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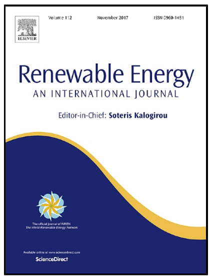

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Condition Monitoring of a wind turbine drive train based on its power dependant vibrations

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Abstract

Increasing the reliability and the downtime of wind turbines is critical to minimise the cost of energy (COE) in the wind sector, especially for offshore wind turbines. Due to the high impact that gearboxes and generator downtimes create on wind turbines, reliable and cost-effective condition monitoring systems (CMS) for the drive train are a great concern to the wind industry. This manuscript presents an approach for condition health monitoring and fault diagnosis in wind turbine gearboxes and generators by means of analysing the power dependant vibrations gathered. This methodology is based on the establishment of the normal operation boundaries for carrying out the identification of deviations related to a defect. The validity of the baseline is studied using q-factor and probability of detection (POD) concepts. Given the nonlinear and nonstationary nature of the faulty vibration signals, envelope analysis is proposed as a demodulation technique to be applied to the signals, prior to the frequency response being extracted. The methodology is validated by field trials in a WINDMASTER300 wind turbine. Baselines for the generator and gearbox were produced as a tool to detect future faults developed within the turbine. Envelope analysis makes the identification of the vibrational frequencies representative of failure very likely.

Keywords : wind turbine, condition monitoring, vibration analysis, drive train, failure, maintenance, baseline, envelope analysis.

1. Introduction

Offshore wind turbine capacity is almost increasing as much as onshore. This growth means that wind energy contributes significantly to the UK's power supplies, providing 11% of our electricity in 2015 (34.01TWh) [1]. The increase in capacity compels the wind industry to redesign its machines (growth in size) and make wind turbines more cost-effective for performing the conversion from kinetic energy to electricity. It has just been commented that there is a trend in shifting from onshore to offshore locations [2]. However, installing wind turbines offshore and, consequently, increasing the size of the turbines has its drawbacks. Large turbines experience higher winds than smaller ones. It implies that the load applied on the internal subsystems of the turbine (drive train) is higher which leads to a bigger deterioration of the machine and thus requires more maintenance [3]. Additionally, restricted accessibility of the wind turbine can make the situation more challenging. All these factors decrease wind turbine's reliability due to the high costs associated with replacement, removal and reinstallation of faulty components and the revenue losses caused by the long downtimes [4]. It increases the cost of the energy (COE) [5,6].

Since wind turbine components fail before the desired 20 years life-time [7] and unplanned maintenance works are costly, condition monitoring systems are employed to decrease the COE by increasing wind turbine's reliability and uptime [8-16]. Since the basic requirements for condition monitoring (CM) of wind turbines were established in 2013 [17] the wind industry has focused its efforts on utilising CMS for drive train fault diagnosis. The most common technique for condition monitoring of wind turbines is vibration analysis (VA). A survey carried out by the UK Supergen Wind Energy Technologies Consortium [18] showed that 14 out of 20 commercially available WT CMS provide vibration monitoring. Another survey accomplished by Durham University [19] showed that 27 out of 36 widely available CMSs are based on drive train vibration analysis. Oil-based analysis CMS are also used for wind turbine gearbox monitoring purposes. This technology is in an early development stage as regards to sensor technology and the validation of its capabilities for fault detection [20]. This technology is at the R&D stage so developed systems are in the pilot stage. Acoustic Emission is becoming a typical drive train condition monitoring practice. AE is primary applied for detecting the generation and propagation of cracks through the material. In [21] Board analysed the stress waves in bearings for the identification of anomalies in the lubrication film. A recent study on wind turbine CM displays a design