Structural Health Monitoring of a Francis Turbine

EnerjiSA Enerji Üretim A.Ş.

Group Members

Ali Yasin Akalın
Kerem Enes Ayyıldız
Jak Kohen Kasar
Semih Pekol

Faculty Member

Bekir Bediz

Company Advisor

Talip Eskikale

ENERJiSA

Sabancı Üniversitesi
FACULTY OF ENGINEERING AND NATURAL SCIENCES

Introduction

Our main purpose has been developing an on-line structural health monitoring system based on VCM for already operating Francis turbines in a hydro-power plant.

Vibration Condition Monitoring (VCM) is about monitoring a plant's vibration in order to understand plant's structural health at a time. It monitors the plant real-time to predetermine upcoming faults in the system.

Objectives

- Obtain natural frequency of structure

- Give warning/critical damage by detecting

- Develop a software

- Train a machine learning model

Damage Identification Levels

Level 1: (Detection)

- Giving a qualitative indication that damage is present with a probability

Level 2: (Localization)
- Locating the position of a damage

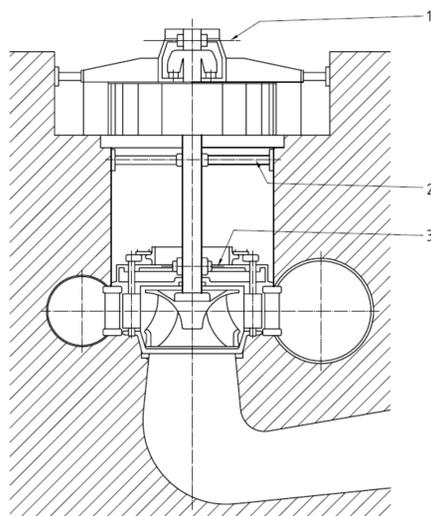**Level 3: (Assessment)**
- Informing on severity of a damage

FIGURE 1: MEASUREMENT LOCATIONS FOR A GROUP 3 MACHINE SET WITH VERTICAL SHAFT AND BEARING HOUSINGS WHICH ARE ALL BRACED AGAINST THE FOUNDATION, USUALLY WITH OPERATIONAL SPEEDS OF BETWEEN 60 R/MIN AND 1800 R/MIN

Level 4: (Consequence)
- Informing about actual health and safety condition of a structure given the damaged status

Methods

Short-time Fourier transform (STFT) is a time-frequency method which is used to condition monitor rotating machines. STFT method can provide more information about a signal in both time and frequency domains.

Therefore, STFT gives a better representation of the signal than the conventional methods in machine condition monitoring.

Methods (contd.)

The basic idea of the short-time Fourier transform is that if one wants to know what frequencies exist at a particular time, then take a small part of the signal around that time and analyse it, neglecting the rest of signal. Compared to FFT, STFT illustrates use both time and frequency domains at the same time.

Furthermore, STFT improves the frequency resolution and time resolution. By providing this it helps us to examine the results more efficiently.
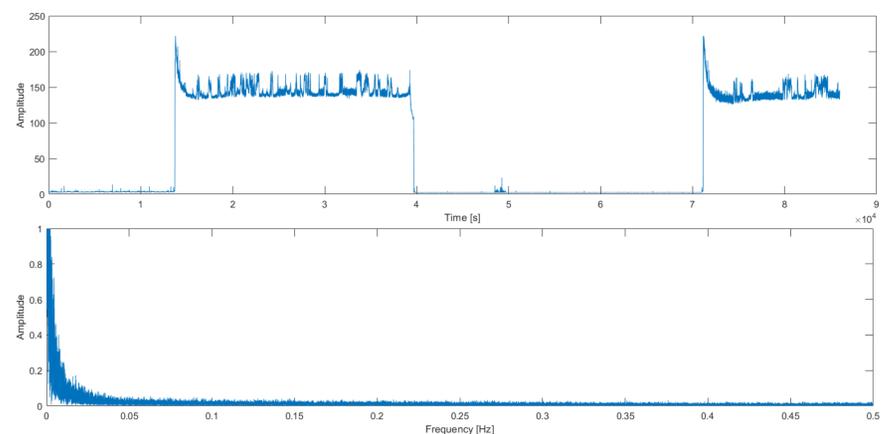

FIGURE 2: ANALYSIS OF DATA FROM PLANT K1; DISPLACEMENT SENSOR ON GENERATOR, LOWER PART RX; 02-07-2018
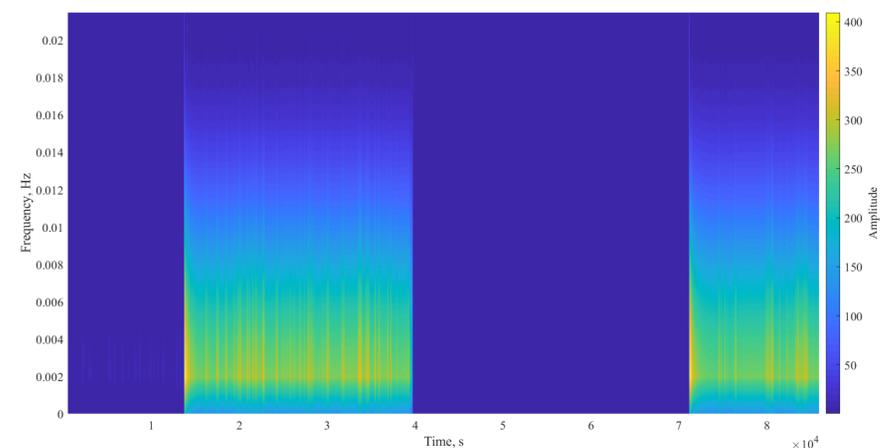**ABOVE:** PEAK-TO-PEAK DISPLACEMENT IN TIME DOMAIN   **BELOW:** FFT

FIGURE 3: SPECTROGRAM OF DATA FROM PLANT K1; DISPLACEMENT SENSOR ON GENERATOR, LOWER PART RX; 02-07-2018

Encountered Problems

In our data, sampling time was 1 second(1Hz). When we converted time domain data to frequency domain we were only able to observe between 0–0.5 Hz frequency range because of the 1 second sampling time. To have a better understanding of frequency domain, we need to have a wider frequency range(up to 50~ Hz). The reason for this is that vibration data was taken from a turbine working at 333 rpm (5.55Hz). Hence our interest was in multiples of this natural frequency; where we expect large harmonic oscillations. Therefore, we should have obtained wider frequency range to analyze the data.

Lee, J. (2013). Sound and Vibration Signal Analysis using Improved Short-Time Fourier Representation.   International Journal of Automotive and Mechanical Engineering, 7, 811-819. doi:10.15282/ijame.7.2012.1.0066
Rytter, A. (1993). Vibrational Based Inspection of Civil Engineering Structures. Aalborg: Dept. of Building Technology and Structural Engineering, Aalborg University. Fracture and Dynamics, No. 44, Vol.. R9314