Improvement of efficiency and fatigue life of vertical-axis wind turbines

Citation for published version (APA):

Document status and date:
Published: 01/01/2015

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.

Download date: 02. Aug. 2019
Improvement of efficiency and fatigue life of vertical-axis wind turbines

F. Geng¹, A.S.J. Suiker¹, B. Blocken¹,², I.M. Kalkman¹

¹ Eindhoven University of Technology, the Netherlands
² KU Leuven, Belgium
e-mail: f.geng@tue.nl

Problem statement
The fast growing demand for wind energy has led to a wide variety of wind turbine designs. A specific contemporary type is the vertical-axis wind turbine (VAWT), where the rotor shaft is oriented vertically and the generator and gearbox are placed at the base of the turbine, as shown in Figure 1. Compared with horizontal-axis wind turbines, VAWTs are generally considered more capable of handling highly turbulent, gusty wind conditions and rapidly changing wind directions. Since these conditions are commonly encountered in urban environments, this type of wind turbine can play a vital role in urban wind energy. On the downside, however, VAWTs are up to now generally less efficient and can be more prone to fatigue.

Methodology

Fatigue modelling
- Interface elements equipped with a cohesive zone model (CZM) will be adopted to model the progressive fatigue damage of blades under increments of load cycles caused by complex wind conditions.

FSI (Fluid-structure interaction) modelling
- The wind flow will be modelled using either the transition Shear Stress Transport (SST) k-ω model or Detached Eddy Simulation (DES) modelling approach; ABL wind tunnel experimental data will be used to validate simulation results.

Coupling process
- The outputs of both models above will be coupled at predefined instants in time. Material degradation derived from the fatigue response can be used as input data for the FSI simulation at a specific time instant, and force spectra from FSI modelling will serve as input for the next load cycle interval of fatigue analysis, as shown in Figure 2.

Current results
The transverse failure behavior of a single fiber epoxy system under a quasi-static axial loading has been analyzed. The crack development is simulated by the cohesive zone model. In parallel, the optimal computational settings for accurately estimating drag and lift coefficients of an airfoil have been explored at a wide range of angles of attack. Figure 3 shows an initial crack pattern and the corresponding horizontal normal stress (left), together with a 2D pressure profile of a blade using a standard k-ε turbulence model (right).