Detection analysis of lubricated gear failures using a vision-assisted condition monitoring system

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MOTIVATION

Gearboxes are commonly used in industry when there is a need to transfer power from one shaft to another accompanied by a necessary change of rotational speed or torque. The two most critical components in gearboxes are gears and bearings. Root-cause analysis of gearbox failure in wind turbines learns that 70% is due to bearing failure, and 26% is due to gear failure [1]. Failure of gearboxes often leads to significant economic losses as a result of substantial downtime and high replacement costs, particularly in harsh operating environments with limited access (such as for offshore wind turbines) and it, therefore, remains an important area for scientific research and innovations.

Currently, the condition of gearboxes are mostly monitored using systems which rely on vibrational monitoring in combination with thermal analysis of the mechanical components and the lubrication system. A few attempts have already been made to create automated defect detection systems using digital image analysis. However, current generation methods are always performed offline and sometimes require a shutdown, and even a (partial) disassembly of the machine.

This PhD project will focus on advancing the understanding and developments of condition monitoring of gears combined with machine learning analysis. The aim is to avoid critical failures, and moreover, to automatically detect wear and damage initiation and quantify the evolution in time, which allows to better schedule maintenance. To achieve this, a vision based condition monitoring system (VCM) will be developed and installed on a back-to-back gear tester at the site of the tribology research group of Soete Laboratory (see figure 1).

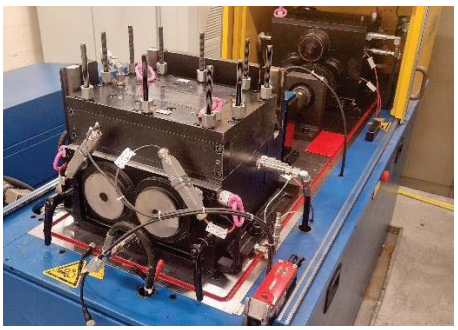

Figure 1: Back-to-back gear tester at Soete Laboratory

OBJECTIVES

The main objective of this project is to develop and assess a multi-sensor condition monitoring framework for detecting automatically initiation of surface damage of gear flanks of a meshing gear-pair and its spatio-temporal evolution. The project envisions monitoring both spur and helical gears with automatic detection of different gear failure modes, i.e. rolling contact fatigue or pitting (shown in figure 2),

The following scientific objectives are defined

- Develop and implement an automated vision-assisted multi-sensor condition monitoring framework for capturing the initiation and evolution of gear damage
- Quantify the degradation of gear flanks through accelerated life testing, resulting in the creation of the 'ground' truth.
- Compare, evaluate, correlate and use direct and indirect measurements for the detection of (specific) damage phenomena of gear flanks.
- Understand the application possibilities and rank different sensors, machine learning techniques and machine vision methods for detecting degradation of gear flanks.

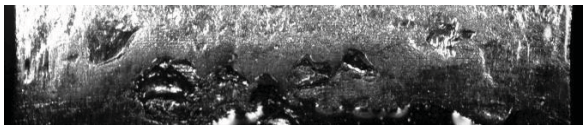

Figure 2: Gear degradation at the pitch line

APPROACH

A vision-based condition monitoring system (VCM) will be installed on a back-to-back gear tester that will be used to perform accelerated lifetime tests for the generation of the previously mentioned surface defects. This VCM system will consist of two major sub-systems:

1) Vision system: A camera will be mounted and aimed at pair of meshing gear teeth so that the surface of the teeth can be captured during the operation of the machine.
2) Indirect measurement system: a system that does not directly observe or measure the initiation and progression of damage and wear in mechanical components but relies on the detection of anomalies or patterns characteristic to pitting in the signals of diverse sensors which measure more global system condition parameters, e.g. temperatures, acoustics, power consumption and vibrations.

Both systems will be studied for their accuracy, robustness and reliability.

After the separate analysis the results from the direct and indirect monitoring system will be coupled so that their application use and effectiveness can be studied. This will result in the possibility for ranking different techniques and methods for condition monitoring system of lubricated gearboxes. A possible result could be a quantified p-f curve that visualises this ranking, an example of a p-f curve is shown in figure 3.

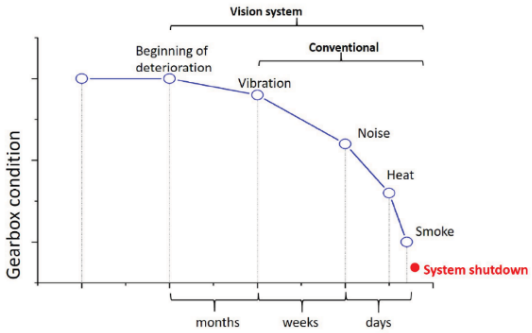

Figure 3: p-f curve ranking different sensors

REFERENCES

[1] htlgroup, "Why do turbine gearboxes fail." https://www.htlgroup.com/general/why-do-turbine-gearboxes-fail/.

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