DYNAMIC CHARACTERIZATION OF HYDROELECTRIC TURBINE IN TRANSIENT USING OBMA AND PHASE-SHIFT ANALYSIS

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RESEARCH WORK

Design and exploitation of hydroelectric turbines relies on the knowledge of their dynamic behavior. This last enables one either to get a good assessments of life duration or to set up predictive-based maintenance sessions. In needed, two sources of information are mandatory to characterize the mechanical behavior of a structure: numerical simulations, and experimental data processing. The first field gives a whole and detailed analysis of the behavior in any expected regime, but needs to be validated by the second to be reliable, which is a straightforward consequence of the strong assumptions made to reduce computing burden. The second method aims at achieving *in-situ* measurements to extract dynamic features; these features will be highly fragmented, but in general closer to reality for a given measured operating condition. These two sources of information are then crossed to obtain a hybrid representation of the dynamic behavior.

However, one of the problems with experimental analysis is the cost of data acquisition. To reduce financial burden of measurements, the idea is to extract a maximum of information from transient records instead of several stationary records, which would make the measurement less time consuming. Our goal is to determine whether the signal processing is able to extract precise and suitable features from these transient measurements.

ABSTRACT

The purpose of this paper is to consider the possibility of extracting modal parameters of a Francis hydroelectric turbine in transient conditions by focusing on resonance regions generated by the interaction of a structural mode with a frequency-variant harmonic pressure pulsation. Especially when numerous modes are in the same bandwidth, this method separates them by exciting only matching shapes. The resonance retrieval is done using Order Tracking (method used to extract a specified harmonic from the signal), and a classical Modal Identification algorithm is then used to feature the isolated mode. Furthermore, a phase-shift analysis is made between captors measuring resonance in order to both localize the mode and determine the shape.

KEYWORDS: Francis Runner, Resonance, Order Tracking, Modal Analysis, Transient

LIST OF REFERENCES

- Di Lorenzo, “OMA for rotating machines, challenges and solutions”, PhD (Fredirico II Naple Univ. KU Leuven Univ.), 2017
- Di Lorenzo et *al*., “Industrial applications of advanced modal identification on operational rotating machineries”, Proceeding of 29th ISMA, p.2833 to 2847, 2016
- Janssens et al., “Order-based resonance identification using operational PolyMAX”, Proceeding of 34th IMAC, 2006
- Stephens et *al*., “Order tracking signal processing for open rotor acoustics”, Journal of Sounds and Vibration 333, p.3818 to 3830, 2014
- Borghesani et *al*., “The velocity synchronous discrete Fourier transform for order tracking in the field of rotating machinery”, Mechanical Systems and Signal Processing 44, p.118 to 133, 2014
- Moisan et *al*., “Self-excitation in Francis runner during load Rejection”, IOP Conf. Ser.: Earth Environ. Sci. 22 032025, 2014
- Léonard, “Phase spectrogram and frequency spectrogram as new diagnostic tools”, Mechanical System and Signal Processing 21, p.125 to 137, 2007
- Siu-Kui, “OMA : Modeling, Bayesian Inferences, Uncertainty Laws”, Springer Editions, 2017
- Peeters and *al*., ‘Uncertainty Propagation in EMA”, Proceeding of the 32th IMAC, 2014
- Arpin-Pont et *al*., “Strain gauge measurement uncertainties on hydraulic turbine runner blade”, IOP Conf. Ser. : Earth Environ. Sci. vol. 15 62042 , 2012
- Seidel et *al*., “Dynamic loads in Francis runners and their impact on fatigue life”, IOP Conf. Ser. : Earth Environ. Sci. vol. 22 032054 , 2014
- Huang et *al*., “Fatigue analyses of the prototype Francis runners based on site measurements and simulations”, IOP Conf. Ser. : Earth Environ. Sci. vol. 22 012014 , 2014
- Nennemann et *al*., “Hydrodynamic damping and stiffness prediction in Francis turbine runners using cfd”, IOP Conf. Ser. : Earth Environ. Sci. vol. 49 072006, 2016
- Gagnon et *al*., “The role of high cycle fatigue (hcf) onset in Francis runner reliability”, IOP Conf. Ser. : Earth Environ. Sci. vol. 15 022005 , p.178 to 187, 2012.
- Nennemann et *al*., “Challenges in dynamic pressure and stress predictions at no-load operation in hydraulic turbines”, IOP Conf. Ser. : Earth Environ. Sci. vol. 22 032055, 2014
- Gagnon et *al*., “On the stochastic simulation of hydroelectric turbine blades transient response”, Mechanical Systems and Signal Processing vol. 32, p.178 to 187, 2012