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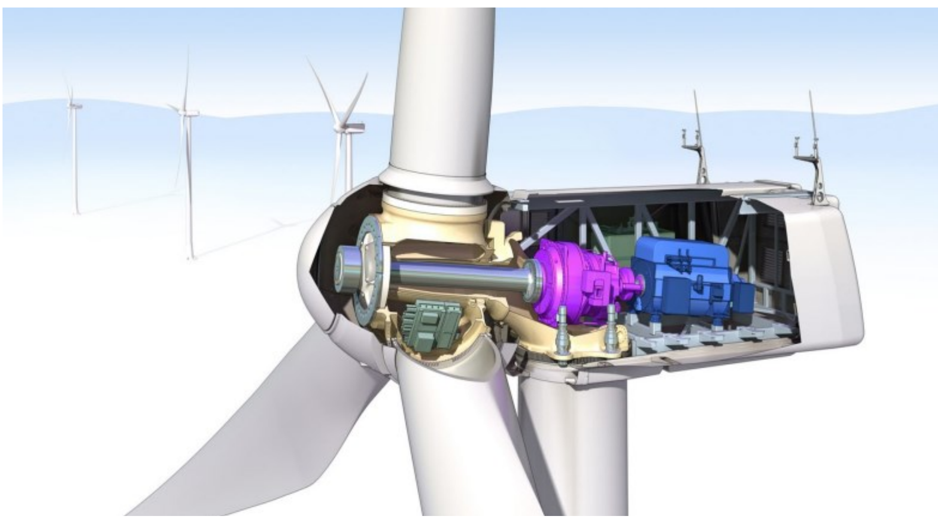
Monitoring system of a wind turbine



Main objectives

Develop and validate on experimental signals a monitoring system dedicated to bearing faults in wind turbines:

- faults effects on the measured quantities,
- monitoring system design (fault detection and localization),
- implementation,
- validation on experimental signals.

