Continuous Operational Modal Analysis of an Offshore Wind Turbine

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Relevance for operational modal analysis

Operational Modal Analysis (OMA) allows to analyze the dynamical behavior of offshore wind turbines during their normal operation. Since wind turbine structures are getting bigger and thus more vulnerable for damage operational modal analysis will be vital to

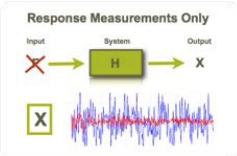
- **improve the design of the structures**
- **achieving an optimal control**
- **prediction of remaining life time**
- **scour monitoring**

Operational Modal analysis

Operational Modal Analysis (OMA) allows modal parameters to be estimated in operational conditions based on vibration responses only, without measuring the excitation forces.

Modal parameters to be estimated

- **natural frequencies**
- **damping ratios**
- **mode shapes**



Measurements at Belwind on Vestas V90 3MW

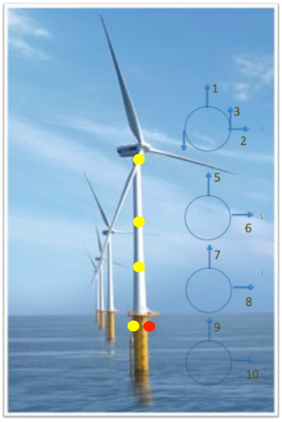
3 months campaign with focus on identification dynamics of wind turbine (tower and foundation)

Location: Bligh Bank, 46 km off shore

Area: 17 km²

Distance between the turbines: 500 – 650m

Sea depth: 20 – 37m



Rotor diameter: 90m

Height above sea level: 117m

Total construction height: 189m

Nacelle weight: 120.000 kg

- **10 MEMS Accelerometers (PCB type 3741)**
  - 4 levels
  - 10 locations

- **Data acquisition system (NI Compact Rio + T&M logger)**

-Continuous logging & online scope

Challenges

During operation an offshore wind turbine is excited by wind and waves. These ambient excitations are capable of exciting the vibration modes of interest.

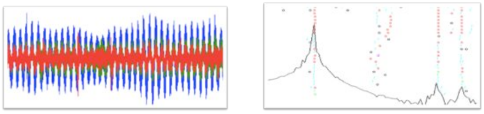


Fig. 1: Example measured vibrations and identified modes in parked conditions

Wind turbines are however complex structures and their dynamics vary significantly in operation in comparison to stand still parked conditions due to change in operating conditions e.g. changing pitch angle or changing ambient conditions e.g. change in wind speed.

This time variant nature of operating wind turbines and presence of harmonic components in excitation, still pose several challenges to application of OMA. For analyzing this data we will consider different techniques, including the recently developed and promising OMA method based on transmissibility measurements.

Operating and Ambient Conditions

In order to classify the operating conditions of the wind turbine following SCADA data is gathered at 1Hz and at 10 minute intervals.

- **power**
- **rotor speed**
- **pitch angle**
- **nacelle direction**

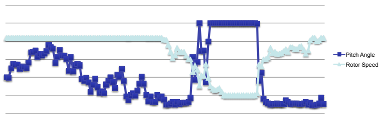


Fig. 1: Example Scada data with 10min interval during one day

In order to monitor the varying environmental conditions the following weather data data is being collected at 10 minute intervals

- **wind speed**
- **wind direction**
- **significant wave height**
- **air temperature**
- **tide level**

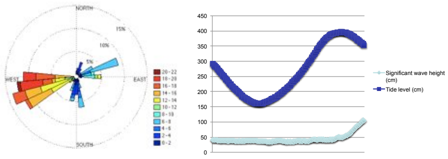


Fig. 2: Example data of ambient conditions: wind speed and direction (left) significant wave height and tide level (right)

Acknowledgments

This research has been founded by the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT) and the Fund for Scientific Research – Flanders (FWO). The authors also acknowledge Belwind and the OWI-lab for providing the test-facilities.

OWI lab Offshore Wind Infrastructure Application Lab

Belwind Offshore Energy

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