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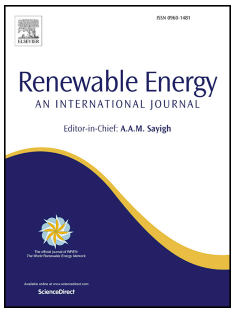

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Detection and Classification of Faults in Pitch-regulated Wind Turbine Generators Using Normal Behaviour Models Based on Performance Curves

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Highlights

- Propose normal behaviour models based on performance curves to detect WTG faults;
- Examine WTG performance under the normal conditions and with pitch faults;
- Demonstrate the feasibility of the proposed approach based on performance curves;
- Validate the criteria for electrical pitch system fault detection;
- Prove the advantages of the proposed approach over the ANN/ANFIS based approaches.

Abstract

The fast growing wind industry requires a more sophisticated fault detection approach in pitch-regulated wind turbine generators (WTG), particularly in the pitch system that has led to the highest failure frequency and downtime. Improved analysis of data from Supervisory Control and Data Acquisition (SCADA) systems can be used to generate alarms and signals that could provide earlier indication of WTG faults and allow operators to more effectively plan Operation and Maintenance (O&M) strategies prior to WTG failures. Several data-mining approaches, e.g. Artificial Neural Network (ANN), and Normal Behaviour Models (NBM) have been used for that purpose. However, practical applications are limited because of the SCADA data complexity and the lack of accuracy due to the use of SCADA data averaged over a period of 10 minutes for ANN training. This paper aims to propose a new pitch fault detection procedure using performance curve (PC) based NBMs. An advantage of the proposed approach is that the system consisting of NBMs and criteria, can be developed using technical specifications of studied WTGs. A second advantage is that training data is unnecessary prior to application of the system. In order to construct the proposed system, details of WTG operational states and PCs are studied. Power-generator speed (P-N) and pitch angle-generator speed (PA-N) curves are selected to set up NBMs due to the better fit between the measured data and theoretical PCs. Six case studies have been carried out to show the prognosis of WTG fault and to demonstrate the feasibility of the proposed method. The results illustrate that polluted slip rings and the pitch controller malfunctions could be detected by the proposed method 20 hours and 13 hours earlier than by the AI approaches investigated and the existing alarm system. In addition, the proposed approach is able to explain and visualize abnormal behaviour of WTGs during the fault conditions.

Keywords: condition monitoring, wind turbine generator, pitch faults, performance curves, normal behaviour model

Abbreviation

WTG	Wind Turbine Generator
SCADA	Supervisory Control and Data Acquisition
O&M	Operation and Maintenance
ANN	Artificial Neural Network
NBM	Normal Behaviour Model
PC	Performance Curve
CM	Condition Monitoring
ANFIS	Adaptive Neuro-Fuzzy Interference System
APK	A-Priori Knowledge
SIMAP	Intelligent System for Predictive Maintenance
CMS	Condition Monitoring System