

Introduction to Nuclear Reactor Kinetics

by:

DANIEL ROZON
Institut de génie nucléaire

Translated by:

BENJAMIN ROUBEN
Atomic Energy of Canada, Ltd

© Éditions de l'École Polytechnique de Montréal

Table of Contents

| | |
|---------------------------|-----|
| Foreword | VII |
| Abbreviations and symbols | XI |

1. Neutron/Nucleus Interactions and Fission

| | | |
|-------|--|----|
| 1.1 | Neutron-Nucleus Interactions ----- | 1 |
| 1.1.1 | Cross Sections | |
| 1.1.2 | Types of Interaction | |
| 1.1.3 | Reactions of Importance in a Fission Reactor | |
| 1.2 | Fission ----- | 8 |
| 1.2.1 | Energy Produced in Fission | |
| 1.2.2 | Distribution of Fission Products | |
| 1.3 | Production of Neutrons----- | 12 |
| 1.3.1 | Production of Prompt Neutrons | |
| 1.3.2 | Production of Delayed Neutrons | |
| 1.3.3 | Photoneutrons | |
| 1.4 | Delayed-Neutron Groups ----- | 17 |
| 1.4.1 | Characterization of Delayed-Neutron Groups | |
| 1.4.2 | Delayed-Neutron Fraction | |
| 1.4.3 | Delayed-Neutron Emission Spectrum | |
| 1.5 | Conclusion----- | 22 |

2. The Diffusion Equation and the Steady State

| | | |
|-------|---|----|
| 2.1 | Neutron Balance in a Reactor ----- | 25 |
| 2.1.1 | Transport Equation | |
| 2.1.2 | Continuity Equation | |
| 2.2 | The Diffusion Equation ----- | 34 |
| 2.2.1 | PI Approximation | |
| 2.2.2 | Diffusion Approximation | |
| 2.2.3 | Delayed-Neutron Source | |
| 2.2.4 | Boundary Conditions | |
| 2.2.5 | Multigroup Formalism | |
| 2.3 | Time-Independent Equation and Eigenvalue Problem----- | 46 |
| 2.3.1 | Steady State and Criticality | |
| 2.3.2 | Effective Multiplication Constant and Static Reactivity | |
| 2.4 | Perturbation Theory and Flux Adjoint----- | 60 |
| 2.4.1 | First-Order Perturbation Theory | |
| 2.4.2 | Perturbation Formulas for the Reactivity | |
| 2.4.3 | AdjointEquation | |
| 2.4.4 | Importance of Adjoint Weighting | |
| 2.5 | Conclusion----- | 75 |

3. The Point Kinetics Equation

| | | |
|-------|---|-----|
| 3.1 | General Formulation----- | 78 |
| 3.1.1 | Flux Factorization | |
| 3.1.2 | Normalization Constraint | |
| 3.1.3 | Amplitude Equations | |
| 3.2 | Common Formulations of the Point Kinetics Equations ----- | 84 |
| 3.2.1 | Formulation for an initially Critical Reactor | |
| 3.2.2 | Dynamic Reactivity | |
| 3.2.3 | The Choice of Weighting Function | |
| 3.2.4 | Conventional Forms of the Point Kinetics Equations | |
| 3.2.5 | Formulation for an Initially Subcritical Reactor | |
| 3.3 | Point Model and Interpretation of the Kinetics Parameters ----- | 95 |
| 3.3.1 | “Point” Reactor Models | |
| 3.3.2 | Interpretation of the parameters | |
| 3.4 | Integral Formulation of the Equation----- | 103 |
| 3.5 | Conclusion----- | 105 |