Development of an Infrared Thermography for Wind Turbines Monitoring by Remote Sensing Techniques

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ABSTRACT: Since wind power generators are built substantially around the world, structural health monitoring is then critical for operations reliability of wind turbines. A structural health monitoring system was developed for large scale wind turbines by using infrared thermography (IRT) in this article. A high-resolution infrared thermal imager with a reflective telescope was established to monitor the operating state of wind turbines. Compared with traditional sensors monitoring system, such as fiber Bragg grating (FBG) and electric strain gauge (ESG), infrared thermography is more proper to monitor the health for operating wind turbines because the IRT can present the temperature gradient on surface of wind turbines instead of just at a few points by using traditional methods. The study shows that abnormal conditions may occur when the temperature gradient exceeded the criteria. It appears that IRT is promising for detecting abnormal conditions at early phase of damage for wind turbines based on remote sensing techniques. This IRT structural health monitoring techniques can also be applied to monitor the offshore wind turbines, high voltage electrical towers, buildings and bridges for more advanced applications.

1. INTRODUCTION

A wind turbine generator is power equipment that converts kinetic energy from the wind into electrical energy. Compared to conventional power equipment, it is exposed to highly variable and harsh weather conditions, including typhoon, lightning and earthquake, especially offshore wind turbine. Since offshore wind turbine is located in the sea and it is not easy to detect their damage using traditional methods, such as manual inspection or early installation of sensors. Therefore, development of a novel remote monitoring system is a very important task for the maintenance of offshore wind turbines. In the past decade or more, many monitoring techniques such as electric strain gauge, fiber Bragg grating, acoustic emission (AE), ultrasonic testing (UT) and X-ray inspection has been developed [1-5]. However, these methods are not suitable for on-site or remote monitoring due to their technique limits. Infrared thermography is one of the most promising technologies for the reasons that it is non-contact, fast, strong field adaptability, applicable to wide range of materials and providing clear image results of the inspection area. Infrared thermography is used to record the entire process of surface temperature variation. It is expected that the information of defects, damage and discontinuous can be detected after data analysis and image processing [6-7]. An infrared thermography for wind turbines monitoring by remote sensing techniques has been successfully developed in this study. The study demonstrates that abnormal conditions may occur when the temperature gradient exceeded the criteria, especially at the root and the tip regions of a blade. The reliable IRT monitoring technique can be applied to the offshore wind turbine, high voltage electrical tower, building and bridge deformation monitoring for further advanced usage.

2. METHODS AND EXPERIMENTAL SET UP

Infrared thermography is a non-contact and long distance non-destructive inspection technique that makes it possible to examine a large area of the wind turbine blades for structural defects. Infrared thermography inspection is usually classified into active infrared thermography and passive infrared thermography. In active infrared thermography, different heating sources are used for heating the object. Figure 1 shows a schematic diagram of the IRT monitoring instrument developed in this study. A high-resolution infrared thermal imager with a reflective telescope was established to monitor the operating state of wind turbines. The infrared thermal imager has a high-resolution of 640 x 512 (Pixel), which is integrated with a refractive optical telescope system of focal ratio f/8. The field of view (FOV) depends on the distance of remote and height of wind turbine. It is judged whether damage is caused by monitoring the difference in heat radiation distribution before and after the damage of the structural surface. In addition, the IRT monitoring instrument developed by this study can also integrate smart phones for intelligent image acquisition.

