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Hydrodynamic damping and stiffness prediction in Francis turbine runners using CFD

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Abstract

Fluid-structure interaction (FSI) has a major impact on the dynamic response of the structural components of hydroelectric turbines. On mid- to high-head Francis runners, the rotor-stator interaction (RSI) phenomenon has to be considered carefully during the design phase to avoid operational issues on the prototype machine. The RSI dynamic response amplitudes of the runner are driven by three main factors: (1) pressure forcing amplitudes, (2) excitation frequencies in relation to natural frequencies and (3) damping. All three of the above factors are significantly influenced by both mechanical and hydraulic parameters. The prediction of the first two factors has been largely documented in the literature. However, the prediction of hydro-dynamic damping has only recently and only partially been treated. Two mode-based approaches (modal work and coupled single degree of freedom) for the prediction of flow-added dynamic parameters using separate finite element analyses (FEA) in still water and unsteady computational fluid dynamic (CFD) analyses are presented. The modal motion is connected to the time resolved CFD calculation by means of dynamic mesh deformation. This approach has partially been presented in a previous paper applied to a simplified hydrofoil. The present work extends the approach to Francis runners under RSI loading. In particular the travelling wave mode shapes of turbine runners are considered. Reasonable agreement with experimental results is obtained in parts of the operating range.