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BOOK REVIEW

Handbook of Nuclear Reactor Calculations, Vols I–III, pp. 475, 523 and 465, respectively. Y. RONEN, Ed. CRC Press, West Palm Beach, Florida (1986).

In the early days of reactor analysis, the procedures of reactor design were a mixture of integral experiments and few group diffusion theory together with some "transport corrections". With the advent of the digital computer and increases in its size and speed, it has now become possible to solve the Boltzmann transport equation in velocity, space and time to a very high degree of accuracy. With few exceptions, the accuracy of our calculations depend only on the accuracy of the basic nuclear data. Nevertheless, computing is expensive and full-scale calculations using many independent variables are not always the best way to proceed to obtain practical results. A reactor physicist has to play a clever game of compromise between expediency and accuracy. Thus, instead of number crunching his way to success, he must often employ various approximations which embody the main physics of the problem and yet are relatively quick and inexpensive to use. A typical example of this, is the use of few-group diffusion theory instead of a many-group transport approximation: in large weakly-absorbing homogeneous (or homogenized) media the former will give accurate results often within a few percent of the latter. Similarly, in resonance absorption calculations, a relatively simple space-independent model involving only the energy variable and collision probabilities will lead to accurate values of resonance escape probability. Time-dependence is yet another area where judicious choice of variables can lead to a significant reduction in the computational effort.

The present books, three volumes, are exceptional in that they represent a bridge between the conventional textbook reactor physics and the specialized computer codes that have been developed to analyze engineering systems. In this respect, these volumes are not for the beginner. A good background in reactor physics to the level of Bell and Glasstone (Bell and Glasstone, 1970) is needed to fully appreciate the contents. But, with this background, these volumes make exciting reading because they take one through real-life calculations. For example, in designing a reactor core there are three basic steps:

1. Cross section evaluation.
2. Homogenization of the core.
3. Whole core calculation.

These three steps hide many problems but the answers will be found in the text. Thus in Step I we find the basic cross section defined, both for neutrons and γ-rays. Resonance structure, Doppler broadening, self-shielding, multigroup representation and group collapsing techniques are discussed in detail and the sensitivity of results is illustrated via examples from criticality, shielding and fusion reactor blanket calculations.

Step 2 requires a detailed knowledge of the neutron flux fine structure in the reactor core; that is, taking into account the geometry of the fuel element, its cladding and associated coolant and moderator regions. Generally, this has to be carried out using some form of transport theory. Thus we are introduced to the unit cell concept and the integral and integro-differential equations for the neutron flux. Collision probabilities and their application in the calculation of thermal utilization and resonance absorption are described in relation to various proprietory computer codes such as LEOPARD, THERMOS, MUFT, GAM and WIMS. We are also shown how to reduce the complex fine structure to useful homogenized effective cross sections for use in whole core calculations as required in Step 3.

Step 3 generally involves diffusion theory for the homogenized core. The books deal with such multigroup-diffusion theory problems effectively. They start with a derivation of diffusion theory from the transport equation, highlighting the various limitations involved. The neutronics problem takes many forms and some space is devoted to outlining how such problems arise, e.g. multigroup eigenvalue, nonlinear effects, adjoint operator, criticality search, fixed source, time-dependence, etc. We then proceed to the methods of calculation concerning synthesis, finite difference, finite element, nodal or coarse mesh techniques and general response methods. Useful numerical examples are given illustrating convergence and errors. Probably one of the most useful sections in this volume was Section VII "regarding the neutronics computation codes". Here a discussion is given of why one should use a specific code for a particular purpose. Some of the questions posed are:

1. Adequacy of physical modelling.
2. Adequacy of physics behavior modelling.
3. Reliability of solution generation.
4. Adequacy of results.
5. Ability to satisfy data requirements.
6. Acceptable enhancement or potential replacement aspects.
7. Competitive in computation cost.
8. Expected ease of making operational in an acceptable mode considering its use with other codes.

These considerations and others are dealt with in some detail and a great deal of practical advice is given.

Volume I concludes with a very comprehensive discussion of transport theory calculations. The transport equation is derived and illustrated in all manner of geometries. The spherical harmonics representation of the solution is given and the various angular harmonics tabulated. We are also introduced to the adjoint transport equation and its special significance. Multigroup transport equations are derived and the group constants defined. Special emphasis is placed on the solution of the transport equation by the Sn method and various quadrature sets are discussed. The spatial discretization and the subsequent inner and outer acceleration and search strategies for optimizing the solution are given in considerable depth. Then there follows a most valuable section on how to choose a code, embracing such factors as: code capability, computing environment, program language, efficiency and accuracy, user-oriented features, availability of codes and test problems. This section of transport theory goes on to discuss 2-D steady-state codes and gives some

practical hints on what might go wrong and how to make sure that your approximations are consistent with the physics of the problem. For example, it is not always obvious how to model a point source: some practical advice is given in this respect.

Volume II of the set comprises 5 sections: Monte-Carlo calculations for nuclear reactors, in-core fuel management of four reactor types, in-core fuel management in CANDU-PHW reactors, reactor dynamics and the theory of neutron leakage in reactor lattices.

Volume III of the set comprises 5 sections: control rods and burnable absorber calculations, perturbation theory for nuclear reactor analysis, thermal reactor calculations, fast reactor calculations and Seed blanket reactors.

In order to keep this review to a reasonable length, it will not be possible to discuss in any detail the contents of these volumes. Suffice to say, each topic is covered by an expert in a way which makes the contribution valuable as a piece of scholarship, and at the same time, a practical guide to the use of these methods in reactor design.

These three volumes, expensive as they are and generally well beyond the financial grasp of a student, must be purchased by all those organizations concerned with the teaching or profession of nuclear engineering. They are a cornucopia of useful information and practical experience. As well as being of technical value, the books are well-written and presented and attractively bound for years of use.

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REFERENCE

Bell G. and Glasstone S. (1970) *Nuclear reactor theory*. Van Nostrand-Reinhold, New York.