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Cavitation pitting by inter-blade vortices on a high-head Francis turbine

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ABSTRACT

Inter-blade vortices (IBV) are inherent to Francis turbines operating at low part load. The presence of IBVs may potentially induce high-amplitude pressure fluctuations in the region between the guide vane and the runner, and even cavitation frosting on the runner blades. In the context of a rehabilitation project for a high-head Francis turbine, a review of historical inspections performed by the owner revealed progressive cavitation damage on the runner crown. This prompted ANDRITZ to conduct a detailed investigation to determine the root cause and assess the operational risk. To this end, a combination of steady-state and unsteady simulations was employed.

In the initial phase of the study, steady-state simulations identified IBVs at locations where cavitation damage had been reported on the prototype runner. However, the predicted pressure levels remained well above vapor pressure for all operating conditions, suggesting no cavitation damage. In contrast, unsteady simulations revealed fluctuating IBVs, intermittently reaching cavitation conditions in their core. The latter established a direct link between IBV-induced pressure fluctuations and the cavitation damage observed on the runner crown. This further highlights the necessity of unsteady simulations for accurately defining cavitation risk zones, as steady-state simulations alone may fail to capture intermittent cavitation events. Additionally, we present methodologies for quantifying the IBV strength and the cavitation intermittency across the operating range.