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Diagnostics and Prognostics of Pitch and Yaw Systems in Offshore Wind Turbines

Requirements and Design of Experiments

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Introduction

- Large offshore wind farms need a farm-level maintenance strategy for economic operation.
- Condition based maintenance (CBM) should be extended to all subsystems that can merit from it.
- Despite high failure rates, pitch/yaw systems are rarely addressed in condition monitoring context.
- State of the art shows > 30 condition monitoring systems, focus so far was limited mainly to generator, gearbox, main bearing and blades.
- Objective: Develop methods for assessing health of wind turbine pitch/yaw systems in offshore conditions.

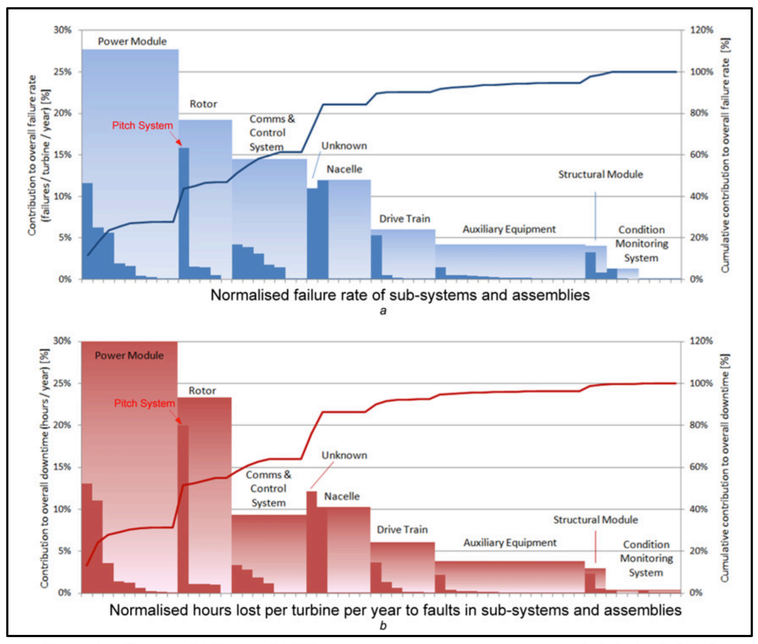


Fig 1: ReliaWind WT reliability analysis 2004-2010

Electrical Pitch/Yaw Systems

Electrically operated pitch and yaw systems considered.

Key components – control, motor, gearbox, slew bearing

Diagnostics & prognostics assessment for pitch/yaw systems is challenging due to:

1. Intermittent operation
2. Low speeds
3. High/irregular loads
4. Corrosive environment

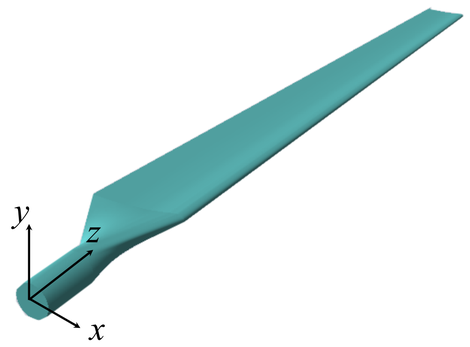


Fig 2: Wind turbine blade root forces translate to the pitch bearing

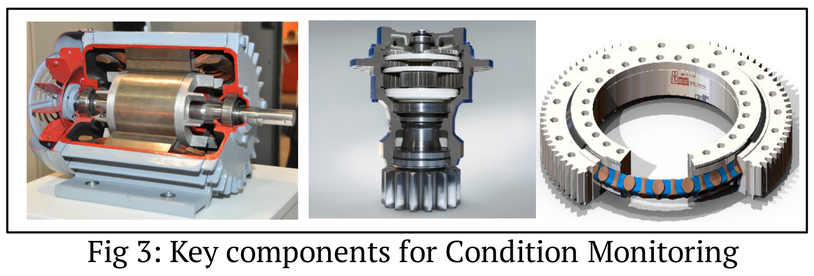
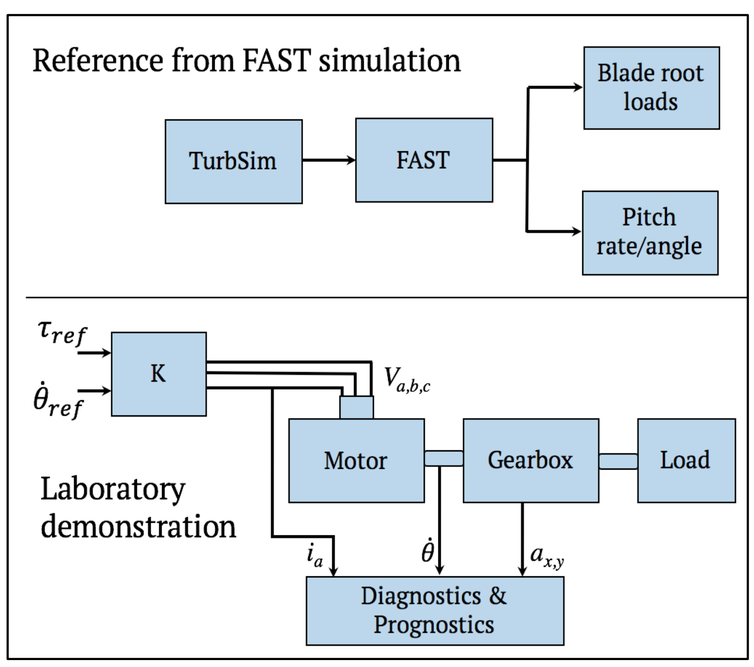
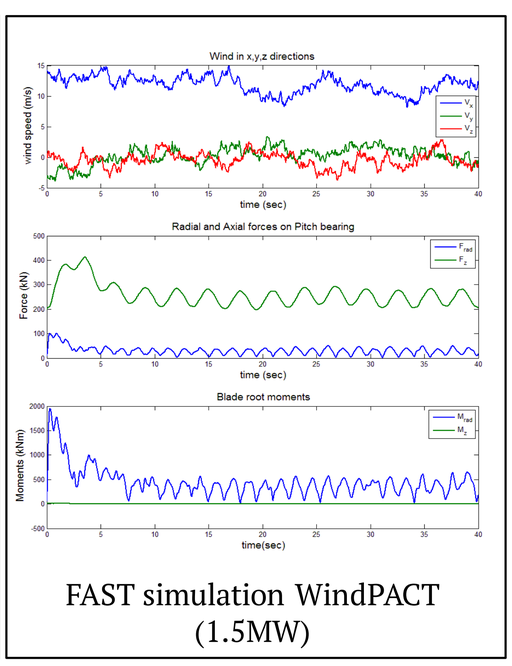


