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Towards the Development of a Comprehensive Nuclear System Analysis Code Based on Two-Fluid Model: Starting with an Isentropic Approach

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In the complex field of nuclear reactor design and analysis, there is a continuous need for sophisticated computational models that can accurately capture the diverse and challenging thermal hydraulic phenomena during steady state and transient conditions. This research sets the stage for the development of a comprehensive system analysis code for nuclear reactor thermal hydraulic design, starting with an isentropic two-fluid model with four governing equations. The computational methodology for this model incorporated the Advection Upstream Splitting Method (AUSM) scheme with a staggered grid arrangement. The nonlinear system of governing equations was solved implicitly by employing Newton's method while a numerical Jacobian matrix was calculated for the derivative terms, enhancing the stability and efficiency of the solution process. The performance of the model was assessed through a code-to-code comparison with the Safety and Performance Analysis Code (SPACE), a licensed tool for design and safety analysis of Pressurized Water Reactors (PWRs). Further validation of the model was also performed using three classical two-phase benchmarks: water faucet problem, oscillating manometer problem, and air-water phase separation problem. The validation results indicate a reliable and accurate prediction of the model. Consequently, the successful development and validation of current two-fluid isentropic model provide a solid foundation for the future development of a comprehensive nuclear system analysis code based on the two-fluid model.

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