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NOVEL DRIVETRAIN MONITORING BY UTILIZING EMERGING INDUSTRIAL BUILT-IN VIBRATION SENSORS

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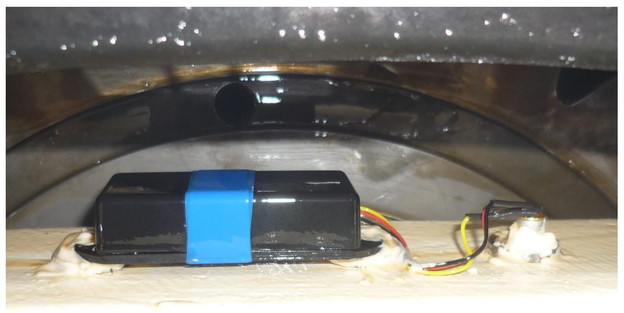
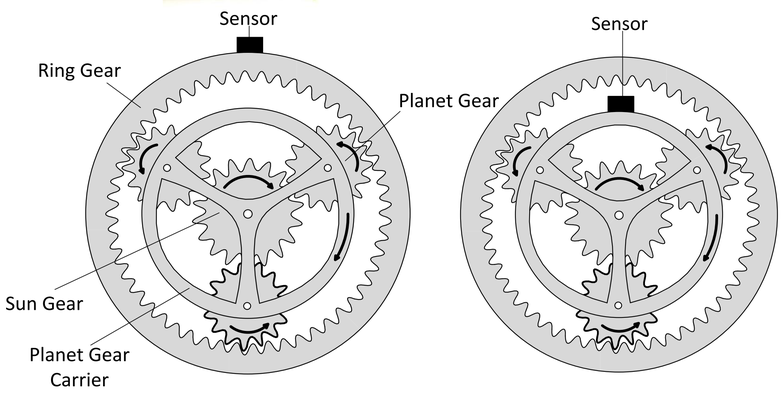
Introduction

Wind turbine (WT) drive train monitoring presents an absolute necessity. In fact, monitoring the condition of mechanical components such as bearings and gears can reduce OPEX and result in lower costs of energy. This effect can be shown for offshore WTs in particular. Taking a closer look at modern offshore WT's, they are designed with large planetary gear stages, mainly because of their high power density. Built-in vibration sensors systems were developed to improve overall condition monitoring results of gearbox components.

Objectives

Figure 1 shows an planetary gear with attachment of the sensor to the outside of the ring gear (left) and planet gear carrier (top and right).





As example of built-in sensors, in this work the vibrations inside the gearbox on the planet carrier with a standard acceleration sensor is measured. Then the composition of the vibration signal is researched with a focus on parasitic effects which would make condition monitoring challenging. A comparison between the sensor positions regarding their parasitic effects on the ring gear and the planet carrier is shown.

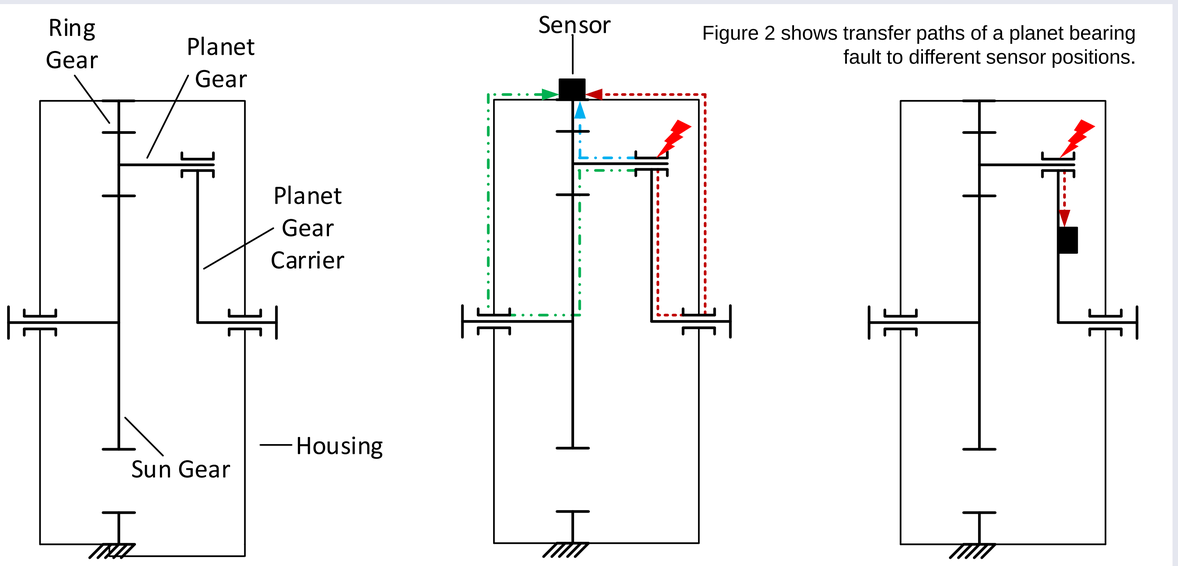
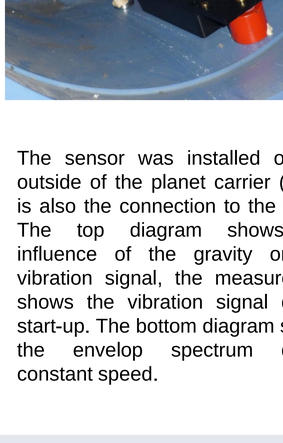


