CFD-based Critical Heat Flux predictions for enhanced DNBR margin

PI: Emilio Baglietto, Massachusetts Institute of Technology

Collaborators: Emre Tatli – Westinghouse
Yixing Sung – Westinghouse
Su-Jong Yoon – Idaho National Laboratory

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ABSTRACT:

The nuclear industry conducts CHF tests on small-scale, 5x5 rod bundle configurations to collect data and develop empirical DNB correlations for PWR design applications. The current approach is to develop DNB correlations based primarily on local fluid conditions in the test bundles, predicted using a subchannel code also used for reactor core analysis. However, for some CHF tests, conditions with similar local flow parameters are predicted by the subchannel code with significantly different CHF values and inlet temperatures. Such occurrences can increase variance in the correlation fit and, consequently, the uncertainties in predicting DNBR margin in the design analysis. The complexity of the CHF mechanisms, in particular their different character at low- and high-quality conditions, combined with the limitations of subchannel codes in reproducing the mixing vane influence on the local flow distributions, have made this challenge refractory to both simple and even more recent Westinghouse machine learning-based DNB correlation development activities. **This project will demonstrate a robust high-fidelity CFD-based methodology to provide greatly increased understanding of the local conditions and their impact on the CHF behavior at varying quality conditions, enabling the development of advanced DNBR correlations with reduced uncertainty in support of improved plant economics.** The availability of a virtual CHF methodology will allow extending the database for DNBR correlations development and will further support radical advancements in the design of high-performing nuclear fuel.