

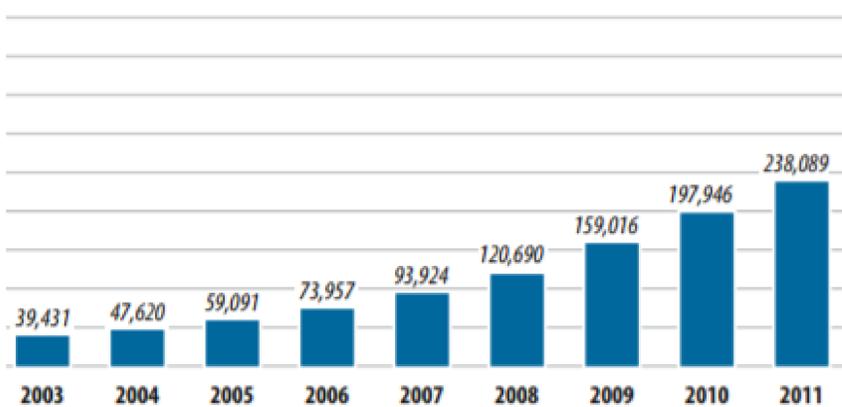
Fault detection of drivetrains in offshore wind turbines by digital twin model approach

Sigrid S. Johansen / Amir R. Nejad / Marine Machinery / NTNU

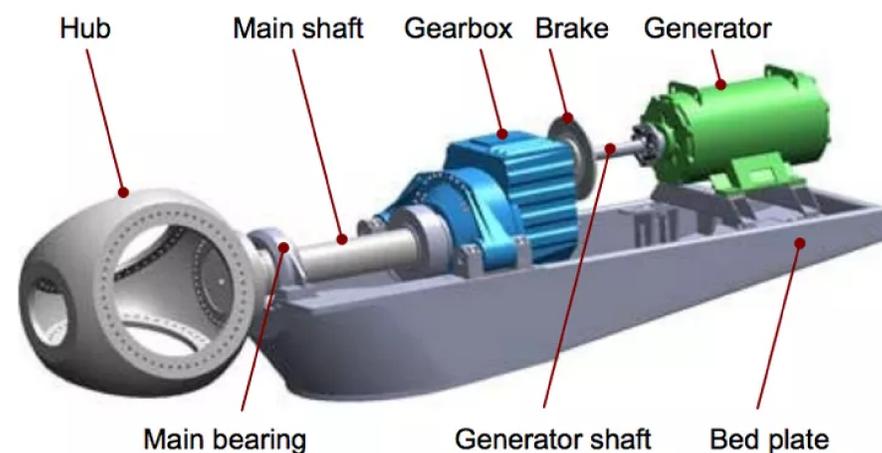
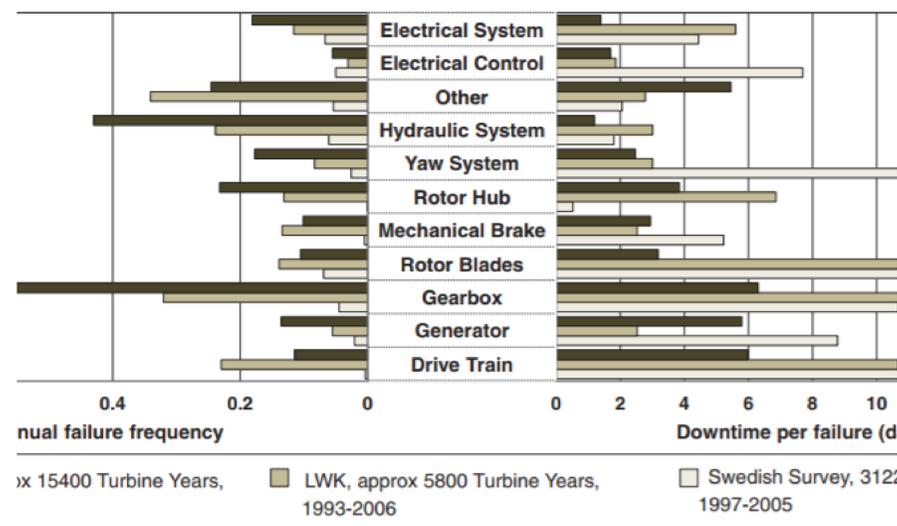
BACKGROUND

Renewable energy in general, and wind energy specifically, is increasing in capacity and is projected to continue to grow. With the expansion of wind turbines, an increased segment is found offshore. Moving from land based to offshore, wind turbines leads to more power extracted, less visual impact and less land displacement. However, new challenges arise, concerning technical issues and cost. There is an increased pressure to reduce costs where ever possible.

GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 2000-2015

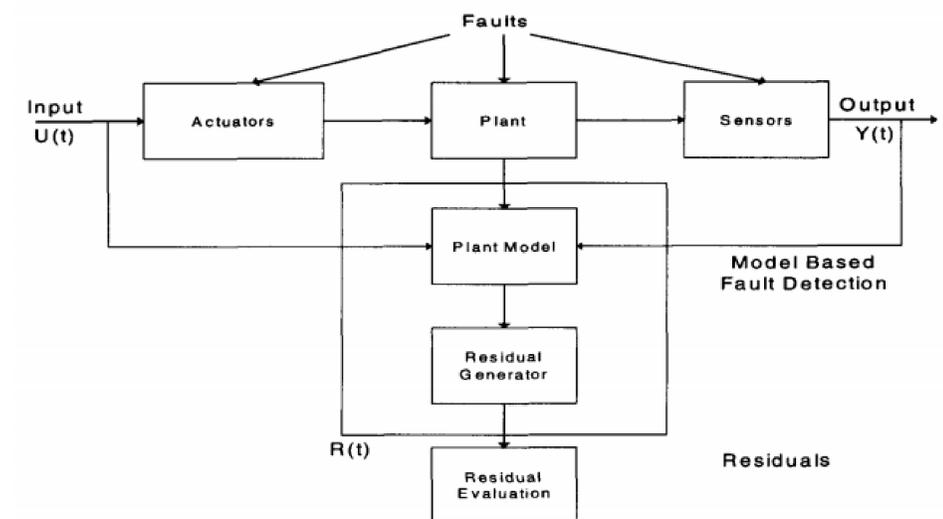


In turbines, the operation and maintenance cost is a significant part of the budget, and a decrease in cost would make wind schemes more motivational to explore and invest in. Operation and maintenance costs could be reduced by optimizing the maintenance strategy used. By focusing on the drivetrain, gearbox and bearings, quality maintenance strategies would contribute significantly as they are heavily causing costly downtime for the turbines.



METHODOLOGY

A data-based condition monitoring approach will be out-staged by a model-based system that could be employed holistically. Here, a digital twin is suggested as a probable solution.

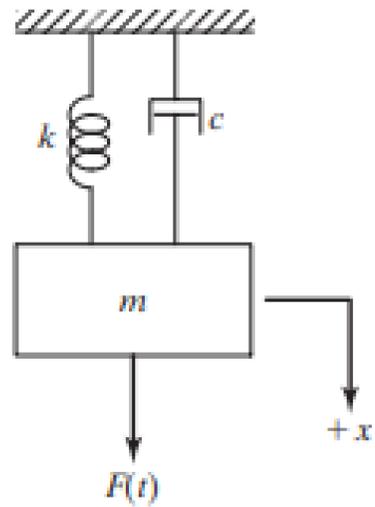


Fault detection done through spectral analysis and FFT shows different patterns for different typical faults such as;

- Misalignment
- Bent shaft
- Unbalance

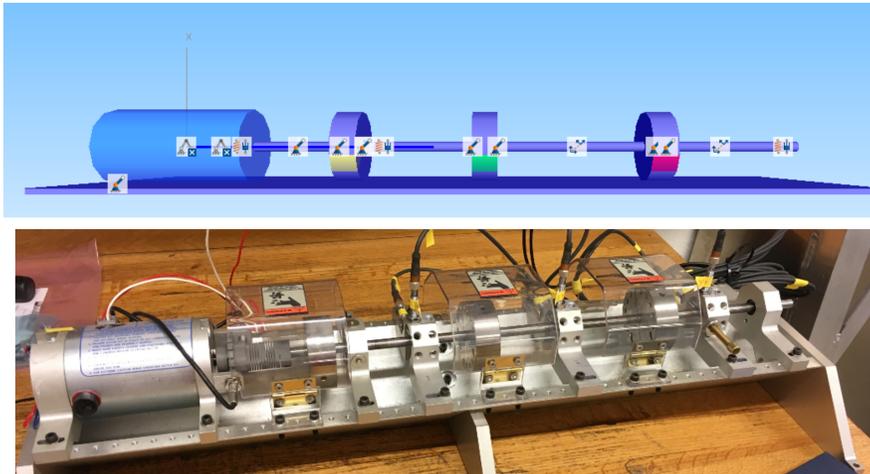
Identifying the xRPM in a FFT analysis, it is possible to evaluate which faults could be present. They could then be modelled in a digital twin through altered stiffness in bearings, or in force input values related to the fault at hand.

MODELS



1DOF

When considering the model in one degree of freedom, the modelling is easier to model and faster to do calculations on. A modal analysis is performed to find characteristic values.