Context

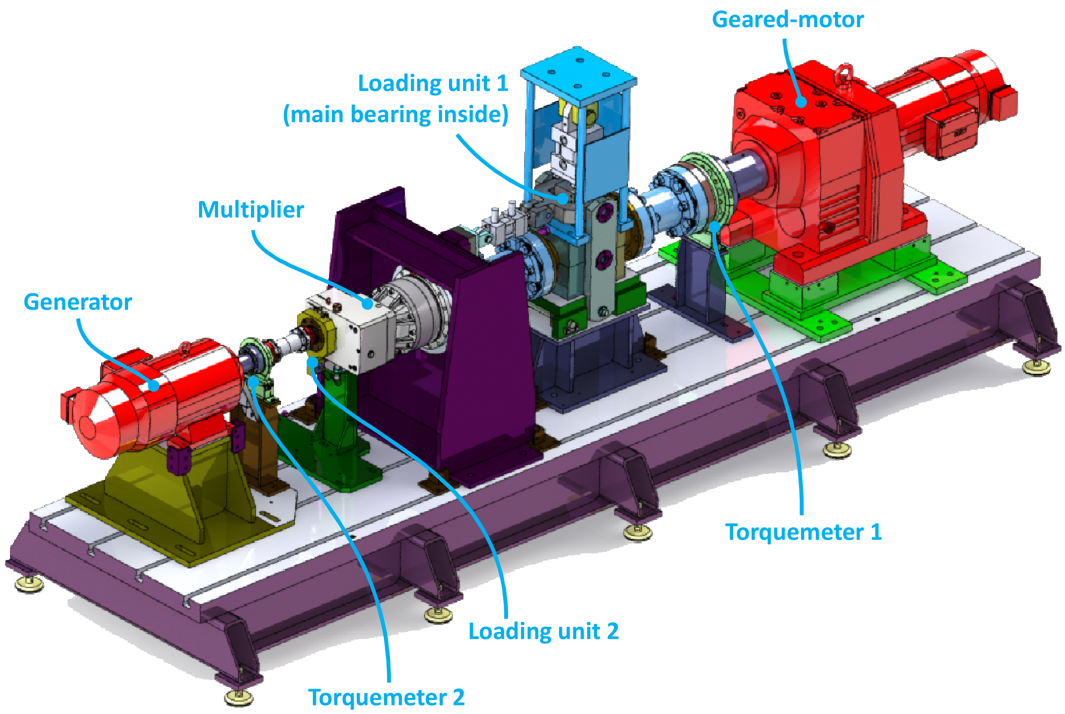


Figure 1: Endurance wind turbine test bench

The test bench illustrated in Fig. 1 was developed in order to mimic the structure of a geared wind turbine, and to simulate its behavior. A geared-motor is supplied with a variable frequency inverter in order to simulate the effects of wind speed variations. This motor drives a low-speed shaft (LSS) which is the input of a gearbox multiplier. The output of the multiplier is the high-speed shaft (HSS), which finally drives an electrical generator.
Thanks to this bench, an endurance test was conducted on the main bearing until it developed outer and inner raceway faults. During this test, several quantities were recorded: LSS and HSS instantaneous rotating speed, vibrations measured by accelerometers on the bearing housing, currents and voltages measured at the stator of the generator. Moreover, the rotating speed of the LSS was set to a constant mean value of 20 rounds per minute. This means that the whole process was running under stationary operating conditions and that the recorded signals can be considered as stationary. Figure 2 shows the internal condition of the bearing at the end of the test, where a high degradation level of both inner and outer races is clearly visible. Such faults generate mechanical phenomena (mechanical impacts, mechanical torque fluctuations...) with a frequency proportional to the shaft rotating frequency f_r:

- outer race fault : $f_o = 7.65 f_r$ Hz,
- inner race fault : $f_i = 10.35 f_r$ Hz.

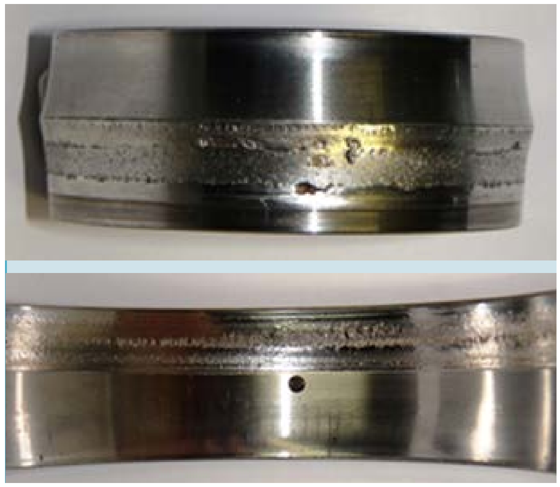


Figure 2: Condition of the bearing at the end of the test (top: inner race; bottom: outer race)

These relations are obtained by using the internal geometry of the main bearing, and are useful to elaborate efficient fault indicators from the measured signals.

Project

1 Objectives

The goal of this project is to use the measured data in order to detect and characterize the faults which occurred in the main bearing during this test:

- determine the faults signature in the different measured quantities,
- from this, propose one or several fault indicators able to detect and identify the type of fault which occurred in the main bearing,
- implement these indicators,
- validate and compare their performance with experimental signals.

2 Hints and additional stuff

The available data are stored in files with the following name : `yyyy-mm-dd-hhmms.mat`, where:

- `yyyy-mm-dd` is the recording date,
- `hhmm` is the recording hour,
- `s` is the quantity which have been recorded (`hss` and `lss` for rotating speeds, `i` and `v` for three-phase line currents and line voltages, `vib` for three-direction vibrations).

Each file contains a structure where are stored the data, and different useful informations (sensor name, units, sampling frequency, ...).

Concerning electrical quantities:

- measured quantities are line quantities,
- data containing line voltages are defined as follows: `v1` $= v_{12}$, `v2` $= v_{23}$, and `v3` $= v_{31}$.

Concerning vibrations:

- the accelerometers are all located around the main bearing but not at the same position,
- the measured directions are defined as follows: `Accel1` = axial, `Accel2` = horizontal, `Accel5` = vertical.