Development of the Inspection Device for the States of Blades of Wind Turbines by Using the Operating Noise from Blades

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1. INTRODUCTION

Reducing operational and maintenance costs is the general need for wind farm operators. The blade is a vital component of wind turbines. External conditions, internal stresses, improper manufacturing, forming process, fatigue, etc. may yield delamination, crack, and damage as time goes by. It can result in the performance deterioration of electrical energy generation. In general, the blade is one of the components in a wind turbine with high maintenance fee. Until now, many studies have proposed wind turbine blade damage detection technologies, including tap testing, ultrasonic examination, penetrant testing, laser shearography, etc. These detection technologies need to stop the wind turbines in advance or install sensors inside the blades to monitor. For large wind turbines, these methods have shown many limitations and inconveniences. Few detection techniques utilized the blade operating noise to detect blades in operating conditions.

This research is intended as a brief describing the diagnostic schemes for wind turbine blade damage by using the feature of emitted noise as the blade passes through the tower. The sound signals time-domain averaging and the short-time Fourier transform are applied to the rapid diagnosis of damaged blades in this study. The damage degree of blades is evaluated through a series of algorithms by comparing the power intensities at different time intervals in the enhanced signal in according to the operation cycle. A portable monitoring device is present to easily assess and rapidly screen the wind turbine blade health conditions.

2. RESEARCH METHOD

The signal processing strategy was shown in Fig. 1. An operating sound signal was obtained from a wind turbine. The signal was divided into several cycles by the periodical rotational features, then summarized each single period cycle with corresponding discrete points. The ambient noise is reduced several times in the enhanced signal. Then the Short-Time Fourier Transform (STFT) is applied to the output signal to obtain the time-frequency spectrum. The marginal spectrum is obtained by the time integration of the time-frequency spectrum. Three distinct peaks can be observed in Fig. 2, in which each peak represents the wind shear sound of the blade while passing through. Finally, the energy at different time intervals in the time-frequency spectrum was calculated and normalized to obtain the blade damage degree. This damage degree index will act as the parameter to inspect the blade condition.

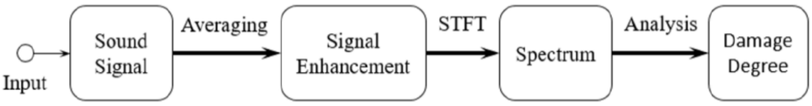

Fig. 1 Blade diagnosis analysis flow chart

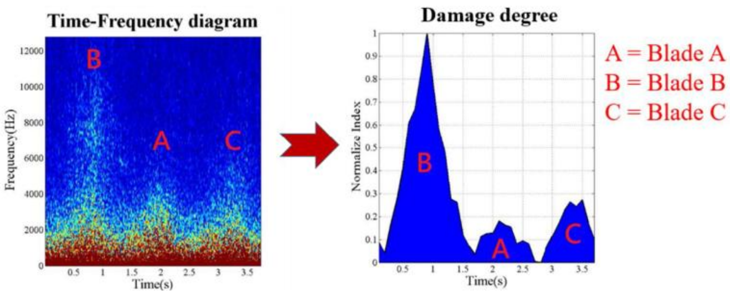

Fig. 2 Result of time-frequency analysis

Through a series of algorithms to calculate the blade damage degree, which is the parameter to be used to judge whether the blade is damaged or not. The diagnostic results of this study were in agreement with in-situ inspection results. This technique has been successfully verified by on-site inspection on wind turbine farms in Taiwan.

For easier noise event capture and rapid blade damage detection beneath the wind turbine in situ, a portable and compact device, as shown in Fig. 3, was proposed. The device was packed into a carrying box in which a microphone and single-board computer were installed. The calculation core for the blade damage index was embedded into the computer. In accordance with the marker interval, the continuous signal will be divided into several cyclically repeated signal segments. The blade damage index evaluation was based on several signal segments through the signal enhanced processing. The layout for the graphic user interface was shown in Fig. 4. The operator was requested to key in or selected the identification for the wind farm and wind turbine, and then click the start button to proceed with the noise events captured. Within the measuring interval, the operator needs to mark “blade A” using the blade identification. The measurement period, ordinarily 20 seconds, can be set in advance by the software or manually stop via the hardware. The blade damage index was available within 1 minute after the measurement stop.

Fig. 3 Design of the portable device for wind turbine blade damage detection

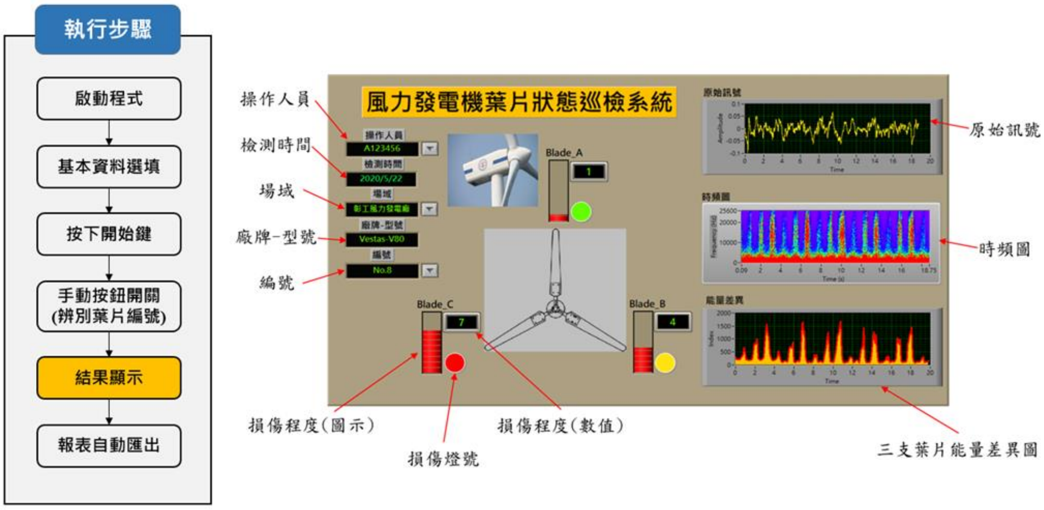

Fig. 4 Graphical user interface for portable device

3. CONCLUSIONS

The increasing demands for the rapid and easy blade damage detection device come from the wind turbine owner and operator. The main advantages of this proposed method using the noise feature to detect the wind turbine blade surface and damage are the ease of use and implementation in situ. To eliminate the unwanted noise components, this study compares the power intensities at different time intervals in the enhanced signal to calculate damage degree. The blade damage degree has been practically verified by on-site monitoring of the wind turbine blade. In the future, the completion of the portable device will significantly help to reduce the working hours for the wind turbine blade inspection.

This research proposes a rapid inspection method for the diagnosis of wind turbine blade damage. It is different from using human's hearing and visual sensing experiences to inspect the health of wind turbines in operating or stopped conditions. The diagnostic results of this study were in agreement with in-situ inspection results. In addition to high correctness, the method can find abnormal events while the traditional methods cannot. The new inspection method can help wind farm operators to monitor the health of the wind turbine blades.