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Experimental investigation of Non-Trivial Runner-Casing Interaction in a simplified hydraulic machine

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ABSTRACT

Rotor-stator interaction (RSI) is a fundamental excitation phenomenon in hydraulic turbines. In Francis turbines, it is mostly related to the interaction between the distributor and the runner flow fields. This interaction induces periodic load fluctuations on the runner and guide vanes and is modulated by the rotating speed of the runner. RSI has been extensively studied over the years for Francis turbines, leading to equations to predict their excitation shapes, characterized by nodal diameters, and their harmonic frequencies related to the guide vanes numbers. RSI can cause severe damage when both the excitation frequency and excitation pattern match a natural frequency and mode shape of the runner, leading to resonance. While Francis runners are designed to prevent resonance associated with RSI, a recent study reveals that every harmonic of the rotating speed – not only those that are multiples of the number of guide vanes as the RSI does – can also induce resonances. This fluid-structure interaction phenomenon is referred to as Non-Trivial Runner-Casing Interaction (NTRCI) and has not yet been extensively investigated.

The presentation will focus on an experimental measurement campaign conducted to investigate the NTRCI under various operating conditions in a simplified geometry mimicking hydraulic turbines. The experimental setup is designed to investigate resonances of a simplified structure – composed of a hub, seven rods and a band – rotating within a distributor composed of sixteen guide vanes. An electrical motor powered by a variable frequency drive is used to control precisely the rotating speed and acceleration rate of the runner. Measurements are conducted at various constant rotating speeds and during speed variation, where RSI and NTRCI sweep a wide frequency range, potentially inducing multiple resonances. Results from this experimental campaign show that resonances are excited by NTRCI for both constant rotating speeds and speed variations. Moreover, the strain amplitude induced by NTRCI harmonics can reach levels as high as that induced by RSI harmonics.