PREFACE: CRITICAL HEAT FLUX

Nuclear power stands out as a highly compact and sustainable energy source. Theoretically, there is no limit to the power which can be generated from nuclear fuel, making it amenable to compactness. However, what limits it is the cooling medium’s ability to extract the heat generated by the nuclear fuel safely; this limits the maximum heat flux that can be removed from nuclear fuel. The existence of such a limit, referred to as the critical heat flux (CHF), was discovered nearly nine decades ago in Japan by Prof. Nukiyama. Since then, hundreds of experiments have been conducted and a large number of models and correlations have been developed to understand and predict the underlying phenomena of CHF. In spite of all this, every time a new fuel cluster has to be designed and used, prototypic CHF tests are inevitably required. This leads to the question: How much do we understand the CHF?

This special volume ARHT on CHF intends to bring together the various aspects of phenomenology, experiments, and modeling of CHF in a systematic manner. It presents the state-of-the-art on the subject. In addition, it deals with the CHF in unconventional geometries like downward-facing boiling in a curved vessel of nuclear reactors and CHF under flow oscillations in natural circulation.

This ARHT volume is organized into separate chapters, each dealing with many different aspects of separate issues. Chapter 1 provides an overview of the flow boiling phenomena in totality. The distinct phenomenology of the departure from nucleate boiling (DNB) and dryout are described. Chapter 2 deals with the experimental methods and results in the determination of CHF. It also provides a glimpse of the available correlations as well as their shortcomings. The message from this chapter is that the correlation-based approach for CHF predictions should be replaced by the mechanistic approaches to predict DNB and dryout to facilitate universal predictions of CHF.

Chapters 3 and 4 are dedicated to the phenomenological modeling of dryout and DNB, respectively. The calculation methodology and results for both tubes as well as rod bundles are presented in these chapters. Chapter 4 also presents predictions of CHF using computational fluid dynamics (CFD) modeling. Chapter 5 describes relatively new situations for which CHF has not been widely studied. They include, for example, CHF in downward boiling under the bottom of the calandria vessel of a pressurized heavy water reactor (IPHWR). This phenomenon is critically important during the retention of core melt in severe accident scenarios. Another phenomenon of interest is the flow oscillations which might occur in certain scenarios when the coolant flows under natural circulation.

The essence of Chapters 1–5 is presented in Chapter 6, followed by a future approach emphasizing the important key areas that need to be addressed for better modeling of dryout and DNB.

It is expected that this compendium will be able to introduce the phenomena and provide in-depth understanding of CHF to its readers and give new insights, challenges, and motivations for future research.

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