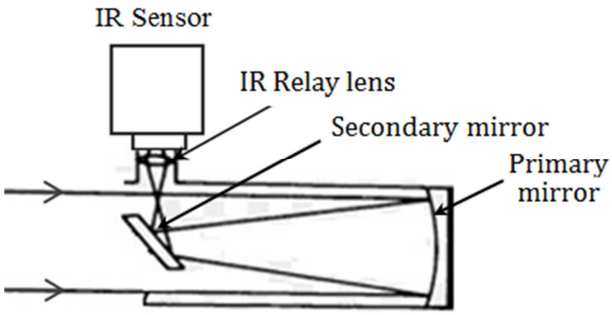
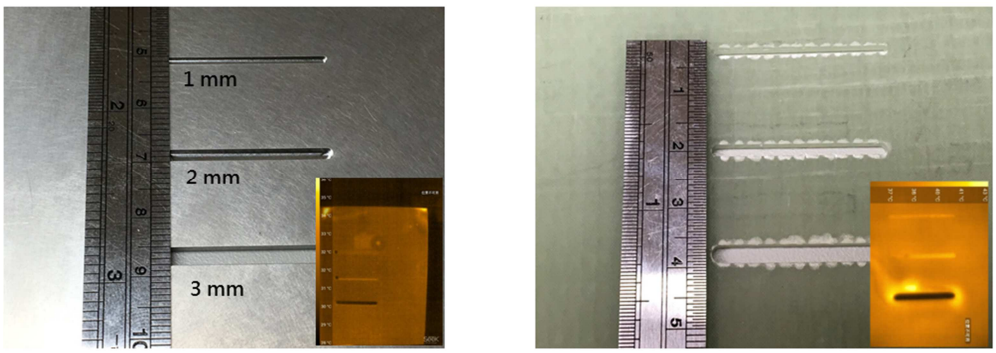


Figure. 1 Schematic diagram of the IRT monitoring instrument

3. RESULTS AND DISCUSSION

Strong wind and air pressure changes have significant impact on the blades of wind turbine. In particular, the continuous influence of the cyclic loads will greatly affect the blade causing damage, such as cracks, delamination, and so on. It may produce temperature differences in the blades during the operation causing high stress or stress release in different areas of the blade. In addition to the stress distribution, small cracks and dry laminates will generate heat by friction due to cyclic excitation. In order to grasp the resolution of infrared thermography, IRT images testing experiments were performed using stainless steel plates and GFRP (Glass Fiber Reinforced Plastic) plates with different line-width features as shown in figure 2.



(a) Line features of stainless steel (b) Line features of GFRP

Figure. 2 Infrared thermography image resolution testing experiment

Figure 3 shows the results of infrared thermograph image of wind turbine by remote monitoring techniques. It can be observed that the thermal infrared image features are different in the root of wind turbine blade and the discontinuous area. The bright areas are warmer as the dark areas and show the heat production due to surface wear. In addition, the IRT image contrast enhanced by exposure histograms makes the images more accurate and easier to discriminate.

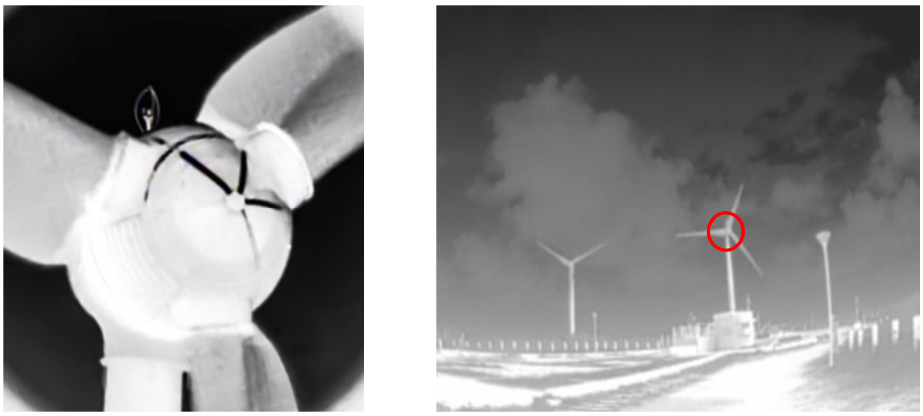


Figure. 3 Infrared thermography image of wind turbine by remote monitoring

4. CONCULSIONS

An infrared thermography for wind turbines monitoring by remote sensing techniques was presented. A high-resolution infrared thermal imager with a reflective telescope was developed to monitor the operating state of wind turbines. The study demonstrates that abnormal conditions may occur when the temperature gradient exceeded the criteria. Moreover, ITR image features are different in the root of wind turbine blade and the discontinuous area. The bright areas are warmer as the dark areas and show the heat production due to surface wear. The reliable IRT monitoring technique can be applied to the offshore wind turbine, high voltage electrical tower, building and bridge deformation monitoring for further advanced usage.

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