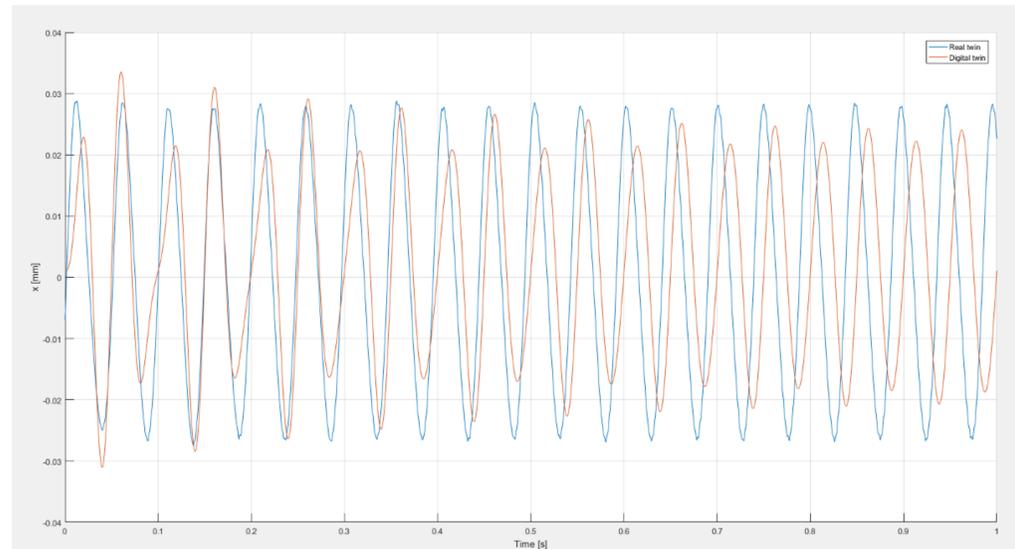


3DOF

When considering the model in three degrees of freedom it introduces more detail and complexity, in regards to i.e. DOF in model and inverse methods. One of the issues is figuring out the correct and coupled stiffness in all directions. Fault detection will be performed through FFT analysis. Uncertainty will be discussed over experimental models.

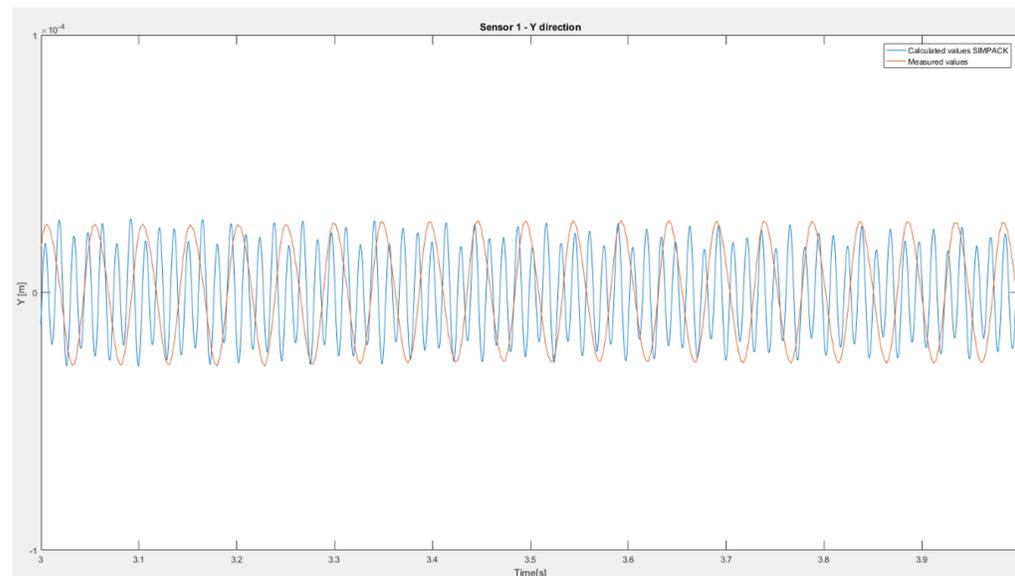
RESULTS

1 DOF



The results in 1 DOF has amplitudes that corresponds closely to the real twin, however, the frequency is not completely compliant.

3 DOF



In 3DOF the resulting response of the digital twin is very close in amplitude, the same issue is with frequency. These issues will be addressed in further work.

DISCUSSION

The results thus far implies that a more accurate digital twin could perhaps be achieved in 1DOF. This could be due to the coupled stiffness throughout the model being difficult to achieve correctly. An experimental model will be proposed in the following weeks to employ a case study to find suitable and sufficient for different fault scenarios.