Wind Turbine Condition Monitoring: Experimental Validation of a Thermal Network Model

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Motivation

- Operation & Maintenance contribute 20-30% of total levelised cost of wind energy [1].
- Gearboxes are responsible for up to one third of all lost wind turbine availability [2], each failure downtime of around 600 hours [3].
- Early detection of incipient faults prevents major component failures and allows for implementation of predictive repair strategies.
- Condition monitoring plays an important part of predictive maintenance.
- Recent state of the art condition monitoring techniques are data driven are rely on large amounts of data.
- This research proposes using physical modelling to understand behaviour

Background & Research Question

- Deterioration of the drivetrain components will often be reflected in an increase in losses, resulting in elevated temperatures [4].
- Monitoring temperature changes are useful to understand how the thermal behaviour of a gearbox can change as a result of a fault.

Can temperature be used to identify gearbox faults?

Spatially	Temporally	Categorically
• Can a thermal model be use to locate a gearbox fault • If so, to what degree of spatial accuracy?	• Can a thermal model be used to identify failures developing in short, medium and long term?	• Which failure modes can be identified? • Which cannot be identified? • Can this technique be applied to different types of gearbox

Methodology

- Figure 1 shows the methodology of analysing thermal behaviour of an 11kW, parallel axis gearbox.

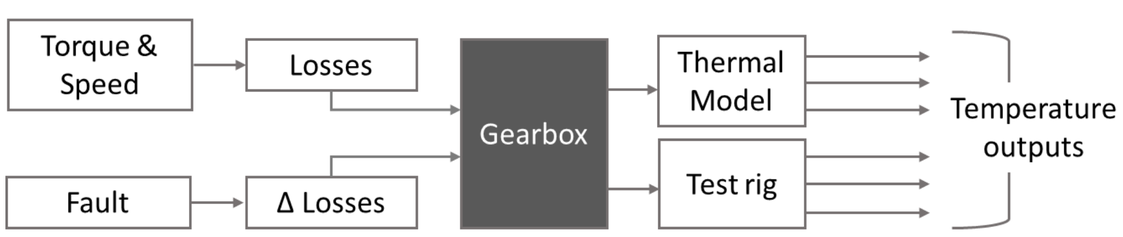

Figure 1

- Thermal model is generated using thermal network method, where components represent nodes, connected by thermal resistances.
- Losses in the gearbox are calculated, based on the torque and speed and are added to the model as heat inputs.
- A fault can be simulated by additional heat at a particular component.
- A test rig at University of Strathclyde is used to collect temperature measurements which can be used to validate the thermal model.

Results

- A preliminary experiment was conducted to verify the methodology used in the thermal model.
- Figure 2 shows temperature measurements of a healthy gearbox from the experiment data (solid lines) and thermal model (dashed lines).
- Temperature results in general agreement.
- In some cases the thermal model measurement were lower than the experimental.
- There are uncertainties in the thermal network model and experimental data acquisition (DAQ) system.

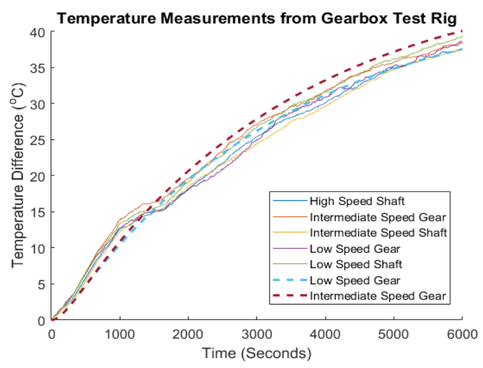

Figure 2

Next Steps

- The DAQ system itself plays a significant role, as temperature measurement method influences diagnostic capabilities [5].
- Next steps involve improving the certainty of the experimental data by redeveloping the DAQ system and experiment strategy to improve accuracy.
- Figure 3 shows all aspects of experiment that will be taken into consideration to ensure validity, reliability and reproducibility.
- Heat pads will also be used on the test rig to simulate faults.

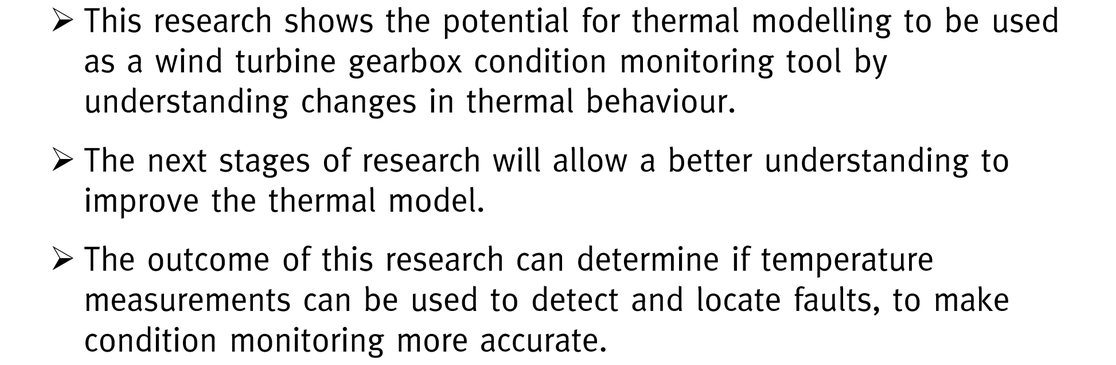

Figure 3

Conclusions

- This research shows the potential for thermal modelling to be used as a wind turbine gearbox condition monitoring tool by understanding changes in thermal behaviour.
- The next stages of research will allow a better understanding to improve the thermal model.
- The outcome of this research can determine if temperature measurements can be used to detect and locate faults, to make condition monitoring more accurate.

References & Acknowledgements

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This work has been funded by the EPSRC, project reference number EP/L01680/1.