Results on built-in vibration sensors inside planetary gears

Hilbert, Marc; Schütz, Markus; Boos, Domenic; Bernet, Christian; Baltes, Ralph; Nienhaus, Karl
Institute for Mining and Metallurgical Machinery, RWTH Aachen University, Aachen, Germany

Abstract

The Internet of Things refers to a network and virtual representations of individual objects (e.g., machine part) in an internet-like structure. This representation enables the comparison of the behavior of the real world object to a virtual counterpart. On the virtual counterpart the reactions of loads or an estimation of remaining life time can be simulated. To realize these industrial visions each object's needs to have cheap and reliable systems that monitor the object conditions during the full lifetime. Only with these data a mapping of the virtual object will be possible and, therefore, an estimation of the remaining life can be provided. This work will describe a method that covers these challenges on condition monitoring of a wind turbine planetary gear, especially the planet meshing and the planet bearing using a measurement system mounted on the planet gear carrier. [1]

Objectives

The goal is to measure vibrations inside the gearbox on the planet carrier with a standard acceleration sensor and transmit the data to a receiver wirelessly. Because the sensor and the transducer are installed on the rotating machine part, they can be placed close to the vibration source. Measuring the vibration directly on the planet gear carrier, as presented in this work, enables the use of conventional analysis methods to monitor the bearings of the planet. This will provide more reliable results of the condition of the gear mesh and planetary bearings as at the moment with conventional condition monitoring systems possible. [2]

Methods

The complex and time-variant transfer function between damage and sensor is the main problem of planetary gearbox condition monitoring. A damage in a planet bearing produces several transfer paths of the signal to the sensor (Figure 2). For the transfer of the signal, the following adverse factors are important:

1. lubrication of the planet bearing and the planet mesh,
2. gap between planet bearing and planet mesh,
3. rigidity of the planet mesh and the gear structure and
4. position of the planet gear respectively to the sensor.

This leads to a substantial time-varying attenuation of the vibration signal. Despite extensive analysis, damage detection of rolling bearings of planet gearboxes with accelerometers on the planet gear housing is very difficult. This work is part of the iMaSS project (integrated machine sensor system) and is a new approach for a measuring transducer installed directly on the planet carrier. [3][4]

Results

A first state of the hardware that is developed, is able to connect to sensors such as strain gauge, accelerometer, temperature sensor, etc. The required energy is provided by a lithium-ion battery. To reduce the energy consumption an intelligent energy management system is integrated. Data preprocessing and transmission is conducted on the main circuit board. On the secondary circuit board a micro SD card is installed. All measurement data can be stored. The data transfer to the PC is realized via wireless low power protocol. [1]

The sensor is tested with two wind turbine planetary gearbox applications so far:

Test bench measurement on a planet carrier of a 2MW wind turbine gearbox:

The measurement was performed on a standard 2MW planetary gearbox on the first gear stage. The sensor was mounted with magnets on the planet carrier through maintenance holes and the vibration was measured in radial direction. While the test different speed and torque were applied. Speed, torque, and the vibration waveform - diagram are shown on the right.

Field measurement on a planet carrier of a 2.5 MW wind turbine gearbox:

The sensor was installed on the outside of the planet carrier (which is at the same time the connection to the rotor). The top diagram shows the influence of the gravity on the vibration signal; the measurement shows the vibration signal during start-up. The bottom diagram shows the envelop spectrum during constant speed.

Conclusions

The introduced new approach allows acquiring vibration data as well as temperature and deformation data directly on the vibration source on rotating parts inside gearboxes of wind turbines. Hence, the known deficits of condition monitoring of planet bearings can be solved. The innovative sensor system provides a tool to verify and improve the simulation of new designs of gearboxes.

Acknowledgement

The iMaSS project is funded by the “NRW-EU-Ziel 2” program and the “Europäischen Fonds für regionale Entwicklung” (EFRE).

References


Analysis of Operating Wind Farms 2014 - EWEA Technology Workshop, Malmö, 9-10 December 2014