Zheng YOU, Jinji GAO, Fulei CHU, Tielin SHI

Special issue: Wind turbine dynamic modeling, condition monitoring and diagnosis

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As one of the typical renewable energy sources, wind energy has experienced an immense growth with respect to turbine size and market share, and this growth has led to a rapid development in wind-powered equipment in the last 10 years. In 2016, China was the world's largest regional market for new wind power development, with a capacity addition of 23.3 GW, which almost equaled the global cumulative capacity in 2001.

The wind power industry has also experienced high failure rates and increased operation and maintenance costs. Therefore, it is necessary to develop an efficient maintenance strategy including dynamic modeling, condition monitoring, and diagnosis tailored to wind turbine technology. For this purpose, this special issue aims to bring together ideas from the international research community, present latest developments, and advance the field of wind turbine condition monitoring. Specifically, this special issue in *Frontiers of Mechanical Engineering* contains 15 papers, including 4 reviews and 11 research articles, contributed by prestigious experts from 3 countries.

These papers cover broad areas, including recent advances in electric power conversion system (EPCS) condition monitoring, new topics of hydraulic-type wind turbines and semiconducting power systems, and condition monitoring and fault diagnosis methods for wind turbine gearboxes. These papers also cover the analysis of how particular factors, such as elastic support, friction coefficients, wind shear (WS), and tower shadow (TS), affect wind turbines, and the proposal of new analysis methods of parameter, control, and characteristic simulation. Other topics of wind power storage and a historical review of the windmill are also included.

Four review papers cover different aspects of wind turbines. Cai et al. reviewed the development of a new fluid and control technology for hydraulic-type wind turbines. The main introduction, the corresponding fluid model, the mainstream control method, and the advantages of the hydraulic-type wind turbine are provided. Faced with the comprehensive transformation of the electric power infrastructure from electromagnetics to semiconductors, Yuan et al. presented thoughts on a theoretical framework for future semiconducting power systems. Sun et al. provides a comparison between long-distance transmission and local energy consumption of large-scale wind power. Huang

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Zheng YOU

State Key Laboratory of Precision Measurement Technology and Instruments, Tsinghua University, Beijing 100084, China

Jinji GAO

Beijing Key Laboratory of Health Monitoring and Self-Recovery for High-End Mechanical Equipment, Beijing University of Chemical Technology, Beijing 100029, China

Fulei CHU (✉)

Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China
E-mail: chufli@mail.tsinghua.edu.cn

Tielin SHI

State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, Wuhan 430074, China

et al. summarized condition monitoring and operation control under faults for an electric power conversion system in a direct-drive wind turbine.

Condition monitoring and fault diagnosis of wind turbine gearboxes are intensively discussed in four research articles. Du et al. realized the multiple fault separation and detection of wind turbine gearboxes by using joint subspace learning, which can directly learn multiple faulty subspaces from observation data and sparsely concentrate the feature information into a few dominant subspace coefficients. Wang et al. proposed a techless order tracking algorithm for wind turbine condition monitoring under varied operating conditions by using cost-function-based ridge detection and Vold-Kalman filtering. Kong et al. proposed a novel feature extraction method based on sSpectral kurtosis and time wavelet energy spectrum (SK-TWES) to enhance the capability to extract repetitive transients buried in a noisy vibration signal with a low signal-to-noise ratio. Xu and Liu proposed a weak characteristic information extraction method based on μ -SVD (singular value decomposition) and LMD (local mean decomposition) to realize early fault evolution in the gearbox of a wind turbine generator.

Three papers discussed how particular factors affect wind turbine systems. Wang et al. analyzed the effect of elastic support on the dynamic behavior of a wind turbine drive train to provide an important basis for the optimization of the elastic support stiffness of the wind turbine drive train. Jiang et al. studied the effect of friction coefficients on the dynamic response of gear systems. The corresponding findings and simulation method provide a theoretical basis for developing monitoring accurate diagnostic techniques. Wen et al. discussed the relationships among power output, WS, and TS from the aspects of power fluctuation and power loss, which can serve as a reference in accurate power estimation and strategy development, to mitigate the fluctuation in aerodynamic loads and power output due to WS and TS.

Three novel approaches have been proposed for generator parameter estimation, power maximization, and brushless electrically excited synchronous generator (BEESG) analysis. In detail, Pan et al. proposed a new hierarchical parameter estimation method for a doubly-fed induction generator (DFIG) and a drive train system in a wind turbine generator (WTG). Hamed et al. studied the control methodology for variable-speed, variable-pitch wind turbines including the effects of uncertain nonlinear dynamics, system fault uncertainties, and unknown external disturbances. Zhang et al. proposed the equivalent circuit model and electromagnetic torque expression of BEESG based on the electromagnetic relation of the machine.

Meanwhile, Rossi and Russo discussed the windmill, which is the ancestor of wind power generation. The description of this ancient world technology can help understand the technical evolution of a significant product of the human mind.

In closing, we would like to appreciate the valuable contributions of all the authors sincerely. Acknowledgment is due to all reviewers for their service and commitment to reach the high quality of this special issue. We hope you enjoy reading the issue.

Guest Editors:

Zheng YOU
Tsinghua University, China

Jinji GAO
Beijing University of Chemical Technology, China

Fulei CHU
Tsinghua University, China

Tielin SHI
Huazhong University of Science and Technology, China

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