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Computational Fluid Dynamics Approach for Optimizing Temperature and Flow Profile in a Natural Circulation Based Integrated SMR

Objective of this work is to demonstrate applicability of computational fluid dynamics (CFD) techniques to perform design and safety assessment of passive primary coolant systems in integrated small modular reactors (SMRs). Passive primary coolant system, or natural circulation- based nuclear steam supply system (NSSS), is one of the most prominent features of SMR configurations where primary loop, steam generator and pressurizer are integrated into one single reactor pressure vessel (RPV). To simulate the primary coolant flow, iterative CFD analyses were performed where each analysis constitutes a certain combination of thermal gradient between the core & steam generator and their size & elevation. Given heat flux of the core, primary coolant temperature and velocity profile were computed along with heat transferred to the secondary side and corresponding temperature reduction on the primary side, in turn, improving the initially computed velocity profile for the primary coolant. The study concludes that CFD simulations offer viable solutions in terms of flow and temperature distributions, thus contributing towards safe and efficient heat transport performance of primary systems in SMRs.

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