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Computation of Cavitating Flow in a Francis Hydroturbine

DANIEL LEONARD, Pennsylvania State University, JAY LINDAU, Applied Research Lab/Penn State — In an effort to improve cavitation characteristics at off-design conditions, a steady, periodic, multiphase, RANS CFD study of an actual Francis hydroturbine was conducted and compared to experimental results. It is well-known that operating hydroturbines at off-design conditions usually results in the formation of large-scale vaporous cavities. These cavities, and their subsequent collapse, reduce efficiency and cause damage and wear to surfaces. The conventional hydro community has expressed interest in increasing their turbine's operating ranges, improving their efficiencies, and reducing damage and wear to critical turbine components. In this work, mixing planes were used to couple rotating and stationary stages of the turbine which have non-multiple periodicity, and provide a coupled solution for the stay vanes, wicket gates, runner blades, and draft tube. The mixture approach is used to simulate the multiphase flow dynamics, and cavitation models were employed to govern the mass transfer between liquid and gas phases. The solution is compared with experimental results across a range of cavitation numbers which display all the major cavitation features in the machine. Unsteady computations are necessary to capture inherently unsteady cavitation phenomena, such as the precessing vortex rope, and the shedding of bubbles from the wicket gates and their subsequent impingement upon the leading edge of the runner blades. To display these features, preliminary unsteady simulations of the full machine are also presented.

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