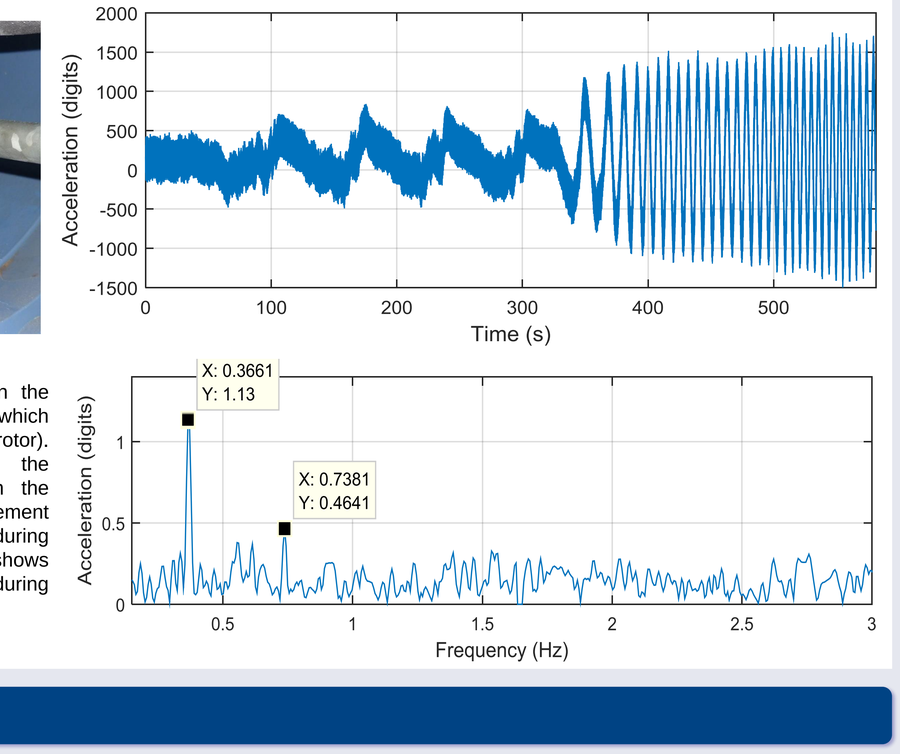
Figure 2 shows transfer paths of a planet bearing fault to different sensor positions.

Measurements

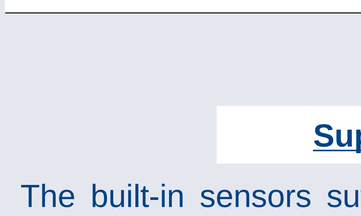
Test bench measurement on a planet carrier of a 2MW wind turbine gearbox:

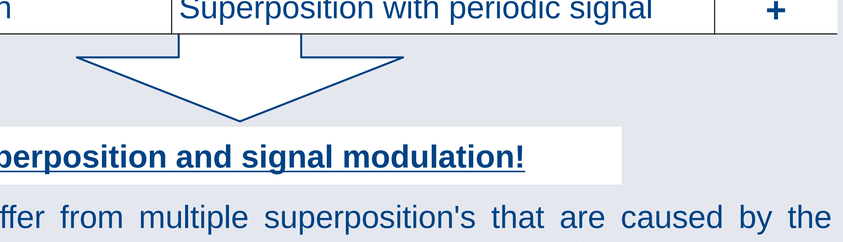
The measurement was performed on a standard 2MW planetary gearbox on the first gear stage. The sensor was mounted on the planet carrier through maintenance holes and the vibration was measured in radial direction





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 also 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.

Comparison of sensor positions

Sensor on the ring gear:

Physical effect	*Signal disturbance*	*Impact*
Lubrication of planet bearing and planet mesh	Damping	+
Gaps in planet bearings and planet meshing	Amplitude Modulation	+++
Rigidity of planet mesh and gear structure	Damping	+
Position of planet gear respectively to the sensor	Amplitude Modulation	+++

Complex and time-variant transfer function!

This leads to a substantial time-varying attenuation of the vibration signal on his multiple complex transfer paths.This can be seen as the main problem of planetary gearbox condition monitoring. Despite extensive analysis, fault detection of rolling bearings of planet gearboxes on the planet gear housing is very difficult.

Built-in sensor on the planet carrier:

Physical effect	*Signal disturbance*	*Impact*
High temperature environment	None	o
Submerging of the sensor in the oil	Amplitude Modulation	+
Centrifugal acceleration	Superposition with offset	+
Gravitational acceleration	Superposition with periodic signal	+

Superposition and signal modulation!

The built-in sensors suffer from multiple superposition's that are caused by the movement of the sensor. Additional there seems to be a amplitude modulation. The signal needs to be analyzed considering parasitic effects, as well as design and position of the sensor needs to be well defined to minimize these effects.

Conclusions

The built-in sensor can be placed close to the vibration source, because it is installed on the rotating gearbox part, the planet carrier. Measuring the vibration directly on the planet gear carrier enables the use of conventional analysis methods to monitor the bearings of the planets. This reduces the impact of the complex and time-variant transfer function on the housing but adds superposition and other signal modulation as parasitic effects to the vibration signal. The impact of that parasitic effects on the vibration signal of the built-in sensor are from more simple nature and therefore can be removed more easily. In general it can be said that built-in vibration sensors provide more reliable results of the condition of the planetary bearings as at the moment with conventional condition monitoring systems possible.

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