problem. But most of this has to do with "effective temperatures" which have never been completely satisfactory and which are no longer needed; chemical binding, which is really the major remaining problem, is merely mentioned in one paragraph.

Comparable situations occur in every chapter. The analysis is developed in successive layers (general discussion; first approximation; its limitation; second approximation; its limitations; third approximation; etc.) to the point where it is quite involved but not accurate enough to lend confidence in the answer to a practical problem. A reader, trying to follow this development is exhausted by the series of increasingly complex stages and frustrated by the fact that the last approximation is still an unknown distance short of the goal.

Reactor Analysis in my opinion fails to give an accurate picture of both the scope and the accuracy of what can be done today in analyzing reactor problems.

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Reactor Analysis. By ROBERT V. MEGHREBLIAN AND DAVID K. HOLMES. McGraw-Hill, New York, 1960. 808 pp., $19.50. [*Review No. 2.*]

What is "reactor analysis"? The authors of the book *Reactor Analysis* define it as dealing "with the mathematical tools for treating the physical behavior of reactors," and this definition seems reasonable enough to me. Whether or not the coverage of reactor analysis is adequate in the book under review is another question, however, and largely because of the authors' sins of omission, I must answer in the negative. On the other hand, the authors have produced a book which covers reasonably well some of the basic concepts of reactor physics in a careful and mathematically rigorous manner. Because more such care and rigor are found in this book than in the other reactor texts with which I am familiar, I feel that *Reactor Analysis* can be recommended as an advanced text in reactor physics (although it is certainly far from ideal).

Some of the sins of omission referred to earlier will be enumerated presently, but first it should be pointed out that one man's "sins of omission" may be another man's trivia. However, in the present case, I do *not* feel that many of the textual lacunae to which I object can properly be classed as unimportant in the field of reactor design. I base this statement on my experience in the reactor core design area, both in the Naval Reactors Program at KAPL and later as a consultant to the AEC and a number of private industries.

Holmes and Meghreblian, on the other hand, have had (so I understand) a fairly "academic" association with reactor physics at Oak Ridge, teaching at ORSORT and, in their own research programs, not being too strongly involved in actual design. For this reason, they may not be, and apparently are not, sufficiently familiar with the design methods commonly in use in the industry to produce an authoritative text on analysis. Some of the more serious omissions are: the Hurwitz-Roe absorption area technique for control rod calculations; the Greuling-Goertzel approximation to slowing-down; the work of Wigner and Wilkins on the calculation of thermal spectrum, and the extensions of this work carried out by Nelkin, Cohen, Amster, and others;[1] Dancoff's corrections to resonance absorption (mentioned only through a reference); the recent work of Bell which provides a useful tool for approximate Dancoff calculations; the use of Fourier-transform slowing down calculations for obtaining group-diffusion constants. The list could go on and on, but perhaps the above will provide enough illustrative examples.

[1] The only thermal spectrum calculations discussed are those of Coveyou, Bate, and Osborn carried out at Oak Ridge.

However, *Reactor Analysis*, considered as a reactor physics text, is acceptable—largely because of its lack of competition. The other leading contenders for use as such a text have serious deficiencies—Glasstone and Edlund is out of date and also too sloppy—Weinberg and Wigner is too erudite, and thus is a far better reference book than a textbook; Murray is somewhat too elementary, although it does have the advantage of including many modern analytical methods, as well as some excellent illustrative problems. It is interesting to note that all of these books, as well as *Reactor Analysis*, are products of Oak Ridge, which fact is probably propagating an "Oak Ridge Bias" in the minds of nuclear engineering graduate students the world over.[2]

As a textbook of reactor physics, most of the deficiences of Meghreblian and Holmes' treatise are due to clumsy and over-formalistic methods. For example, I have never been able to understand why the elegant Hurwitz-Brooks approach to perturbation theory, via iterated fission probability, is not generally used in textbooks. Perhaps this is due to the "Oak Ridge Bias" mentioned above. This is a real pity, as not only are the resulting formulas much easier to work with, but the whole approach is much more comprehensible, particularly to students. Also, the discussion of resonance escape probability could be handled in a much clearer fashion than the one which the authors have chosen—this choice is particularly unfortunate, as it makes a physical understanding of some of the important approximations (for example, the neglect of multiple scattering in the NRIA approximation) rather difficult to come by. The chapter on transport theory suffers from the same illness that one finds in Davison and Weinberg and Wigner—"subscriptitis." I am sure that it must be possible to discuss this topic without confusing the reader as thoroughly as all of the writers in the field have succeeded in doing. (In passing, one notes the rather startling omission of any discussion of double P_n calculations or numerical quadrature schemes such as S_n in the chapter on transport theory). The chapter on nuclear physics is so weak that it should have been omitted entirely. And the section on group-diffusion theory follows the same tortuous treatment initially (and unkindly) foisted on a gullible public by Glasstone and Edlund. (I say gullible because apparently a generation of reactor physicists and engineers has blindly accepted this treatment without realizing that a good treatment exists.)

A final gripe is the absence of such fundamental experimental techniques as inverse multiplication, rod drop, and pile oscillator measurements. (Of course, if the title of the books were changed to "Reactor Theory," I suppose this would not be a legitimate complaint, but as the book stands the coverage of experimental techniques is very poor.)

The best features of the book are first, as was mentioned previously, the care and at least partially rigorous approach so lacking in many other texts (notably Glasstone and Edlund) and the measure of clarity also notably absent elsewhere (notably Weinberg and Wigner.) Of particular excellence is Chapter 12 on hydrogenous systems and

[2] As an example of this bias, we find no reference to fast reactor calculations in the book. Furthermore, the design methods which originated or have been popular at Oak Ridge are strongly stressed—the methods associated with other laboratories tend to be ignored.