

Preface

The emerging importance of ground-breaking technologies for nuclear power plants has been widely recognized. The supercritical pressure light water cooled reactor (SCWR), a generation IV reactor, has been presented as a reactor concept for innovative nuclear power plants that have reduced capital expenditures and increased thermal efficiency. The SCWR concepts that were developed at the University of Tokyo are referred to as the super light water reactor (Super LWR) and super fast reactor (Super FR) concepts. This book describes the major design features of the Super LWR and Super FR concepts and the methods for their design and analysis.

The foremost objective of this book is to provide a much needed integrated textbook on design and analysis of water cooled reactors by describing the conceptual development of the Super LWR and Super FR. The book is intended for students at a graduate or an advanced undergraduate level. It is assumed that the reader is provided with an introduction to the understanding of reactor theory, heat transfer, fluid flows, and fundamental structural mechanics. This book can be used in a one-semester course on reactor design in conjunction with textbooks on BWR and PWR design and safety. In addition, the book can serve as a textbook on reactor thermal-hydraulic and neutronic analysis.

The defining feature of this textbook is its coverage of major elements of reactor design and analysis in a single book. These elements include the fuel (rods and assemblies), the core and structural components, plant control systems, startup schemes, stability, plant heat balance, safety systems, and safety analyses. The information is presented in a way that enhances its usefulness to understand the relationships between various fields in reactor design. The book also provides the reader with an understanding of the differences in design and analysis of the Super LWR and the Super FR which distinguish them from LWRs. Though the differences are slight, the reader needs to grasp them to better understand the fundamental and essential features of the design and analysis. This knowledge will enhance in-depth understanding of the design and safety of LWRs and other reactor types.

The second objective of this book is to serve as a reference for researchers and engineers working or interested in the research and development of the SCWR. This book is the first comprehensive summary of the reactor conceptual studies of the SCWR, which were begun initially by researchers at the University of Tokyo and are continuing to be led by them.

Methodology in SCWR design and analysis, together with physical descriptions of systems, is emphasized more in the text rather than numerical results. Analytical and design results will continue to change with the ongoing evolution of the SCWR design, while many design methods will remain fundamentally unchanged for a considerable time. The book's topics are divided into six areas: Overview; Core and fuel; Plant systems, plant control, startup, and stability; Safety; Fast reactors; and Research and development.

The first chapter provides an overview of the Super LWR and Super FR reactor studies. It includes elements of design and analysis that are further described in each chapter. The reader will also be interested in what ways the new reactor concepts have been developed and how the analyses have been improved.

Chapter 2 covers design and analysis of the core and fuel. It includes core and fuel design, coupled neutronic and thermal hydraulic core calculations, subchannel analysis, statistical thermal design methods, fuel rod design, and fuel rod behavior and integrity during transients.

Chapters 3–5 treat the plant system and behaviors. They include system components and configuration, plant heat balance, the methods of plant control system design, plant dynamics, plant startup schemes, methods of stability analysis, thermal-hydraulic analyses, and coupled neutronic and thermal-hydraulic stability analyses.

Chapter 6 covers safety topics. It includes fundamental safety principles of the Super LWR and Super FR in comparison with that of LWRs, safety features, safety system design, abnormal transient and accident analyses at supercritical pressure, analyses of loss of coolant accidents (LOCAs) and anticipated transients without scram (ATWSs) and simplified probabilistic safety assessment (PSA).

Chapter 7 covers the design and analysis of fast reactors. The features of the Super LWR and Super FR are that the plant system configuration does not need to be changed from the thermal reactor to the fast reactor. The analysis of plant control, stability, and safety of the Super FR as well as core design are provided.

Chapter 8 presents a brief summary worldwide on research and development of the SCWR.

Reviews of supercritical fossil-fuel fired power plant technologies and high temperature water and steam cooled reactor concepts in the past are described in the Appendix.

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