Fig 3: Key components for Condition Monitoring

Design of Experiments - I

- Simulate various weather conditions, wind profiles and turbulence effects using TURBSIM.
- Blade root loads, blade root moments and pitch rates from FAST simulation to study effects on pitch bearing and pitch actuators.
- Test efficacy of diagnostics/prognostics in intermittent operations.





FAST simulation WindPACT (1.5MW)

Fig 4: Design of Experiments for Diagnostics & Prognostics

Design of Experiments - II

- Laboratory setup to assess the efficacy of diagnostics and prognostics.
- The setup consists of a 3-phase induction more and a multistage planetary gearbox (pitch drive).
- Load and speed profiles simulated based on blade root loads & moments (obtained from FAST)
- Motor current signature analysis (MCSA) and gearbox vibration, acoustic emission to be tested for diagnosis of high priority failure modes.

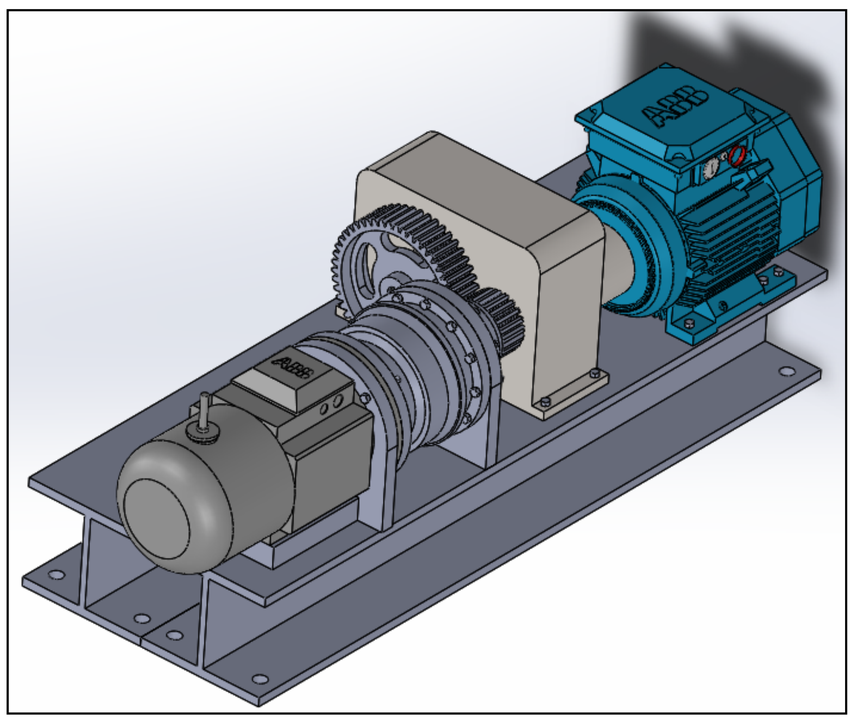


Fig 5: Design of test bench for pitch/yaw drives

Requirements

- The motor current diagnostics system shall detect incipient bearing, air-gap eccentricity and rotor bar faults in variable load, intermittent operations.
- The gearbox diagnostics system shall detect scuffing and cracking of gear teeth in planet, ring and sun gears in variable load, intermittent operations.
- The systems shall communicate health condition in case of faults to the onshore center.
- The communication follows IEC 61400-25 standards with metadata specifying the turbine and fault location.
- The prognostics system shall estimate the remaining useful life (RUL) of the component after fault has been detected, accounting for degradation due to fatigue and corrosion.
- The RUL estimation shall be sensitive to operating conditions.

Conclusion

- Requirements for diagnostics & prognostics of pitch/yaw systems in offshore wind turbines are identified.
- Loads effecting pitch system were studied using FAST simulation under various wind conditions derived using TURBSIM.
- A design of lab setup to test the efficacy of diagnostics in intermittent operational scenarios of pitch/yaw systems as in wind turbines is prepared.

References

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