Sensitivity Analyses of a Multi-Physics Long-Term Clogging Model For Steam Generators

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Abstract

Long-term operation of nuclear steam generators can result in the occurrence of clogging, a deposition phenomenon that may increase the risk of mechanical and vibration loadings on tube bundles and internal structures as well as potentially affecting their response to hypothetical accidental transients. To manage and prevent this issue, a robust maintenance program that requires a fine understanding of the underlying physics is essential. This study focuses on the utilization of a clogging simulation code developed by EDF R&D. This numerical tool employs specific physical models to simulate the kinetics of clogging and generates time dependent clogging rate profiles for particular steam generators. However, certain parameters in this code are subject to uncertainties. To address these uncertainties, Monte Carlo simulations are conducted to assess the distribution of the clogging rate. Subsequently, polynomial chaos expansions are used in order to build a metamodel while time-dependent Sobol' indices are computed to understand the impact of the random input parameters throughout the whole operating time. Comparisons are made with a previous published study and additional Hilbert-Schmidt independence criterion sensitivity indices are computed. Key input-output dependencies are exhibited in the different chemical conditionings and new behavior patterns in high-pH regimes are uncovered by the sensitivity analysis. These findings contribute to a better understanding of the clogging phenomenon while opening future lines of modeling research and helping in robustifying maintenance planning.