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Assessment of Numerical Models in Predicting Flow Pulsation in a Closely-Spaced Bare Rod Bundle

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Abstract

Flow pulsations in tightly spaced fuel rod bundles are an important phenomenon in reactor thermal-hydraulics, as they can cause vibrations that may compromise structural integrity. These pulsations, originating from coherent gap vortex streets between fuel rods, can induce vibrations and fatigue in reactor components. In this work, we investigate this behavior using Computational Fluid Dynamics (CFD) simulations based on Reynolds-Averaged Navier–Stokes (RANS) models within the ANSYS Student Version. The Shear Stress Transport (SST) k–ω turbulence model is applied to capture unsteady flow characteristics in a rod bundle geometry inspired by the Hooper experiment, which features a pitch-to diameter ratio of 1.107. The geometry and flow parameters are simplified and scaled to remain within the limits of available computational resources, while preserving the essential physics of axial flow pulsations. While high-fidelity methods such as DNS or LES provide more accurate representations of turbulence, they are computationally demanding, so the focus is on testing the capability of RANS turbulence models to reproduce the essential features of axial flow pulsations. Velocity data from the simulations are analyzed in both the time and frequency domains to identify characteristic pulsation patterns. In particular, time histories of the gap-center velocity are examined using power spectral density (PSD) to extract the dominant pulsation frequency, which is then compared with values reported in the literature. The project highlights both the strengths and the limitations of RANS-based CFD in capturing this phenomenon and provides a useful baseline for future work with more advanced methods

Technical Track

Student Competition

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