Preliminary experimental modal analysis of a model Francis runner in operation using piezoelectric actuators

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ABSTRACT
Nowadays, hydraulic turbines are used more and more to regulate the power grid to compensate the production fluctuation of other power sources. Therefore, turbines operate more often outside the operating condition they were designed for, reducing the life span of the runners. The phenomena that lead to the reduction of the life span at those regimes are still not well known. Knowing the exact natural frequency and damping factor of each mode in operation is essential to investigate the dynamic behavior of the runner. However, performing an experimental modal analysis of a model runner in operation is challenging because of the rotation of the runner, the close space, the small clearance, and because the sensors and the actuators need to have a minimal impact on the flow. Also, the natural frequencies of the runner are closely spaced and highly damped, making the identification of the natural frequencies and the damping challenging. This paper presents an experimental modal analysis of a model Francis runner in operation using piezoelectric actuators and semiconductor strain gauges. Because of their small size, strain gages, and piezoelectric actuators are chosen. Also, piezoelectric actuators have been successfully used on other submerged structures in the literature to perform experimental modal analysis. Different excitation signals are used to excite the specific mode of the runner and help identify the natural frequencies and damping at different regimes. The runner is installed in the Hydraulic Machines Laboratory (LAMH) test stand and is excited with eight piezoelectric actuators during the speed-no-load operating condition and at the best efficiency point. It will be shown that it is possible to excite a specific nodal diameter mode by injecting a specific excitation shape to the piezoelectric actuators, using stationary and traveling wave excitation.