Identification of full-load cavitation surge onset in hydropower units through monitoring data clustering

Arthur Favrel, Ghofril Kahwati and Quentin Dollon

Institut de recherche d'Hydro-Québec (IREQ), 1800 boul. Lionel-Boulet, Varennes, QC, J3X1S1, Canada

E-mail: `favrel.arthur@hydroquebec.com`

Abstract. In this paper, a novel approach for identifying and modelling the onset of cavitation surge in hydropower units is proposed. For the considered test case, three regimes of cavitation surge are identified through data clustering based on experts' criteria. This clustering allows predicting onset conditions of each regime as a function of the unit's operating parameters by using a Machine Learning classifier algorithm. The influence of the surge frequency and amplitude on the response of both the shaft line and generator is also highlighted. Finally, the potential for automatising this approach through data dimension reduction and clustering algorithms is briefly explored and discussed.

1. Introduction

Francis turbines experience various unsteady flow phenomena while operating in off-design conditions [1]. At full-load, the onset of the so-called cavitation surge can be observed, inducing power oscillations and shaft vibrations [2]. In this case, hydropower operators set up power restrictions at full-load to maintain those vibrations levels and power oscillations below an acceptable threshold. These restrictions are usually based on the analysis of data from field tests performed after unit's commissioning. However, the onset and amplitude of the cavitation surge depend on various parameters, whose influence cannot be considered through only analysing field tests data measured at specific conditions. Even if continuous monitoring data are used, considering the multi-dimensionality of the phenomenon to define appropriate restrictions remains challenging without pertinent tools. This represents an important challenge for hydropower operators since improper restrictions can lead to operations in damaging conditions or, on the contrary, a lack of generation in the case of too restrictive limits.

To overcome these limitations, ongoing research at the Hydro-Quebec Research Institute aims to develop data-driven methods for identifying and characterising draft tube (DT) flow instabilities in hydropower units. The methods will be based on Machine Learning (ML) algorithms applied to continuous monitoring data. They should allow predicting DT instabilities onset and provide probabilistic estimates of their effect on shaft vibrations and power oscillations as a function of multi-dimensional parameters. The methodology is presented in Figure 1. This paper presents preliminary results demonstrating the potential of data-driven methods for flow instabilities detection and characterisation. This is achieved through analysing monitoring data of one medium head prototype Francis turbine operating in full-load conditions.