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An Evaluation of a Phase-Lag Boundary Condition for Francis Hydroturbine Simulations Using a Pressure-Based Solver[1] ALEX WOUDEN, JOHN CIMBALA, Pennsylvania State University, BRYAN LEWIS, Halliburton — While the periodic boundary condition is useful for handling rotational symmetry in many axisymmetric geometries, its application fails for analysis of rotor-stator interaction (RSI) in multi-stage turbomachinery flow. The inadequacy arises from the underlying geometry where the blade counts per row differ, since the blade counts are crafted to deter the destructive harmonic forces of synchronous blade passing. Therefore, to achieve the computational advantage of modeling a single blade passage per row while preserving the integrity of the RSI, a phase-lag boundary condition is adapted to OpenFOAM® software's incompressible pressure-based solver. The phase-lag construct is accomplished through restating the implicit periodic boundary condition as a constant boundary condition that is updated at each time step with phase-shifted data from the coupled cells adjacent to the boundary. Its effectiveness is demonstrated using a typical Francis hydroturbine modeled as single- and double-passages with phase-lag boundary conditions. The evaluation of the phase-lag condition is based on the correspondence of the overall computational performance and the calculated flow parameters of the phase-lag simulations with those of a baseline full-wheel simulation.

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