Development of Wind Turbine Blade State Inspection Device

(Energy Lab：Chung, Chiou-Fong)

1. INTRODUCTION

Maintenance and repair of wind turbine components are important for the operation of the wind power industry. The wind turbine blades may be damaged gradually because of long-term operation under severe weather conditions, especially typhoon seasons in Taiwan. Wind farm operators still rely on the field technicians' visual and auditory judgements to assess the health conditions of wind turbine blades. The traditional methods are inefficient and inaccurate. This paper aims to provide a blade fault inspection method by using wind turbine noises to conduct on-site wind farm inspection through portable devices. The advantage of this device is that it can inspect in-operation wind turbine blades. The routine inspection work can keep tracking the condition of each blade, and the records could be further used for in advance maintenance and repair. It is expected that this will help improve the operational efficiency of Taiwan's wind power industry in the future.

2. ANALYSIS PROCESS

We used a series of algorithms to calculate the blade damage degree, a parameter used to judge whether the blade is damaged or not. The signal processing strategy was shown in Fig. 1. The diagnostic results were compared with the field inspection results provided by the wind farm maintenance staff. Two steps were adopted in the inspection method by the staff, for easier noise events captured beneath the wind turbine and quick detection of the on-site damage condition. A compact portable device, as shown in Fig. 2、3, is recommended and under developing now. The device can be packed into a carrying box along with a microphone and a single board computer. The calculation core for the blade damage index is embedded into the computer along with the storage device. The operator has to mark the blade A when it passes through the tower for blade identification. In accordance with the marker interval, the continuous signals will be divided into several cyclically repeated signal segment. The blade damage index evaluation uses the repeated signal segment and the signals to enhance processing. The user interface layout of the portable device is shown in Fig. 4. The operator will be asked to key in or select identifications for the wind farms and wind turbines, then click a button to start the noise event capturing. Within the measuring interval, the operator needs to mark the blade A by using the blade identification. The measurement time can be defined in advance and manually stopped- ordinarily 20 seconds measuring interval is enough. The blade damage index is available within 1 minute after the measurement stop.

3. RESULT

The data used in the development of the portable inspection device had beencollected by the team from 2015 to 2019. A total of nine field measurements were made, with a total of 83 events (Table 1). The diagnosis result was used to compare with the actual condition of the blade, including the inspection report, the maintenance result, and the damaged photo. The result may serve as a reference for correctness, and the algorithm is constantly revised to optimize the diagnostic logic. Taking the data as an example (2019/03/26), the diagnosis results are listed in Table 2. The condition of each blade will be quantified as a degree of damage from 0 to 1.0, and used to compare with the results of three professional hearing experience judgments. It can be seen from the results in the table that the results of the two inspection methods are consistent. According to the test result of No. 2, the damage

degree of the blades A and B is 0.4 and 0.2, respectively, which is slightly damaged, and the damage degree of the blade C is 0.7, which belongs to the damaged blade, indicating that repair work needs to be arranged to prevent irreversible damage and rupture. There is increasing demand for rapid and easy blade damage detection devices from wind turbine owners and operators. Using noise features to detect the wind turbine blade surface and damage provides a method of easy field access and implementation. To eliminate 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 inspection on wind turbine blades. In the near future, portable devices will significantly help reduce the working hours for wind turbine blade inspection.

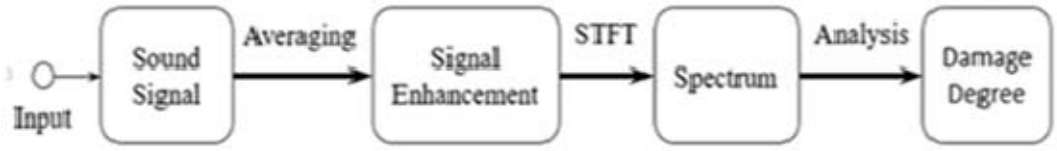

Fig. 1 Flow chart of blade diagnosis

Fig. 2 Portable device

Fig. 3 Portable device (top cover)

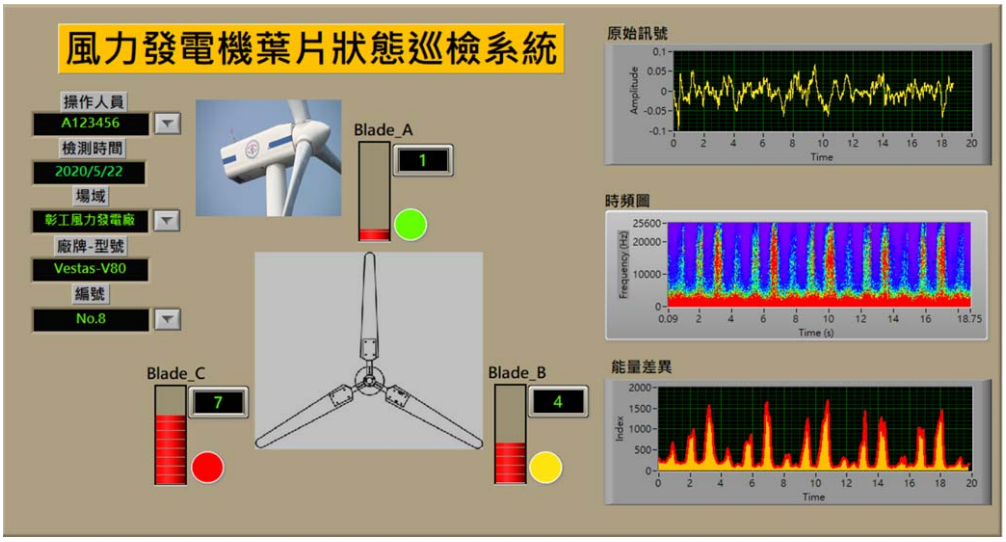

Fig. 4 Graphical interface of the portable device

Table 1 Database of wind turbine blade noise

Database of wind turbine blade noise			
Items	**Date**	**Wind farm**	**Events**
1	2015.04.29	CK	2
2	2015.06.29	CK	4
3	2016.03.04	CK	9
4	2016.07.14	CK	6
5	2017.03.28	CK	4
6	2017.12.27	CK	6
7	2018.03.09	CK	29
8	2018.05.03	CK	14
9	2019.03.26	CK	9
The total events			83

Table 2 Diagnostic results of 2019/03/26

Number	**Field inspection results (Index)**			**Diagnosis results of this paper (Index)**		
	Blade A	**Blade B**	**Blade C**	**Blade A**	**Blade B**	**Blade C**
NO.1	0.1	0.1	0.1	0.1	0.1	0.1
NO.2	0.4	0.2	0.6	0.4	0.2	0.7
NO.3	0.3	0.5	0.1	0.3	0.5	0.2
NO.4	0.3	0.4	0.2	0.4	0.5	0.3
NO.5	0.2	0.5	0.1	0.5	0.5	0.3

Number	Field inspection results (Index)			Diagnosis results of this paper (Index)		
	Blade A	**Blade B**	**Blade C**	**Blade A**	**Blade B**	**Blade C**
NO.6	0.3	0.5	0.5	0.4	0.5	06
NO.7	0.1	0.1	0.3	0.1	0.1	0.2
NO.8	0.1	0.1	0.1	0.1	0.1	0.1
NO.9	0.2	0.4	0.4	0.2	0.4	0.4